"AN AGRICULTURAL GEOGRAPHY OF SOME SEMI-ARID PARTS OF THE MEDITERRANEAN REGION IN RELATION TO THE PROBLEMS OF WEST PUNJAB."


THESIS presented to the University of Edinburgh for the Degree of Ph.D.

January 1950.
NOTE: - Due to an error on the part of the binder, the first ten pages of Chapter 19 (AGRICULTURAL REGIONS III) have been placed after page 648 in the concluding chapter. After page 591, please turn to page 592 after p. 648 and then come back to p. 602 which is in its correct place.
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ACKNOWLEDGEMENTS.

The persons who assisted me in various ways in the preparation of this thesis are far too numerous to be mentioned individually. I can only name a few to whom I am specially indebted.

Dr. C.J. Robertson and Dr. A. Geddes both gave much of their valuable time in guiding my research. Prof. A.G. Ogilvie's encouragement and advice is also acknowledged gratefully. The uniform courtesy and help accorded by Captain A. Hawkins, Secretary of the Royal Scottish Geographical Society and his assistants was of value during several months of work in the Society's Rooms. In London, the Librarian of the India House Library, Miss W.K. Thane provided every facility to me and later on permitted prolonged loans of several works of reference and maps.

During my study tour, Mrs. Geddes' letters of introduction were of great value. In Rome, Signor Sicardi, Assistant Librarian of the F.A.O. Library not only extended courtesy and help in the Library but also assisted in procuring literature. In Tunisia, I owe much to the continuous assistance of M. Murad Sharif who accompanied me most of the time.

M. Mohammad Badra, President of the Tunisian Chamber of Commerce, was responsible for most of the opportunities I got of visiting several farms in that country. He also gave me useful introductions in Algeria and Morocco. My special thanks are due to M. Mohammad Salah ben Hamouda whose farm at Mateur I visited and in whose car I travelled to Sousse and Kairwan.
In Algeria, M. Ahmad Toufig el Madani, author and journalist provided me with much information and gave useful introductions. The assistance of the Service de l'Hydriolique et de la Colonisation is thankfully acknowledged in arranging an official tour of the plains of Affreville and Orleansville and visits to several irrigation projects. M. Kergomard, a cousin of Mrs. Geddes provided valuable literature and introductions and thanks are also due to M. Jacques Regnier, colonist at El Marsa for hospitality and later help through despatch of literature.

In Morocco, the help of several government departments, especially the Service de la Production Agricole is thankfully acknowledged in arranging official tours in the plains of Beni Amir and Marrakesh. M. Celerier, Agregé de Géographie, Institut des Hautes Etudes Marocains provided me with valuable guidance and much useful literature. Of Moroccan friends the assistance of M. Marnissi, President of the Moroccan Chamber of Agriculture, Fez and of the several leaders of the Istiqlaal Party is gratefully acknowledge. M. Mehdi ben Barka accompanied me on a tour of the Gharb plain and looked after my programme most efficiently.

Of those who helped me by post from Pakistan, I am specially indebted to Dr. R. M. Gorrie for sending me numerous photographs and valuable literature on the problem of Soil Erosion in West Punjab. Dr. K. S. Ahmad, Head of the Department of Geography, West Punjab University, also gave me constant encouragement and advice.
Chapter 1
INTRODUCTION

This study of the agricultural geography of Barbary as a largely semi-arid part of the Mediterranean Region has been made side by side with comparable aspects in West Punjab. It represents an attempt to look at the problems and distribution of crop-production in these regions from a fresh angle by interpreting them in the light of the common features of their physical and human background. While no effort has been made to force the individual pattern of these wide-apart regions into an identical mould, the community of many of their problems has been demonstrated on the basis of a first hand survey.

The Boundaries of Regions Studied

Barbary comprises the three French territories of Tunisia, Algeria and Morocco which are referred to in French literatures simply as "North Africa". The region has been called "Maghreb" or "Maghreb-ul-Aksa" meaning "the West" or "Far West" by the Arabs. Both the French and Arabic terms are unsuitable because while North Africa, as understood geographically embraces the entire region from Egypt to Morocco north of the Sahara, the Arabic term is simply a historical reminder of the fact that the region comprised the westernmost part of the Islamic countries and was also considered to constitute the western extremity of the known land-mass. The name Barbary belongs to the region by ancient tradition and is derived from the dominant race, the Berbers. Its use is sometimes extended to cover Tripolitania but throughout this study, it shall be applied to the region which covers the Protectorate of Tunisia, Algeria north of the
Saharan Atlas (comprising the three departments of Oran, Algiers and Constantine) and French Morocco. These territories constitute a geographical entity being linked by the Atlas ranges which dominate their relief. They lie between $28^\circ$ and $38^\circ$ North latitude and between $11^\circ$E and $12^\circ$W of the Greenwich meridian. Their areas are given as follows:

<table>
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<th>Country</th>
<th>Area (square miles)</th>
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<tr>
<td>Tunisia</td>
<td>48,332</td>
</tr>
<tr>
<td>Algeria(i)</td>
<td>80,117</td>
</tr>
<tr>
<td>Morocco</td>
<td>154,375</td>
</tr>
<tr>
<td></td>
<td>282,824</td>
</tr>
</tbody>
</table>

The Saharan parts of Morocco and Tunisia have also been excluded so that the Barbary of this study is bounded on the north and east by the Mediterranean, on the south by a line along the southern edge of the Anti-Atlas, and Saharan Atlas ranges continued into Tunisia along the north of the Great Shotts (Jerid and Ferjaj) and on the west by the Atlantic Ocean. Out of the region thus bounded, Spanish Morocco has been excluded.

West Punjab constitutes that part of the former Indian province of the 'Punjab' (meaning "the land of five rivers") which after the partition of the sub-continent of India in August 1947 between the two dominions of Pakistan and India has become a part of Western Pakistan. Map gives the dividing boundary between the two parts of the former province. West Punjab includes a little over 16 of the 29 original districts and has an area of 62,046 square miles. It lies between $28^\circ$ and $34^\circ$N latitude and $69^\circ$ and $76^\circ$ longitude east of Greenwich. The latitudinal range of Barbary and West Punjab, it may be noticed, is similar.

(i) Administratively, Algeria embraces a large part of the Sahara. The essential Algeria however lie north of the Saharan Atlas and for the rest of this study, the name Algeria will refer to the northern three departments.
The Physical Bases of Comparison: Superficially, Barbary and West Punjab appear to be regions of contrast, the former largely mountainous with a Mediterranean climate and the latter consisting of an alluvial plain having a monsoonal climate. The contrast in orographic features is very real and has far-reaching affects on the amount of cultivable land as well as on other aspects of the physical and cultural landscape. It is in climatic aridity that a striking parallel exists and from the agricultural point of view this factor is of supreme importance.

Certain similarities in the geographical position of the two regions may be indicated. Both Barbary and West Punjab lie in warm temperate latitudes on the fringes of great hot deserts, the Sahara in the case of the former and the Thar Desert in that of the latter. In both cases, the deserts have constituted a real barrier between the peoples to their south and the north. The races of Peninsular India differ almost as much from those in the Punjab as the negroid races of Tropical Africa from the Semites and Hamites of Barbary. The position of the two regions at the two extremities of a continuous block of Muslim countries is also of interest culturally. That the two regions might come closer economically was foreshadowed by the participation of representatives from Barbary in the Islamic Economic Conference at Karachi held in December 1949.

Agriculturally, the main inherent weakness of the two regions has always been climatic aridity and as climate is the one element of natural landscape that is readily adaptable to quantitative analysis, a closer examination of this parallel can be undertaken.

Two original maps of Barbary and West Punjab have been
drawn on the basis of De Martonne's index of aridity \( \text{Ar} = P(T + 10) \). According to this formula, indices below 5 characterize the true deserts. In Barbary, the aridity line of 5 practically coincides with the southern limit of the areas to be studied. In West Punjab again, only a small region to the south-west has an index of below 5. It is striking that in both regions, the indices of aridity range from 5 to over 30, the areas having an index of over 30 covering limited tracts in the north. In both regions, the greatest developments in irrigation have taken place in areas having an index of below 20. The influence of the more complex relief in Barbary is reflected in the trends of the various lines of indices. De Martonne's formula is based on a simple combination of rainfall and temperature. Some of the well-known classifications of climate which derive their basis from a more refined and elaborate treatment of meteorological data may also be applied. According to Köppen's classification a large part of West Punjab has a "hot Steppe climate with a dry winter" (BShw) while southern Barbary has a "hot Steppe climate with a dry summer" (BShs). In Thornthwaite's classification the distinction has again been made between the summer and winter incidence of the dry periods in Barbary and West Punjab respectively, otherwise large areas in both are included in the DB (Temperate steppe) zone. Both Köppen and Thornthwaite accord northern Barbary a more humid regime than any parts of West Punjab. This is because of the factor of evaporation as measured indirectly. Rainfall in West Punjab occurs in summer, a period of high temperatures so that it is less "effective" than the predominantly winter rainfall of Barbary. These observations on major classifications are made from scale world maps and it is probable that the parallel would be closer if the respective formulas of Köppen and Thornthwaite

(i) E. De Martonne "Regions of Interior-Basin Drainage", G.R. Vol.17, 1927
were applied in detail. New refinements are continually being evolved with regards to the classification of climate, and the availability of evaporation data would certainly facilitate a more definite comprehension of the real water-requirements of crops in relation to the losses of moisture by evaporation and transpiration as determined by climate.

The climatic parallel may be summed up as follows:

(a) Both regions show a passage from humid and sub-humid conditions in the north through a broad semi-arid belt to desert conditions in the south.

(b) Both regions have a pronounced periodicity of rainfall with a long season of drought occurring in the summer in Barbary and winter in West Punjab. Periodic drought and the insufficiency of total rainfall combined with high temperatures and consequently high evaporation are the main climatic hazards for agriculture in both regions. Apart from necessitating the development of irrigation and dry farming, high evaporation is responsible for the occurrence of many handicaps in the constitution of the soil - limestone and salinity. Soil-erosion is precipitated in both regions by the occurrence of rainfall in heavy showers during short periods. The climatic similarity is also reflected in the most important annual crops grown, these being wheat and other cereals.

Cultural Factors Agriculture and the associated modes of life are an aggregate of cultural as well as physical factors. It is in their cultural background that the two regions resemble each other most closely. Historical influences, present life and culture have all combined to produce a similar system of land-ownership and tenures and fundamentally identical problems with regard to the size
and sub-division of holdings, the traditional cultivation methods and the attitude to progress.

The history of both Barbary and West Punjab is a long tale of foreign invasions ending with the establishment of a European power. The impact of the west on these essentially eastern countries has had important repercussions on the increase of population, the improvement of communications, the linking up of their economies with that of the world and finally, most important of all, a slow evolution towards improved crops and production. In both regions, present life and culture is based on Islam, a religion which stands apart from all other creeds in the completeness with which it permeates every institution of a society and the enduring and even fanatical devotion to its tenets it inspires. The present native populations of Barbary and West Punjab retain, if any, traces of the pre-Islamic days. Their system of landed property and of tenancy is rooted in Islam and their choice of crops is influenced by religious tradition, i.e. in their refusal to cultivate vines for wine-making in Barbary. Most of them are not only steeped in tradition but are also illiterate so that they are resistant to progress as brought by the westerner. Their poverty is their greatest handicap towards the improvement of agricultural standards. Small-holdings prevail. Thus the social and cultural problems of agriculture in the two regions may be said to be identical.

Recent developments in both regions have been initiated by western powers. The French policy in Barbary and the British policy in West Punjab up till 1947 can be broadly compared and contrasted in this study in their relative success in improving the standard
of agriculture. One important result of the influence of the west has been that the modes of life have been in evolution. The development of canal irrigation in West Punjab has spread sedentary agriculture to all parts of the province. A slower but nonetheless sure movement in the same direction has been in progress in Barbary though its cause is more the acquisition of land by Europeans than any comparable development in irrigation.

While any contrasts between the two regions will be pointed out in the subsequent chapters and local peculiarities described, it can be concluded from a discussion of physical and cultural features that there are adequate grounds for making a parallel study of Barbary and West Punjab.

The Scope and Arrangement of the Work This study has been divided into four principal parts. In the first part the physical background has been described. The chapter on structure and relief purports to give only an outline in the context of which the other physical and cultural factors may be considered. Detailed descriptions of areas studied closely in the field or from large-scale maps has been given under agricultural regions. The account of climate, hydrography, vegetation and soil similarly treats only of essentials in relation to agriculture and its problems. The factor of variability of rainfall in Barbary has been given special attention and some correlations have been established, i.e. between autumn rainfall and the total area sown and between spring rainfall and the yields.

The second part treats of the cultural background. In this section, two aspects have been studied in special detail. European colonization in Barbary and its impact on the native cultivators
of Barbary has been discussed in relation to its history and development. The modes of life and settlement in Barbary have been described regionally after a detailed examination of physical, cultural and economic factors.

In the third part a number of outstanding agricultural problems have been examined in considerable detail with special reference to recent developments. The account of irrigation embraces the traditional and modern systems, their influence on crops and on the cultivators. Settlement of newly irrigated regions has also been examined in some detail. For Barbary the problem has been documented by studies in the field. Thereafter, waterlogging and saline soils, soil erosion and dry-farming are treated rather generally mainly on the basis of documentary material. Attention has however been drawn to the most pressing problems to be faced today and the types of solutions that have been attempted.

The final part includes first an account of land-use and agricultural methods, followed by a brief description of the production and distribution of principal crops. Then, in the chapters on agricultural regions, all the factors described earlier have been integrated. Most of the micro-geographical studies made in the field and from 1:50,000 maps are incorporated into these chapters. The division of Barbary into agricultural regions and their detailed description with the help of sample regional and farm studies thus constitutes the principal result of this study.

A brief account of present attempts towards modernisation is followed by the Conclusion in which several constructive suggestions have been made in relation to the population problem
and the low standard of living.

Throughout the study, the emphasis has been placed on Barbary which was the region studied in the field and on which a large proportion of documentary research was carried out. West Punjab stands, as it were, in the background. A fuller understanding of the agricultural landscape and of the problems of agriculture which has followed the study of Barbary may later lead on to an attempt at a closer survey of West Punjab on the basis of field work.

Limitations and Handicaps

The ground that has been covered in the course of this study precluded the possibility of maintaining the same degree of detail or originality of approach. Certain aspects have had to be treated more briefly than was planned because of the absence or non-availability of necessary data or the impossibility of conducting an adequate amount of field work to provide details. The size of holdings in Morocco and Tunisia is a case in point. Details of various type of ownership of land and tenures is another. The technical side of certain agricultural problems such as soil erosion or saline and water-logged lands may show imperfections because while the study of the geographical and economic causes of these problems is within the writer's competence, the details of their solutions is not, and at best, a summing up of accessible documentary material has been attempted.

The most serious limitation of the study is the inadequacy of statistical matter which forms the basis of distribution maps. Five years' normals are an accepted
minimum in the compilation of such maps if they are to have a lasting value, especially in regions where production is so variable along with the climate.

This weakness in the case of Barbary arose partly out of the inadequacy of documentary sources outside the region itself and partly due to the pressing requirements of field work when the region was visited. Published data were scarce and their collection from departmental sources would have involved prolonged office work whereas the fundamental aim of travel in Barbary was to view the actual rural landscape and visit farms typical of different regions. The latest year for which alone detailed figures were available - 1945-46 - was abnormal in certain ways as is indicated by comparisons with quinquennial averages in an appendix at the end. The following redeeming features of the scheme adopted may however be given:

(1) For figures of total production of important annual crops by territories, five year averages have been taken. Details by statistical sub-divisions in any year would give a reasonably accurate idea of geographical distribution unless the abnormal conditions were strongly localised in limited regions. As far as the present writer is aware, the effects of the drought in 1945 were widespread in Morocco and Algeria.

(2) In any case the imperfections of official statistics as at present compiled are considerable and have been described in another appendix. The details of agricultural regions, the core of this work, are derived primarily from field work and from authoritative documentary, rather than from such inadequately

The year for which figures of detailed production were available - 1945-46, was abnormal as consequent upon the drought in 1945, the area sown under cereals was reduced in Morocco and Algeria as the following table will show.

<table>
<thead>
<tr>
<th></th>
<th>MOROCCO</th>
<th>ALGERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>1207</td>
<td>977</td>
</tr>
<tr>
<td>Barley</td>
<td>1599</td>
<td>1012</td>
</tr>
<tr>
<td>1941-45</td>
<td>1649</td>
<td>842</td>
</tr>
<tr>
<td>1945-46</td>
<td>1450</td>
<td>729</td>
</tr>
</tbody>
</table>

The Tunisian figures were normal. The areas of orchard or plantation crops remained constant so that the percentage of cereals in Morocco and Algeria was lower than normal.
recorded statistics. The map of Dominant Crops by statistical divisions may thus be compared to map of Dominant Crops as determined by field studies and documentary work to find out how limited is the utility of these figures.

For West Punjab, again only one year has been taken for statistical analysis. The year selected - 1944-45 - is however, a normal one as shown by the official comparisons made in the Season and Crops Report for that year with the averages. The calculation of averages for the province as a whole as well as the indication of trends over prolonged periods was difficult because the partition of the Punjab has rendered provincial statistics useless. The compilation of agricultural statistics for West Punjab ought to be undertaken all over again.

With regard to field work, it will be noticed later on that although small-holders form the overwhelming majority of agriculturists in Barbary. Only two of their holdings were visited as compared to 13 belonging to large native landowners and 9 belonging to European colonists. Even though the mode of cultivation by the small peasant is fairly uniform over Barbary, a closer acquaintance with his methods and crops in different regions would have been advantageous. Herein a limitation was imposed by the lack of opportunities. The small cultivator, being illiterate, is not accessible to the foreign visitor who does not speak his dialect. Even local officials and notables who guided the writer did not reveal more than a general conception of his agricultural methods and standard of life.

(i) See appendix on the year 1944-45 in West Punjab.
In a work covering such large areas and extending over a vast subject, imperfections of detail in content or presentation are bound to exist. No effort however has been spared to make it a useful contribution towards the understanding of the agricultural landscape and problems of the two regions.
Chapter 2

STRUCTURE AND RELIEF

Barbary constitutes a compact geographical unit and consists of a massive "island" of elevated ground wherein relief is dominant. West Punjab, on the other hand, is a segment of the great Indo-Gangetic Plain and only a sixth of its area has hilly landscapes this being the Potwar Plateau in the northwest. The last-named region which lies between the Himalayan outliers of Murree Hills and the Salt Range is comparable in many ways to the characteristic relief of Barbary. Similarly the extensive plains of western Morocco and eastern Tunisia present a comparable aspect to the land of five rivers, a parallel which is reflected in agriculture.

The landscape in Barbary abounds in contrasts wherein low valleys and plains alternate with high and rugged mountains; at the same time there are large elevated stretches of boundless monotony. West Punjab is remarkably simple physically with the exception of the Potwar region. To understand these striking differences in the topography of the two regions we must go to their geological origins. Such a study is specially important for Barbary in which geology has a profound influence on the water-regime of rivers as well as on soils, both factors of great significance from the agricultural point of view.
GEOLOGICAL STRUCTURE

BARBARY

Looking at the geological map (see pocket at the end) one sees that the structural pattern of Barbary is intricate; yet the broad features are essentially simple. Two structural zones may be differentiated. The ancient African platform has tended to remain above water and has acted as a block against which the deep marine sediments of a long-sustained geosyncline have been folded during successive orogenic epochs. The latter zone also contains fragments of the ancient hypothetical Tyrrhenian continent in the Kabyle massifs along the coast of eastern Algeria.

Several phases of folding and faulting are responsible for the present aspect of Barbary. The sea which once extended to the Sahara has retreated steadily during geological time so that the northern ranges of the Atlas are younger than the southern ones.

The Pre-Cambrian and Hercynian mountain-building movements have not left any widespread traces as later movements were super-imposed on their domain. Their folds run generally transverse to the Atlas geosyncline and are in evidence mainly in south-western Algeria and in Morocco. It may be noted here that within the Atlas older rocks are progressively exposed from east to west.

As regards the Tertiary mountain-building movements and their different phases, there has been a long-continued controversy particularly with regard to the question whether
the Rif Mountains and the Tell Atlas belong to the same orogenesis. P. Russo (i) in a recent synthesis of existing opinion, shows that on the whole the idea of them being of contemporaneous origin is favoured. The High and the Middle Atlas as well as the Saharan Atlas belong to the earlier i.e. Pyrenean phase and show simple open folds. The High Plateaux to their north mark the extensive zone which remained a land surface and was not affected greatly by the last – the Alpine phase of folding which gave rise to the Rif Mountains and the Tell Atlas. The latter are both characterised by intense overthrusting and nappe-formation.

The climax of orogenesis was followed by a predominance of vertical movements which greatly modified the structure. The absence of extensive coastal plains in the north is explained by the series of fractures along the coast.

Denudation has been continuous since Miocene times and the beds of sediments laid down are largely undisturbed in the valleys and basins where they were deposited. In Morocco, the Atlantic has receded with the deposition of alluvium from streams coming down from the Atlas chains and a considerable coastal plain has been formed. Large inland lakes and basins have been integrated into river systems giving rise to striking hydrographical features to be

studied later. The Quaternary Ice Age has not modified the landscape except in the higher mountains, particularly the Moroccan High Atlas.

Summing up the structural features of Barbary, we get the three celebrated divisions from north to south:

1. The Northern Mountain System consisting of the Rif Mountains and the Tell Atlas and including within it the continued depression behind these ranges, extending from the Sebu Basin to the Sheliff valley.

2. The High Plateaux extending east of the Middle Atlas in Morocco to the Tunisian Dorsal.


This generalised zonification has been adopted as a convenient guide and should not be applied too rigorously as both the eastern and western sections of Barbary present striking departures from this scheme.

**WEST PUNJAB**

West Punjab has a remarkably homogeneous structure over most of its territory. With the exception of a few Archaean fragments forming the Kirana Hills, the vast plain consists

(1) Ibid
of an immense thickness of alluvial deposits the exact depth of which it has not yet been possible to measure. In these, sandy and clayey beds alternate according to the shifting of the river beds while the sub-montane tract also has gravelly beds in the series, marking excessive floods.\(^{(1)}\) The deposits are all Pleistocene and Recent. A distinction may be made between the older alluvium known as bhangar which often contains limestone concretions (kankar) and the newer alluvium, khadir, lying along the flood plains.

The Potwar Plateau with its bordering ranges shows a structure comparable to Barbary, the Murree Hills to the north being intensely folded, the plateau itself showing a synclinal formation while the Salt Range to the south has acted as a "stable block"\(^{(ii)}\) Some parts of the plateau are covered with a mantle of fine sub-Recent loessic material transported by the wind. Folding and faulting have sometimes combined in the Potwar region to give it the complexity typical of Barbary.

**RELIEF**

We may now proceed to study the landscape in detail and establish sub-division into natural regions. These have been established with special reference to their agricultural

\(^{(1)}\) T. Login, Memoranda on the most Recent Geological Changes of the Rivers and Plains of Northern India *Q.J.G.S.* Vol. 28, 1872

\(^{(ii)}\) Wadia calls it a wedge over which folding occurred *R.G.S.I.* Vol. 75
importance and their role in the rural set-up of the respective area.

BARBARY

The topography of Barbary shows striking variations not only in the disposition of mountains and plains but also in the intensity of the relief. There is a progressive diminution in the altitude of the Atlas mountains from over 13,000' in Morocco to 5,000' and less in Tunisia. Moreover the two Atlas ranges merge in the east so that the Sahara stretches further towards the north. From the Rif to Tunis the Mediterranean littoral presents a scarped face towards the north but the western coast of Morocco and the eastern coast of Tunisia are backed by large plains. Thus with the Atlas at its highest and its plains occupying considerable areas, Morocco contains the greatest contrasts in relief. Algeria is the most compact of the countries of Barbary wherein the three east-west zones are best defined. These plains are limited to narrow elongated valleys between lines of ranges parallel to the coast. Tunisia has neither the striking compactness of its neighbour nor the accentuated contrasts of Morocco.

The extent to which landscape has been shaped by fluviatile erosion is greatly limited in Barbary owing to the generally semi-arid conditions. Features of the normal cycle of erosion are restricted to the northern Tell region.
Although rivers will be studied in a later chapter, it may be stated here that climatic and topographic conditions have been unfavourable to the development of a well-integrated drainage system and most river-valleys show youthful profiles. Geological origins are still the most potent factor in the existing landscape over the greater part of the region.

In the following classification into natural regions, political boundaries have largely been ignored as they bear no relation to the physical constitution of the country. The extreme east of Algeria belongs to the Tunisian chains while eastern Morocco is a prolongation of the Algerian High Plateaux and the Oran Meseta. Although a large number of existing works (1) and maps have been consulted and found very useful, the following classification has been worked out personally on the basis of field observations. It has been found convenient to devise several north to south segments. Several natural regions which, from the point of view of physical geography, are full of interest have had to be passed over with brief comments, in the interest of the real objective of this study. Such for instance are the High and Middle Atlas ranges of Morocco and most of the elevated Massifs in Algeria

MOROCCO (excepting eastern Morocco)
The following sub-divisions are proposed:

1. The Sebu Basin and the Taza Gap
2. The Atlantic Lowlands
3. The Moroccan Meseta
4. The Middle and High Atlas and the Muluya Valley
5. The Sous Plain and the Saharan Fringe

1. The Sebu Basin and the Taza Gap

This region includes a great variety of features from the southern slopes of the Rif chain to the alluvial plain of Gharb. It includes that remarkable depression between the Middle Atlas and the Rif which is known as the Taza Gap. The entire region is drained by the Sebu, one of the largest rivers of Barbary, and has a length of 150 miles from east to west, the maximum width being 130 miles.

The broad surface configuration of the Basin may be likened to a half funnel of which the Rif on the north and the Middle Atlas and the Moroccan Meseta on the south are the sides. The Rif is an intensely folded zone which has an altitude of over 8000 feet. Most of it, however, lies in the Spanish zone. The southern slopes are drained principally by the Wargha and have a rugged relief which becomes subdued towards the east. The Taza Gap and the Sebu Basin mark an ancient (Miocene) arm of the sea which receded to a gulf gradually filled in by the sediments brought down by the Sebu to become the Gharb Plain. The Taza Gap is barely two miles across and
lie at an elevation of 2000 feet. To the south the Middle Atlas rises with an impressive steepness towering over the landscape. The northern slopes — those of the Rif — are gentler.

The regions of the Fes and Meknes plains occupy the bed of a Pliocene freshwater lake and fall gradually from 3000 feet in the south and south-east to 1500 feet in the north west. In the centre of the Sebu Basin there are several isolated massifs of which the largest is the Zerhoun rising to over 3500 feet. Further west, the Gharb plain extends to the sea and its northern part contains the meandering course of the Sebu. The southern part is largely occupied by the Mamora Forest uplands and climbs imperceptibly southwards to 1000 feet. Elsewhere the lowland lies below 50 feet above sea level and consists of a clayey alluvium. The Sebu has built up high natural leveses (spill-banks) for itself and often flows higher than the surrounding plains which are inundated after a heavy flood. This coupled with the bad drainage owing to the consolidated coastal dunes has given rise to a number of large seasonal marshes or merjas that are dry except for the period of maximum flow of the river. The largest of these is the Merja of Beni Ahsen in the south.

2. The Atlantic Lowlands

A coastal lowland of varying width extends from Rabat to Mogador bordered on the south east by an escarpment 300 to 600 feet high. Across it flow the lower courses of the Bu Regreg, the Um-er-Rbia and the Tensift, the most important rivers of Central Morocco. The plain is narrow in the north but
broadens out in the regions of Shawia, Dokkala and Abda. Further south it narrows again as the mountains approach the coast. The lowland has very little relief and that too is caused by the outcrops of crystalline or secondary rocks, i.e. near Casablanca and Mazagan. The plain is everywhere below 900 feet and is bordered on the coast by series of dunes.

3. The Moroccan Meseta

This region has been so called because of the close analogy with the Spanish meseta. The peneplaned surface of the primary platform is covered by a thin veneer of Secondary and Eocene sediments. The whole region was largely buckled up with some fractures here and there during the period when the High and Middle Atlas were upheaved. The primary base-rock is now exposed principally in the Central Massif and the Massifs of Rehamna and Jebilet. The Central Massif has generally preserved the aspect of a peneplane though the upper waters of the Beth, Bon Regreg and Oum-er-Rbia have carved out a series of narrow basins with deep gorges.

Between these crystalline regions of rugged topography lie sedimentary plateaux and alluvial plains. South of the central Massif of Zaer Zayan lies the limestone plateau of Settat at an elevation of 2,000 feet and over. To its east is the Tadla plain lying between the Rehamna and

the Middle Atlas. This is a large featureless expanse which is continued along the flanks of the Jebilet by the basin of Bahira.

Further south surrounded by the Jabilet, Middle Atlas and High Atlas lies the Haouz or the Marrakech Plain, a vast alluvial plain with a few undulations drained by the Tensift. Both the Tadla and the Haouz plains lie between 1,000 and 1,500 feet.

4. The Middle and High Atlas and the Muluya Valley

Aligned north-east to south-west and separating eastern from western Morocco, the Middle Atlas is the principal watershed of Morocco as well as the source of most of its important rivers. Much of it is a plateau dissected by river gorges. From lower elevation of 4,000 in the valley of the Um-er-Rbia near Khenifra, it rises to heights of over 10,000 feet in the mountains of Bou Iblane and Bou Naser in the north-east. It is covered by valuable forests over large areas. The Beni Mguild region in the north is covered with recent volcanic lavas.

The High Atlas is the main chain of the Atlas ranges and acts as a barrier between the Sahara and Morocco. There is thus a striking contrast between the green northern and the bare southern slopes. Rising steadily from the coast and more abruptly from the Sous plain, the range reaches its most impressive heights south of Marrakech where it surpasses 13,000 feet. Typical young folded topography is encountered here with high steep parallel ridges rising above deep narrow
valleys. The Eastern High Atlas is separated from the western part by a depression and after rising to over 12,000 feet in Jebel Ayashi overlooking the Muluya, the chain loses height and dies away.

The Muluya Valley separates these two chains in its upper part but constitutes a region in its own right further down where it consists of a series of basins of fine alluvial deposits which were once occupied by lakes. The valley contracts to a gorge before opening out into the plain of Guercif which is structurally a continuation of the Taza Gap.

6. The Sous Plain and the Saharan Fringe

The Sous Plain is a depression between the High Atlas in the north and the Anti-Atlas in the south. It is open to the Atlantic but shut in by Jebel Sirwa (11,000') at the eastern end. The Sahara lying to the east and south of the Sous Basin is progressively more arid in these directions and in fact constitutes a region which lies beyond the scope of this study.

ALGERIA (including eastern Morocco)

In Algeria the three Zones of the Tell Atlas, the High Plateau and the Saharan Atlas are very well defined in the west but merge in the east with the effect that the Tell Atlas is taken to extend right up to the Sahara. This latter idea takes its origin not only in the changed physical make-up but also in the climatic regime which has given a canopy of
Photograph shows the Jurjura range with its top still snow-covered in mid-May, the steep upper limestone slopes bare and the gentler lower slopes wooded. Dense vegetation at the foot of the range is olives which occur as isolated trees in the middle distance. Cultivated fields are under hard wheat for the most part. Harvested soft wheat seen in a field on the left. Barren slope with tufts of grass lies along the railway embankment from which photograph was taken.
2 Close-up of a bare hill in eastern Morocco. Geological strata are exposed clearly showing alternating limestones and sandstones. Ruined houses seen in the centre. Notice the steppe-like vegetation.

3 The southern slopes of the Saharan Atlas north of Biskra. Photograph shows the el Kantara gorge as well as the oasis settlement at the foot with flat-roofed houses and palm trees. Foreground is blurred as picture was taken from a moving train.
luxurious vegetation to the upper heights of the Aures Massif at the very edge of the desert. From an agricultural point of view this conception is useful for the basic idea behind the appellation "tell" is one of a well-watered and productive region. We shall, therefore, treat the Tell Zone in two regions - western and eastern. This gives us the following natural regions which will further be sub-divided when they are studied in some detail:-

I. The Tell Zone: - i. Western Algeria
   ii. Eastern Algeria

II. The High Plateaux

III. The Saharan Atlas

I. THE TELL: (i) The Western Tell

The relief of this section of the Tell Atlas has everywhere two characteristics - great variety of land forms and extreme youth. The latter feature is due as much to the geological history of the region as to the deficient rainfall under which the cycle of erosion slows down. The mountainous and plain regions alternate and give us five narrow bands of relief.

(a) The Coastal Mountains
(b) The Northern Plains and Valleys
(c) The Median Chain
(d) The Southern Plains
(e) The Interior Mountains
(a) The Coastal Mountains:— This region includes the Sahel of Oran, the plateau of Mostaganem and the massifs of Dahra and Miliana. In the west the massif of Murjajo dominates the Bay of Oran, presenting a steep slope towards the north. The sandstone plateau to the east of Oran is 2,000 feet high which continues across the marshes of Macta into the plateau of Mostaganem. After the deep narrow valley of the Shelif, the plateau rises into the massif of Dahra aligned south-east to north-west. This is continued across the Damous river by the mountains of Miliana wherein heights of over 5,000' are reached. These massifs present a steep slope towards the north and the south but the topography is gentler in between where the surface often has a rolling aspect.

(b) The Northern Plains and Valleys:— These comprise the plains of Mleta, Mekerra-Sig and Habra and the valley of the Sheliff. The plain of Mleta is a flat lowland to the south of the Sebkâ of Oran, which is the centre of an interior basin. The lower plains of Mekerra-Sig and Habra constitute a rich alluvial lowland the northern part of which is covered with marshes.

The Sheliff valley occupies a depression between the Dahra-Miliana massif in the north and the Warsenis in the south. With a length of a hundred miles and a varying width which reaches a maximum of 40 miles near Relizane, it is divided by transverse ridges into three sections. The uppermost of these, the plain of Affreville, has a width of 6-8 miles.
Further down is the plain of Attafs and lastly the plain of Orleansville extends for 40 miles up to Relizane.

(c) The Median Chain: This extends from the mountains of Beni Snassen in eastern Morocco through the massif of Traras, the mountains of Tessala and Beni Shougran to the massif of Warsenis. It is broken through by a number of rivers, notably the Tafna, Mekerra, Habra and Mina through deep valleys which do not affect the continuity of the range.

The Beni Snassen mountains are a rugged mass rising to an elevation of over 5,000 feet while the Traras massif has an equally inhospitable landscape cut up by numerous deep ravines. Recent volcanic rocks occur extensively in the latter and provide an excellent black soil. The Tessala chain across the Tafna and further east the Beni Shougran range are both steep and bare and rise to over 3,000'. The massif of Warsenis to the south of the Sheliff depression is crowned by the limestone mass of Kef Sidi Amar which rises impressively to over 6,000 feet and has scarped slopes. Several affluents of the Sheliff rise in these mountains, the most prominent among these being the Sly and the Fodda.

(d) The Southern Plains: These occupy the tectonic depression which extends from the Taza Gap eastwards and include the plains of Angad, Marnia Gossels, Sidi Bel Abbes and Mascara. They are, generally speaking, high plains occupying an average height of 1,500 feet. The first mentioned
lies in eastern Morocco and the plain of Marnia is only its eastern continuation. The plains of Sidi Bel Abbes and Mascara occupy the sites of late Tertiary lakes since integrated into river systems. The plateau of Sersou to the south of the Warsenis massif may also be included within this region.

(e) The Southern Mountains:-- The mountainous country lying along a line passing through Tlemcen, Daya, Saida and Frenda is higher than the coastal and median chains, being over 5,000' in elevation. The relief is strongly accentuated to the east of Tlemcen and everywhere limestone topography is so much in evidence that the region has been called the causses of Oran.

(ii) Eastern Algeria

Except up to the west of the Hodna depression, the clear differentiation between the Tell and the Saharan Atlas disappears here. The high plains of Constantine and Setif are sometimes compared to the High Plateau but the analogy can hardly hold. The landscape in the former is diversified by isolated ridges and peaks that rise abruptly from the plains whereas the latter is marked by great monotony. The saline shotts of the high plains are also of insignificant size as compared to the High Plateau. The height and the variety of relief of the Tell Atlas becomes very great and ancient crystalline blocks, jagged limestone ridges and high sandstone brows mark the dominating role of geology in the shaping of the landscape. Apart from the two plains of
Mitija and Bone at the two extremities, there is a general absence of lowlands. We may now divide the region into the following sub-regions:

(1) The Mitija Plain and the Sahel of Algiers
(2) The Blida Atlas, the Plateau of Medea and the Titteri Mountains
(3) The Kabylie Massifs
(4) The Bone Plain
(5) The Chains of Biban and Hodna
(6) The Constantine-Guelma Region
(7) The Mejana and the High Plains of Setif
(8) The Aures Mountains

(1) The Mitija Plain and the Sahel of Algiers

The surface of this plain which is 60 miles long and about 10 miles wide is remarkably flat. Several rivers emerging from the mountains on the south have formed alluvial fans of which the most notable are those occupied by Blida and Arba. The plain itself may well be a piedmont one and the position of the hilly Bouzarea peninsula behind Algiers suggests that it was once an island which has since become land locked. Marshes cover a section of the plain south of Algiers, though a large area has been drained.

The Sahel of Algiers or the Bouzarea region consists of an indulating surface that descends gradually towards the south and west.

(2) The Blida Atlas, the Plateau of Medea and the Titteri Mountains

The Blida Atlas rises boldly south of the Mitija
plain and attains steeply to a height of over 5,000 feet. The surface is rugged and has been deeply ravined by the streams. Eastwards the Blida Atlas merges into the Massif of Tablat which has a lower elevation. South of these prominent ranges lies the plateau of Medea which is an important watershed between the headwaters of the Shelif and the Isser. The Titteri Mountains further south have a much-ravined topography and are bare and rugged, the southern slopes being particularly badly denuded.

(3) The Kabylie Massifs

They represent a unique feature in the topography of Barbary and are thought to be the remnants of the ancient Tyrrhenian land-mass of which the other fragments are found in Sicily and Sardinia. The westernmost of these massifs is a well-defined physiographic unit bounded by the valleys of the Summam, Isser and Jemma and is capped by the "sierra-like"(1) Jurjura range which rises impressively from the valley of the Summam to attain to a height of over 7,000 feet. The coastal chain is separated from the main massif by the valley of the Sebao. The whole region is ravined deeply and both settlements and routes avoid the precipitous valley slopes to follow the crests of the ridges. The Summam valley separates the Kabylie of Jurjura from the two eastern massifs, those of Babors and Collo. It is a narrow alluvial plain which provides an entrance to the interior.

The Kabylie of Babors (also known as Little Kabylie) is a rugged mountain mass with steep scarped limestone ridges

rising to over 6,000 feet. The Kabylie of Collo stretches from Jijeli to Bone and is divided into two parts, the massifs of Collo and Edough by the Safsaf depression. The southern limit is formed by the Numidian Chain.

(4) The Bone Plain

This is an alluvial plain lying between the eastern end of the Numidian chain and the Edough Massif. It is about 60 miles long and up to 30 miles wide. Since it is almost entirely level there are extensive marshes. The region is drained by the Sebouse. The coast is fringed by a belt of fixed dunes that widen out towards the east.

(5) The Chains of Biban and Hodna

These lie roughly parallel to each other to the south of the Jurjura range. The word Biban (plural of bab) means doors and refers to the many deep gorges of which the most celebrated are the Portes de Fer. The Biban chain reaches a height of over 5,000' and is well-wooded in many parts.

The Hodna chain further south diverges south-eastwards to join the Aures Mountains and thus to unify the Tell and the Saharan Atlas ranges. It rises to over 6,000 feet and is divided into a number of streams draining to the Shott-el-Hodna. Here occur the small plains of Zana, Seriana and Bellezone.

(6) The Constantine-Guelma Region

The two centres of this region lie along rivers hemmed in by the Numidian chain on the north and the Perjone
The valley of the Isser south-west of the Jurjura range. The river flows as a braided stream in a pebbly bed. The low-lying ground on either side is under fodder crops and vines with cereals higher above. Scattered olive trees seen across the bed with bare and much eroded hills in the background.

Relief in the high plains of Constantine. Photograph shows a grassland steppe of plain surface with gentle slopes towards a stream-bed. Broken and bare hills rise to the south. Notice the grazing cattle.
Picture shows the gorge of the Rummel over 200 feet deep with the city of Constantine on both sides. Modern buildings are in the foreground, the older part of the city in the distance. Notice the horizontal strata in the gorge.

The Mateur plain in northern Tunisia. White patches are marshes formed on a flat surface during the very rainy spring of 1949. Scattered olive trees lie among fields of wheat. In the distance lies the isolated hill of Ashkel. One is never far from hills and mountains in the plains of Barbary.
Mountains on the south. The St. Arnaud tract is the watershed between rivers flowing to the Mediterranean and those flowing to the interior. To the north of Constantine is the site of an ancient lake basin at a height of 1000-2000 feet above sea level. This area now has an undulating but deeply dissected surface and is dominated on the south by the faulted and deeply eroded mountains of Constantine, cut transversely by deep gorges. The most celebrated of these is the Rummel gorge, 200 feet deep above which stands the city of Constantine. The Guelma region consists of a number of depressions along the Sebouse. The relief in the region as a whole is mature.

(7) The Mejana and the Plains of Setif

The bare high plains of Setif extend westwards to those of Mejana and are bounded by the Guergour mountains on the north and the Hodna chain to the south. They lie at an elevation of 2500 to 3300 feet and isolated hills rise here and there to heights of up to 1000 feet above the plain. The southern part is an area of inland drainage. There is an imperceptible gradation from the seaward draining region of small crests in the north to the region of enclosed basins further south.

(8) The Aures Mountains

This folded massif contains the highest peaks in Algeria (over 7000 feet) and consists of a series of long straight ridges capped by weathered peaks and needles. It
dominates the huge arid high plains to its north as well as the Saharan landscape which stretches to the north.

II. THE HIGH PLATEAUX (1)

From the valley of the Muluya in eastern Morocco up to the Hodna depression extends a vast region of undulating high plains slightly crumpled here and there and bounded by the two main Atlas ranges on the north and south. Occasionally a line of mountains rises, island like to disappear in the vast steppes. The region has an altitude of 3000-4000' in the Department of Oran where two great Shotts, the Gharbi and the Sherquili entrenched in a depression. Further east, the chains of Zahrez and Sahari rise above the monotonous expanse and are covered with forests. The general elevation is reduced as we proceed eastwards and the plateau terminates at the faulted basin occupied by the Shott of Hodna. The arid cycle of erosion is seen "par-excellence" in the High Plateaux where the occasional heavy showers cause torrents to bring down huge quantities of debris which tends to choke the different basins. The entire region is generally one of inland drainage.

III. THE SAHARAN ATLAS

The Saharan Atlas commences near Figuig in Morocco and continues up till the depression of Ziban to the north-west

(1) J. Despois is of the opinion that the term plateaux is a misnomer and should be replaced by the term "High Plains", in this region as its present topography is largely a result of deposition (Op. Cit. P. 45) The writer has however, adopted the established term to distinguish it from the High Plains in the Tell Zone.
of Biskra. It consists of several discontinuous mountain ranges i.e. the Mountains of Ksour, Amour, Oulad Nail and Ziban. Its general trend is south-west to north-east and it often exceeds 6,000 feet in height. The evolution of relief is quite advanced and there are instance where inversion of relief has taken place, i.e. synclines stand out as the hills while anticlines have been eroded into valleys. The aridity of the climate has resulted in the chains being largely buried under their own debris. The Saharan Atlas often shows a marked escarpment to the south.

TUNISIA

Of the three broad relief zones adopted for Barbary, only one is really present in Tunisia - the Tell Atlas whose coastal and interior ranges are the chief mountain features of the country. Lowlands occupy a much larger proportion of the area (almost 80% if the Saharan section is included) and the general topography is of a reduced magnitude as compared to Algeria and Morocco. South of the Dorsal which shows some affinities with the Saharan Atlas lie the steppes that merge gradually into the Sahara. The Sahel, a plain of structural origin, stands out as a region unique in Barbary, being a vast coastal lowland with inland drainage.

The customary three-fold division of Tunisia into a northern, central and southern zone has much to recommend, it as

(i) J. Despois, Op. Cit. P. 57
a way of facilitating a comprehensive view of the relief.

1. Northern Tunisia

This region lies between the Mejerda valley and the northern coast and may be considered in the following sub-regions:

1. The Northern Tell:— The mountains of Mejérda, Kroumiri and the Mogods mark the continuation of the coastal range of the Algerian Tell and are aligned north-east to south-west. The northern slopes are generally steep although there are narrow coastal plains between the Kroumiri and the Mogod chains. The general height diminishes from over 2,500 feet in the west to about 1,500 feet eastwards where the relief is gentler. The western section drains into the Mejerda whereas the waters of the Mogods find their way into the inland basin of Garaât Ashkal. Relief is considerably developed because of the proximity of the sea on the north and the Mejerda Valley on the south which also acts as a base-level.

2. The Beja Region occupies the south-eastern slopes of the northern Tell and constitutes an undulating zone in which ridges rise here and there out of extensive lowlands. A range of hills 1500-2000 feet high separates this region from the Mejerda Valley. The region itself lies between 600 and 1250 feet.

3. The Mateur Plain This plain is a zone of inland drainage. It is diversified by the isolated hills of Ashkel
and Keshebta north of which lie the lakes of Bizerta and Garact Ashkel. The plain lies all round these and has been extending at the expense of Garact Ashkal which is being filled up by alluvial deposits.

4. The Mejerda Valley is the most highly developed feature of the fluviatile erosion and deposition in eastern Barbary and lies between the Northern Tell and the Central Tunisian highlands. After a deeply entrenched mountain course in Algeria, the river Mejerda debouches into its alluvial plain below Ghardimaou. The valley consists of a number of basins separated by hilly terrain. The upper basin below Ghardimaou is known as the plain of Rekba while the plains of Dakhla and Merja with their respective centres of Souk-el-Arba and Souk-el-Khemis form a large lowland region covering over 250 square miles. The sudden change of direction above Testour represents an elbow of capture of the drainage of the Dakhla plain by the lower Mejerda. East of Testour the river flows through a relatively wide plain. Below Jedida the river has a large delta covering 275 square miles, the only one in Barbary. There are historical records of the gradual extension of land outwards by deposition and the present position of the mouth of Mejerda is 12 miles below its position in the Carthaginian times.

5. The Lower Tell and the Region of Tunis

The highlands south of Mejez-el-Bab and Tunis are a prolongation of the Tunisian Dorsal ("backbone") and continue
into Cap Bon. They attain to a height of over 2000 feet and are drained by Wadis Siliana and Miliana. Between these two streams is a series of plains, those of Fays, Bou Arada and El-Eroussa. Between the hilly Cap Bon and the highlands of Ressas lies the plain of Grombalia. The Gulf of Tunis is a region of former submergence which has been modified considerably by deposition.

II. Central Tunisia

South of the Mejerda Valley is a high mountainous belt, the High Tell of central Tunisia. Its southern boundary is another mountainous massif - the Tunisian Dorsal. Both these regions, particularly the latter have series of dome-like hills rather than continuous chains as a result of the combination of transverse folding and faulting movements. South-eastwards the country passes into barren steppes where isolated ranges break the monotony of landscape. These pass eastwards into the Sahel. The southern limit of Central Tunisia is marked by the great shotts.

1. The Central Mountain Mass including the High Tell and the Dorsal extends from the Mejerda valley to the massifs of Maktar and Thala in the south. The general trend of the relief is from west to east. The mountains attain to a height of 3000 feet. While the chains of Le Kef and Teboursouk prolong those of eastern Algeria, the Maktar and Thala massifs are a continuation of the Tebessa region in
south-eastern Algeria. To the south-west, the greatest heights in Tunisia are reached, exceeding 5000 feet. Alluvial basins divide the region as a whole into fertile basins and bare mountains. The basins often lie one above the other, marking the once enclosed lakes.

2. The Steppes:— South-east of the Central Mountains, the landscape opens out into vast stretches of plains out of which parallel and discontinuous chains rise abruptly. They show two general trends—north-east to south-west and north to south. Drainage is ephemeral and imperfectly developed.

3. The Sahel:— This lowland region extends from the Central Tunisian Tell to Gabes at the border of the Sahara. The western limit is ill-defined and the transition from the steppes imperceptible. The Sahel seldom rises above 600 feet but the drainage is so imperfectly developed that for 180 miles of the eastern coast, not a single water-course reaches the sea. Solid rocks concealed beneath a mantle of recently-weathered debris characterise the surface. The landscape is marked by small limestone hills rising here and there steeply out of the sandy plains.

III. Southern Tunisia by its exclusively desert features does not come into the scope of this work.
WEST PUNJAB

The land of five rivers may be divided into the following regions:-

I. The Potwar Plateau (1) Murree Hills
   (2) The Soan Basin
   (3) The Salt Range

II. The West Punjab Plains
   (1) The Sub-Montane Tract
   (2) The Central Plain and the Kirana Hills
   (3) The Thal
   (4) The Derajat Tract

I. The Potwar Plateau

Although, strictly speaking, the name Potwar is associated only with the undulating country between the Soan river and the Salt Range, current geographical usage applies it to the entire plateau stretching between the Indus and the Jhelum rivers up to the Murree Hills. The writer found it convenient in his recent regional study (1) to use the term more comprehensively still and include within it the Salt Range and the Murree Hills. This rather loose application (from the viewpoint of physical geography) is upheld by the hydrographic unity of the entire tract as well as the striking similarity in the human response and agricultural practice.

(1) Bhatta, M.A., "A Regional Study of the Potwar Plateau" Dissertation presented to the Punjab University, Lahore, for the degree of M.A. in Geography, 1947.
An aerial view of the Salt Range showing the southern ridge. Erosion of the sloping dipping strata of limestone has produced a spectacular scenery of sharp edged heights, steep slopes and gorge-like valleys. The West Punjab plain is seen faintly over the crest. Rare scrub clings to the sides.

Landscape in the Potwar Plateau. Low, bare rounded hills in the background. The dry sandy bed of a torrent can be seen winding in a gullied plain. In the foreground a rocky slope covered with scrub. Terraced fields can be seen to the right in the valley.
The Thal Desert with the Salt Range in the background. Notice the low sand dunes fringed by productive soil marked by abundance of trees in the background. This scene with the caravan of a wandering group, might well be from the Saharan fringe in Barbary.
The three constituting regions may, however, be studied separately:

1. The Murree Hills

They are outliers of the Himalayan system and consist of a series of parallel ridges which extend southwards with a progressive diminution in their elevation. The greatest height is near Murree itself and exceeds 7000 feet. These hills have the typical young-folded topography, the narrow valley between the ridges being as much as 2000' deep.

South of the Murree Hills are two more ranges of lesser magnitude - the Kala-Chitta and the Margalla ranges which attain to heights of 3500' and 2500' respectively.

2. The Soan Basin

This undulating tract stretches southwards right up to the Salt Range and is also referred to as the Soan syncline. Its surface varies in height from 1000 to 2000 feet and here and there rise ridges of bare rock of which only one assumes a considerable size - the Khaire Murat (Sandal shaped) running south-west of Rawalpindi. The general slope of the basin is from east to west and the Soan descends from a height of 1800 feet at its emergence from the mountains to less than 900 feet at its confluence with the Indus. The tract is broken up by innumerable deep ramifying ravines called Khaderas which give it a typical "badland" appearance. Erosion here has reached some of its extreme forms.
3. The Salt Range

Forming the southern rim of the Potwar region, the range extends in an irregular arc, concave towards the plateau, from the Jhelum to the Indus river. It consists of two almost parallel ridges with heights ranging from 2500 to 3700 feet between which lie a series of plateaux, separated from one another by the knots formed by the junction of the two ridges. The Salt Range presents a steep scarped face towards the south but the northern flank towards the plateau descends very gradually.

II. The West Punjab Plains

This vast alluvial expanse stretches south and east of the Potwar Plateau and is a monotonous lowland, everywhere below 1000 feet but for a few rocky fragments of the Kirana Hills. The plain slopes very gently towards the south-west, the gradient never exceeding 2 feet in the mile except in the sub-montane tract. Over the deep alluvium, wind-blown sand has been deposited, mainly in the south-west. The large gently sloping interfluves (between the rivers) are known as dvaless and those in West Punjab comprise from east to west.

(a) The Bari Doab between the Ravi and the Sutlej.
(b) The Rechna Doab between the Ravi and the Chenab.
(c) The Chaj Doab between the Chenab and the Jhelum.
(d) The Sind-Sagar Doab between the Jhelum and the Indus.

Dr. A. Geddes has recently mapped the Punjab plain with contours at 50 feet. (1) These show the northern part of

(1) Map consulted with the kind permission of the author.
the plain consists of the alluvial fans of the rivers and that the shape of the doabs has been determined by the area and texture of deposits, the texture grading from coarse to relatively fine from the Indus eastwards and from the gorges downwards. The rivers deposited their load in the shape of fans on emerging from the mountains due to the slowing down of velocity. The outstanding example is of the fan of the Indus formed below Kalabagh on emerging from the Salt Range. It forms a great cone of very coarse and much-ridged material which constitutes a greater part of the Sind-Sagar doab. According to Dr. Geddes' map, the coalescing fans of the rivers are in evidence up to the 700 foot contour after which the general seaward slope prevails. The stage of the deposition of fans and the plains was followed by a stage of incision and lateral erosion. It is this which has developed the two well-known major surfaces - the upper doab surface and the lower riverain surface broadly approximating to bhangar and khadir. The plain can be divided into sub-regions for a detailed study:

(i) The Sub-Montane Tract:— This includes the major part of the districts of Gurdaspur, Sialkot and Gujrat. The outer range of the Himalayas, the Siwaliks which lie outside the province, are fringed by a strip of gravelly deposits whose coarse soil absorbs moisture copiously by percolation. Further south is a band of slightly undulating country in which sandy beds of ephemeral streams known as
"chos" criss cross each other in a network. As the distance from the hills increases, this feature diminishes in importance the beds narrowing down and joining up with the perennial streams. The unstable sands of the chos are sometimes spread by floods or wind over the neighbouring countryside, doing considerable damage to arable land.

(ii) The Central Plains (including the Kirana Hills)

These consist of the three eastern doabs extending from the Sutlej to the Jhelum. In each doab there is an almost imperceptible rise in the level of the land away from one river which then falls again, quite as gradually, towards the next one. These slight differences in elevation cause important variations in soil and sometimes even in land use. Each river meanders in a wide flood plain. Periodically, the land on both sides of a river is inundated by the late summer floods. The moist area fringing the river bed is divisible into two strips.

(a) "Sailaba" or "Kachchi" - the tract actually flooded and subject to changes in the course of the river.

(b) Dhaya or Khadir - the comparatively lower part of the doab along the rivers which is moistened by percolation and where the water-table is high.

After a further intermediate zone, the bar "uplands" are reached occupying the highest tract in the middle of the doab. They once constituted a desert prairie
with "rolling sand dunes patched with grass and...hard, unfruitful plains glistening with salt"\(^{(1)}\). The best-known of these tracts were the Ganji and Nili Bars in the Bari and Rechna doabs respectively, now transformed through irrigation.

Crystalline fragments of the oldest mountains in India, the Aravallis, emerge through the alluvium in four places between the Ravi and the Jhelum. These are the Kirana Hills aligned N.W. to S.E. and their elevation above the plain decreases from over 900 feet in the north-west south-eastwards. These bare, dark-coloured and stony hills present a striking contrast to the surrounding plains.

(iii) The Thal This is a sandy desert occupying the Sind-Sagar Doab south of the Salt Range with the exception of the southern part. The western or the Great Thal is a complete desert but eastwards, the sand hills open out and patches of arable land occur. The Powah is a narrow strip of upland on which villagers whose lands lie in the riverain tract seek refuge from the floods. South of the Salt Range, the Thal is a flat barren plain with a hard salt-impregnated soil. This part is known as the Chhach tract.

(iv) The Derajat Tract This includes the trans-Indus territory of south-west Punjab covering the Dera Ghazi Khan district. Its western boundary consists of the eastern slopes of the Suleiman Range which are generally low, bare and rocky, cut through by several passes. A high zone flanking these slopes is known as Pachad. The land along the Indus which can be irrigated by inundation canals is called Sindh after the vernacular name of the river and is separated from the Pachad region by a zone known as the "Danda" tract.

\(^{(1)}\) K.S. Ahmad - Agricultural Geography of the Punjab
Chapter 3

CLIMATE.

With climate we come to what has always been recognised as the most fundamental factor in agriculture. Despite their contrasted seasonal regimes, West Punjab and Barbary show a comparable variability and deficiency of rainfall combined with extremes of temperature, conditions which are, as a rule, associated with a semi-pastoral life or irrigation agriculture. Human life in the major part of these two regions has since long been adapted to a semi-arid or arid habitat and one has to comprehend the facts of climate in order to understand it. So intimate indeed is the relation between climate and man that the extensive development of irrigation has produced an interesting chain of social reactions and changes which present a fascinating field of enquiry.

The study of climate thus assumes a special importance, constituting, as it does, the background for these far reaching human developments.

The development of irrigation on a large scale does not minimise the dominating role of climate with regard to agriculture. The effects of good or bad seasons are still reflected in the total agricultural production as later chapters will show. The ultimate source of irrigation water is once again the climate as also of the most serious problems of irrigation - floods and erosion.

A study of the vast field of meteorological phenomena is beyond the scope of this work. Thus even though
this account represents an endeavour to interpret the climate of these regions in terms of dynamic meteorology and the results of the latest researches have been considered, only those elements of weather have received emphasis which have some bearing on agriculture, the peasant and their problems.

**BARBARY**

In the simplest terms Barbary belongs to the transition zone in which the seasonal alternance of marine westerlies and the continental trade winds produce respectively a mild wet winter and a hot dry summer. This does not take into consideration the influence of air masses whose lines of discontinuity give rise to frontal disturbances which are responsible for most of the rainfall. The great complexity of relief is yet another factor which produces considerable variations of climatic conditions over short distances and hence those striking changes in the agricultural landscape one observes in travelling over the region.

Tunisia, Algeria and eastern Morocco form a continuous zone facing the Mediterranean in which the general alignment of relief is from east to west. Consequently most climatic gradations take place in a north-south direction. Western Morocco differs from the rest of Barbary being sheltered both from the Mediterranean and the Sahara by high mountain ranges and in that it owes many of its climatic features to the influence of the Atlantic. This influence has very often been exaggerated because Queney has recently
established the climatic unity of Barbary (i) by proving that the climate of the region as a whole is determined by the circulation of the atmosphere between heights of 10,000 and 13,300 feet where it is not influenced very much by relief. Furthermore, the essential features of the whole region such as the seasonal distribution of rainfall and of temperature are everywhere similar.

PRESSURE AND GENERAL CIRCULATION:—

The Rôle of Air Masses and Fronts

It has been customary to explain the weather conditions of a region in terms of the distribution of pressure over the region itself and the neighbouring seas. Thus during the summer, from May to September, there is a low pressure over the Sahara and the winds around it blow parallel to the North-East trades which prevail. All these winds being either continental or travelling from a cooler sea to the hot land, bring no rain. In winter, the pressure conditions are reversed: a high pressure exists over the Sahara while the westerly winds blow constantly over Barbary. These being oceanic and moisture-laden, cause widespread precipitation.

This ideal simplicity of conditions does not help us to understand the considerable divergence of weather from the seasonal "normals", nor does it account for the great variations from year to year. The recent advances in weather

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(i) P. Queney "Types de temps en Afrique du Nord et au Sahara Septentrional" Travaux de l'Institut de Meteorologie, fasc. 3, Alger., 1943
knowledge which have introduced the concept of air masses have been incorporated into the latest works on the climate of Barbary. According to these, weather conditions in Barbary are only a part of much wider phenomena which result from the interaction of several air masses. These are briefly described as follows:–

1. The cold polar air mass
2. The two anticyclonic masses covering respectively the Eurasian continent (continental air mass, disappearing in summer) and the North Atlantic (commonly referred to as the Azores High; maritime)
3. The masses of tropical air which flow between the two anticyclonic air masses. (i)

When polar air flows over Barbary, the temperatures are below normal and winds blow from the north-west. The air from the Eurasian mass is characterised by little cloudiness, a high daily range of temperature, very low humidity and winds that blow generally from the north-east. The tropical continental air mass covers Barbary during the summer when high temperatures and the development of storm clouds are noticed and some rainfall occurs on the southern slopes of the Atlas ranges. (ii)

The movements of these air masses is seasonal and

(ii) Ibid, P.152
with them are associated the lines of discontinuity or fronts of which the two most important are as follows:(1)

(a) The Polar Front between the polar air and the two anticyclonic masses.

(b) The Trade Winds Front between the N.E. Trades and the South West Anti-Trades which exists in the upper air and includes the so-called Mediterranean Front.(ii)

The types of weather in Barbary result from the position and activity of these two fronts.

The regime of the Polar Front occurs when this discontinuity occupies a position in Europe southerly enough to affect the climate of Barbary. This happens in autumn, winter and spring. S.S.W. to N.N.W. winds, associated with the Warm Front, bring heavy rains to the north of the Saharan Atlas and sandstorms to the south of it. Sometimes, these polar depressions, travelling in a North-South or N.W. to S.E. direction, take a direct W.E. course which produces a contact with the Trade Winds Front and torrential rains occur, mostly in Algeria.

The regime of the Trade Winds Front is in evidence when the Polar Front is confined to the north of Europe and the North Atlantic air mass extends its influence up to


(ii) R. Capot-Rey quotes Queney (Ibid) to say that "The discontinuity which appears sometimes in the western Mediterranean between the N.E. winds from Europe and the S.W. winds from Africa which is sometimes called the Mediterranean Front may be included in the Front of the Trades".
eastern Europe. If Trade wind Front is in the upper air, Barbary is swept by a N.E. or E. wind and the weather is pleasant in the interior and foggy near the coast. Again it may happen that the front is on the ground but is not active in which case the anti-trades blow over Barbary and the weather is hot and dry in summer, cold and slightly rainy in winter. Finally the front may be active on the ground. It is during such spells that heaviest rains are recorded in the High Plateaux and northern Sahara. The disturbances associated with the Trade Winds Front are most frequent in spring but do not occur at all in summer. No explanation of this phenomenon is forthcoming at present. (i)

Lastly it sometimes happens that the two fronts co-exist. Each has its own current of disturbances which may either neutralize each other or combine. In the latter case powerful storms are produced towards the east of Barbary. It is the combination of all these phenomena that makes weather conditions so variable.

TEMPERATURE:

The most important single factor with regard to the temperature is the sea. Mean annual isotherms are generally parallel to the coast, a fact which is particularly striking in Morocco where they run from north-east to south-west showing thereby that the influence of latitude has been negativized by that of the sea. The effect of the sea is most marked in winter and is as prominent on the eastern coast of Tunisia as on the western coast of Morocco. Thus "Tabarka, Mehdia and Jerba which spread over 3° of latitude have the same

(i) R. Capot-Rey, Ibid. P.42
average temperature in January." (1)

The mean annual temperatures increase from the coast inland and in the case of Algeria and Tunisia, a general increase from north to south is also recorded, noticeable even on the eastern coast of Tunisia. Here temperatures increase from 65° at Bizerta to 67° at Gabes. In Algeria where the latitudinal trend coincides with the distance from the sea a greater difference is observed between the 64° at Philippeville and 71° at Biskra. The mean annual temperature figures do not constitute a factor of any importance in themselves. From that point of view the seasonal average and extreme temperatures are of much greater significance.

Everywhere near the coast, the effect of the sea tends to make conditions equable. This is again especially noticeable in Morocco where the cold Canaries Current gives rise to mild summers and a small range of temperature. The following figures for the Moroccan coast speak for themselves.

<table>
<thead>
<tr>
<th></th>
<th>January</th>
<th>August</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rabat</td>
<td>54° F</td>
<td>74° F</td>
</tr>
<tr>
<td>Casablanca</td>
<td>54° &quot;</td>
<td>73° &quot;</td>
</tr>
<tr>
<td>Mogador</td>
<td>56° &quot;</td>
<td>67° &quot;</td>
</tr>
<tr>
<td>Agadir</td>
<td>59° &quot;</td>
<td>73° &quot;</td>
</tr>
</tbody>
</table>

In Algeria and Tunisia too, the mean January temperature on the coast ranges from 50° to 55° and frosts

(1) A. Bernard, "Afrique Septentrionale et Occidentale, P.42
are extremely rare. The mean summer temperatures are similarly uniform and lie between 75° and 80°.

Inland, however, the oceanic conditions merge into continental extreme and with increasing distance from the sea the difference is apparent not so much in the mean temperatures as in the magnitude of seasonal and diurnal range. The contrast between the coast and the interior is more marked in winter than in summer. Thus whereas Rabat has a January temperature of 54°, Fes records only 39° and Marrakech 35° and at both of these places frosts are frequent. A similar difference in temperature during the summer will not have the same critical significance for crops.

In his recent work on the 'Climate of Algeria', (i) P. Seltzer has drawn attention to a peculiar distribution of temperatures during the cold and the hot seasons, conditions which can be expected to continue to Tunisia as well. "During the cold season, the lowest temperatures are found along a zone approximately parallel to the coast which follows the chain of the Tell Atlas and traverses the high plains of Constantine. North and south of this temperature increases. It decreases, however, from east to west in the interior. During the hot season (ii) the temperature increases continuously from the coast inwards". In Morocco, however, the decrease is fairly

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(i) "Le Climat de l'Algerie", Alger 1946, P.49
(ii) The hot season is taken to extend from May to October when the mean monthly temperature is more than the annual mean. The cold season covers the remaining six months when mean monthly temperature is lower than the main yearly value" Ibid P.49
continuous even in winter.

**Range of temperature:** The diurnal range of temperature increases from the coast inland being $7^\circ$ and $9^\circ$ respectively for January and July at Algiers whereas it amounts to $13^\circ$ and $26^\circ$ for the same months at Setif.\(^{(1)}\) The range inland is much higher during the summer than in winter while it is always low near the coast and is always high toward the Sahara.\(^{(ii)}\) The annual range of temperature also shows a general increase from the coast inwards although some sheltered valleys near the coast possess a marked degree of continentality. The Tunisian and Algerian littoral has an average range of $25^\circ$. The Atlantic coast of Morocco, being subject to the influence of the cold Canaries current, has a lower range which amounts to less than $15^\circ$ in the regions of Mogador and Agadir.

The annual range of temperature is a very useful criterion for measuring the degree of continentality and the range of $36^\circ$ has been widely accepted to mark the commencement of extreme continental conditions.\(^{(iii)}\) In Tunisia and Algeria this lies along the south of the Tell Atlas although there are "islands" of extreme continentality, like the valley of the Sheliff, on account of their topographic situation. In Morocco, the $36^\circ$ limit extends along the eastern and southern sides of the Atlas ranges although again there are pockets of continental conditions south of Marrakech and Tadla.

\(^{(1)}\) *Ibid* P.44
\(^{(ii)}\) A very high diurnal range of temperature is usually due to intense nocturnal cooling which constitutes a serious danger to the cultivation of certain early vegetables as well as fruits, particularly when accompanied by frost.
The Extreme Temperatures:— The study of monthly mean even though it constitutes a useful basis for the general study of climate, does not fulfill the requirements for the consideration of agricultural production. Many crops have critical limits and the suitability of a region for their cultivation can only be determined in the lights of the extreme temperatures recorded there in each season.

The lowest temperatures are recorded in the interior where they often fall below the freezing point - Fez and Constantine for example record 23°F and Oujda 19°. On the coast, however, they seldom fall below 32°.

The extreme maximum temperature is everywhere higher than 104° except for certain stations at high altitudes (i.e. Ifrane, in Morocco, 97°) and they reach over 120° near the desert or even at places like Orleansville and Taroudant which are situated in low-lying valleys.

The hottest and coldest times of the year are not in mid-summer and mid-winter but occur a month afterwards.

RAINFALL

This is by far the most important element of climate both for crops and man and Bernard does not exaggerate when he states that rainfall "determines the great natural regions and their limits, the possibilities of cultivation and of sedentary life"(i) The terms, "Tell", "Steppe" and "Sahara" it may be recalled, represent essentially the degree of aridity in a region.

(i) Op.Cit. 4.
It is preferable when considering the rainfall conditions of Barbary to fix the starting point for the year at the 1st of September "because there is an almost complete absence of rainfall during the summer and the choice permits a study of rainfall during a complete vegetative cycle as well as an agricultural year. The total of rainfall according to the agricultural year facilitates its comparison with the yield of crops.\(^{(i)}\)

**Annual Rainfall:**

A study of the annual rainfall map of Barbary will reveal the following characteristics:

1. The amount of rainfall increases with altitude but the increase is more marked on the slopes exposed to the rain-bearing winds. In this sense, the rainfall is orographic.

2. Over the whole of Barbary, rainfall decreases from north to south as also with distance from the coast. This is mostly due to the fact that since rainfall in Barbary is largely due to the depressions generated along the Polar Front, those parts which lie further away from the usual west-east path of these disturbances receive much less rainfall.\(^{(ii)}\)

3. Excluding western Morocco, a decrease of rainfall is also noticed from east to west. The classic explanation of this phenomenon is the one given by A. Angot\(^{(iii)}\) which is still

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\(^{(i)}\) Seltzer, Op.Cit. P.129  
\(^{(ii)}\) Bidault et Debrache - Ibid P.155  
\(^{(iii)}\) "Etude Sur la Climat de l'Algerie", Annales du Bureau Centrale Meteorologique 1881
widely accepted. According to him the winds which come mostly from the north-west, cover a much longer distance over the Mediterranean in the case of the eastern half of the littoral of Barbary whereas those which affect the western part have already been deprived of their moisture by the mountains of Spain. This in the opinion of Seltzer(1) does not agree with other observed facts. There is no increase in atmospheric humidity from west to east which should be an essential corollary of Angot's contention. He suggests that the reason for this feature of rainfall can be sought in the greater activity of depressions to the north of Tunis. Furthermore the Atlas ranges in Morocco largely deprive the passing cyclonic disturbances of their moisture so that western Algeria and eastern Morocco are in the rain shadow, not of the Sierra Nevada, but of the Middle Atlas.

Taken in the regional perspective, the tracts with moderate to abundant rainfall are very much limited being confined mostly to the higher altitudes in northern Morocco, eastern Algeria and northern Tunisia. The greater part of these regions has a rugged relief so that it may be said that the zones of higher rainfall are, in general, regions of minor agricultural importance. The most prominent exceptions are the Sebou Basin and the Mitidja Plain. The limit of such regions may be fixed at 20" of annual rainfall.

(1) Op.Cit. P.144
North Africa Rainfall Graphs
By far the larger part of those regions which may be considered to be topographically favourable for agriculture have rainfall ranging from 8" to 20" and these constitute the main core of this study.

Among the regions that are completely arid, the most notable from our point of view are the Marrakesh and Tadla plains in Morocco which in several respects come closest to the similarly arid parts of West Punjab in respect of recent developments in agriculture.

**Seasonal Distribution of Rainfall**

The statistics of annual rainfall do not in themselves give the complete picture of the suitability of any region for crop production. Rainfall occurs in considerable quantities in spring, winter\(^1\) and autumn but the summer season from June to August is absolutely dry and, combined with high temperatures, constitutes a wholly negative season for all forms of vegetative life. This is the feature, typical of the Mediterranean climate, which is the basis for the growth of xerophytic characteristics in the natural vegetation as well as the special development of vine and citrus fruits both of which are well-adapted to this régime of rainfall.

The seasonal distribution of rainfall is not constant but varies considerably from year to year, and has a governing influence on the yield of various crops, particularly cereals.

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\(^1\) There is usually a short period of lesser rainfall in mid-winter, particularly in Morocco, dividing the rainy season into two, one of autumn, one of spring.
VARIATIONS IN THE RAINFALL OF ALGIERS FROM 1838 TO 1932 ACCORDING TO L. PETITJEAN.
Variations in the Annual Rainfall at Tunis and Gabès 1885-1920. The pecked lines show the mean annual rainfall at the two stations.

(Source: Geographical Handbook, Naval Intelligence Division, "Tunisia")
The variability of seasonal as well as annual rainfall will be considered in the following paragraphs. Diagram 2 shows the rainfall regime of four stations typical of different regions. They record a double maximum one in autumn and one in spring.

**VARIABILITY OF RAINFALL**

The annual and seasonal rainfall varies a great deal from year to year. A glance at the graphs showing the annual rainfall of Algiers, Tunis and Gabes over a prolonged period will indicate that the rainfall is subject to violent fluctuations and rarely comes very close to the normal.

The following figures of the lowest and highest rainfall recorded between 1913 and 1938 show the extreme variations for four stations, representative of different regions as well as of different quantitative groups.

<table>
<thead>
<tr>
<th>Station</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Max/Min</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algiers</td>
<td>20.4&quot;</td>
<td>45.4&quot;</td>
<td>2.24</td>
</tr>
<tr>
<td>Bessombourg</td>
<td>46&quot;</td>
<td>97.3&quot;</td>
<td>2.04</td>
</tr>
<tr>
<td>Setif</td>
<td>12&quot;</td>
<td>24.1&quot;</td>
<td>2.01</td>
</tr>
<tr>
<td>Casablanca</td>
<td>7.3&quot;</td>
<td>24.2&quot;</td>
<td>3.1 (1)</td>
</tr>
</tbody>
</table>

The average variations are also considerable and variability increases with aridity, i.e. the lower the average rainfall, the higher the variability tends to be. Taking Algeria (for which alone calculations have been made) variability reaches 20-30% in the semi-arid western part.

---

particularly in the low-lands, and increases even to a higher figure towards the Sahara.\(^{(1)}\) In the more humid parts of the country, it is generally less than 15\%. It can be reasonably assumed that if the extreme maximum and minimum figures in other parts of Barbary are comparable to those in Algeria, the percentage of variability\(^{(ii)}\) will also show the same distribution.

As significant as the variability of annual rainfall is the variability of its seasonal distribution. Whereas the ratio of recorded minimum to recorded annual maximum may be 1:3 or 1:4 at the most, in the case of annual rainfall, the rainfall of crucial months may vary from nothing in one year to several inches in the next year. The effect of this on agriculture is far-reaching and it is now proposed to establish some correlation between the area and yield of crop and the amount and distribution of rainfall.

**VARIABILITY AND CROP PRODUCTION**

The annual figures of the production and yield of wheat in Tunisia have been compared with the annual and seasonal rainfall at Tunis for a period of twenty years (1911-1930). Before the results can be discussed, it is necessary to establish that variability at Tunis is representative of conditions in the rest of the country. In this respect the comparison of rainfall

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\(^{(1)}\) Op.Cit. Map facing p.145

\(^{(ii)}\) Variability has been calculated by taking the average rainfall to be 100 and then taking the mean of variations in both directions between 1913 and 1938, and their relationship has been worked out. Seltzer p.129. Same principle was adopted by Williamson A.V. and Clark G.T. for India. The variability of the Annual Rainfall of India, Quarterly Journal of the Royal Meteorological Society, Vol.57 1931.
at Tunis and Gabes over a 35 year period on graph $5$ is quite convincing. Broadly speaking the years of rainfall below or above the normal are similar although the extent of fluctuations varies. Tunis may be accepted as more representative also because over two-thirds of wheat in Tunisia is produced in the northern part.

Graph 6 shows the annual rainfall and the total annual production of the two kinds of wheat along with their yields. It will be noticed that any striking rise or fall of the annual rainfall is accompanied by a corresponding rise or fall although there are some years when a decrease in the rainfall has been accompanied by an increase in both total area and production. Thus in 1918, rainfall was over 50 millimetres (2") below 1917 yet the area and production both went up considerably. These anomalies are explicable by considering the seasonal distribution, in others, of course, political and economic factors must be taken into account.

A detailed study was made of the area cultivated and the yields obtained by Europeans as well as Tunisian cultivators in relation to the monthly distribution of rainfall. Through drawing a number of graphs it was discovered that the Tunisian cultivators' figures for hard wheat approximate more closely to certain features of the seasonal distribution because of their rudimentary methods. Although the corresponding European figures do show a relationship to these features of seasonal rainfall, this relationship is neither so close nor so constant.
Graph showing annual rainfall at Tunis (black line) 1911-1920 and the total area under wheat, both hard and soft (red line) and the total production (discontinuous black line).
Relationship of the September to November rainfall at Tunis and the area devoted to hard wheat by Tunisian cultivators, 1911-1930.

Relationship of the March-April rainfall at Tunis and the yields of hard wheat obtained by Tunisian cultivators, 1911-1930.
For example, the European yield of hard wheat in 1914, a year of very low and ill-distributed rainfall which is reflected in the Tunisian yield of less than a quintal per hectare, was higher than in 1917 when the Tunisian yield was 2.7 in response to a higher and better distributed rainfall. Two graphs are reproduced, one showing the relationship of autumn (September to November) rainfall to the area sown by Tunisians with hard wheat and the other of the yield of the same crop in relation to the early spring (March to April) rainfall. Soft wheat had to be excluded from the comparison because the Tunisian figures are not recorded before 1918 and also because it was cultivated mostly by European colonists.

The relationship between the autumn rainfall and the area sown with hard wheat by Tunisians is very close firstly because this is a crucial period for the crop itself and secondly because the Tunisians cannot plough the drought-parched lands unless they are softened by rain. If rains come late or are inadequate, the sowings are reduced considerably. This stands out prominently in the graph. The relationship between early spring rainfall and the yields obtained is even more striking and almost all the ups and downs of rainfall are followed by the yields.

How the seasonal distribution of rainfall is even more important than the annual total is proved by the following example. (i) It also shows the ideal distribution

(i) P. Seltzer - Op. Cit. 148-149
Seasonal Distribution of Rainfall at Algiers During Two Consecutive Agricultural Years (September to August)
of rainfall - that for 1924-25 as illustrated.

The two consecutive agricultural years 1923-24 and 1924-25 had the same total rainfall at Algiers, 27.3", but the seasonal distribution was very different as may be noticed from the accompanying diagram. The result was a great difference in the yield of cereals for the two years. The spring rains of 1924-25 gave rise to exceptionally high yields, whereas the rainfall of 1923-24, being confined mostly to the autumn and winter, the yields were extremely poor. Here are the figures for the yields of the two types of wheat recorded at Maison-Carree (which lies within ten miles of Algiers and showed the same distribution of rainfall)

<table>
<thead>
<tr>
<th></th>
<th>1923-24</th>
<th>1924-25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard Wheat</td>
<td>4.7</td>
<td>21.8</td>
</tr>
<tr>
<td>Soft Wheat</td>
<td>1.3</td>
<td>23.8</td>
</tr>
</tbody>
</table>

Attempts have been made to establish some system of cyclical variation in the amount of rainfall on the basis of obtainable data. Unfortunately for agricultural forecasts no method has been found in the ups and downs of the annual
rainfall curve so that variability must continue to be an erratic factor.

**INTENSITY OF RAINFALL**

The agricultural value of annual rainfall figures is further diminished by the occurrence of rainfall in torrential localised downpours during brief periods, causing serious damage to crops and irrigation works through erosion. These are usually associated with thunderstorms.

Some of the heavy falls of rain recorded over short periods are given below:

<table>
<thead>
<tr>
<th>Place</th>
<th>Amount of Rainfall</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Tunisia</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tunis</td>
<td>3.8&quot;</td>
<td>11th November 1911</td>
</tr>
<tr>
<td>Sousse</td>
<td>6.2&quot;</td>
<td>16th October, 1912</td>
</tr>
<tr>
<td>Gabes</td>
<td>4.1&quot;</td>
<td>20th October, 1911</td>
</tr>
<tr>
<td><strong>Algeria</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Algiers</td>
<td>6.4&quot;</td>
<td>12th November, 1935</td>
</tr>
<tr>
<td>Fort National</td>
<td>3.3&quot; (in half an hour)</td>
<td>13th September, 1931</td>
</tr>
</tbody>
</table>
It has been noted in the correlations of torrential rains with the seasons that on the whole, the rains of the winter are less liable to be torrential than those of the summer. \(^{(i)}\)

Various attempts have been made to find out what is the optimum intensity of rainfall from the point of view of agriculture. If the precipitation is too light, the rain water evaporates as quickly as it falls. The effects of heavy downpours have already been indicated. Seltzer quotes one investigation which concluded that the fall of 1 millimetre per hour is ideal as losses by evaporation and run-off are the least in this case. In fact such an intensity is rarely encountered and rainfall tends to be usually in excess of this. "INVISIBLE PRECIPITATION";

Apart from the visible rainfall several parts of Barbary benefit from the nightly condensation of moisture following unhindered radiation through the cloudless skies. These play a significant role in south-eastern and southern Tunisia, otherwise a region of very scanty rainfall. Here the maritime N. and N.E. winds bring plenty of moisture during the autumn and in the summer. The air is particularly rich in moisture during the dry summer, a season when the intense heat is followed by considerably cooler nights due to free radiation and there is widespread condensation in the shape of dew.

\(^{(i)}\) P. Seltzer Op. Cit. P.154  
\(^{(ii)}\) Ibid P.149
The annual amount of water thus available through this invisible precipitation has been estimated to be equivalent to 10" - 20" of rainfall according to the number of cloudless nights. *(i)* It is this factor which has been responsible for the successful extension of olive-orchards southwards in Tunisia.

The importance of nightly condensation in agriculture has not been measured in other regions in the same way, but is obviously a major factor particularly in the Atlantic plains of Morocco where the air is heavily laden with moisture and enables such crops as maize to flourish in a region that gets only 10-15" of rainfall.

**Snow and Frost:** Snow seldom occurs on the coast but is more common inland where snowfalls may occur as early as October although the heaviest ones take place between November and April. The depth and the duration of the snow cover depends mainly upon altitude. From 2000 to 3000 feet it may lie for a week or two; from 3000 to 6000 feet for a month and above that height for several months. As the highest altitudes in Barbary occur in Morocco, snow cover is much more important here and persists on the High Atlas up till July in favourable years. Eastwards, with the reduction in altitude, the role of snow is much less. Over the Jurjura range snow often persists till May.

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*(i)* G. Ginestous "Aperçu Climatologique", E.C.M. "Tunisie" P.93
Snow has an important regulating influence on the water of wadis and rivers. Like rainfall, snowfalls vary greatly in magnitude from year to year.

The number of days with frost depends upon altitude and distance from the sea and with increase in either or both, there is a corresponding increase in the frequency of frost. Near the coast, frosts are rare. They occur most frequently on the High Plateau and in the interior mountains where the number of days with frost may exceed 50. Frosts occur mostly in winter.

**Thunderstorms and Hailstorms:** Thunderstorms are a local phenomenon that record their highest frequency in May and June and again in September. They are associated with development of convection currents in the superheated dry summer air. A connection may also be found between these periods and the movement of the polar front which retreats early in summer and advances towards its end. The frequency of thunderstorms has been recorded in Algeria and Morocco; in the former the number of days with thunderstorms varies from less than 20 in the north-eastern Algeria to over 30 in the higher parts of eastern Algeria and the High Plateau; in Morocco, the frequency of 25-30 days with thunderstorms is recorded in the higher mountains.

Hailstorms are also a local phenomenon and occur almost exclusively from December to March. The distribution of their frequency is analogous to that of thunderstorms,
being the highest in eastern Algeria and central High Plateau where it exceeds 10 in the year. Hail occurs in Morocco mostly along the southern part of the coast and in the Middle Atlas.

The Sirocco:— This is a hot dry wind which blows sometimes from the Sahara over Barbary with withering effect on vegetation and humans alike. Temperatures may rise to more than $110^\circ$ and the relative humidity greatly reduced. It is rare in winter and occurs mostly near the coast as a result of depressions in the Mediterranean. In summer when it is most frequent, particularly in July, it is most often encountered in the interior and is associated with depressions developing over the Sahara. The exact origin of the sirocco has not been clearly established. Although very often a foehn effect accentuates its normal attributes of heat and dryness accentuated relief is by no means necessary to give it its peculiar character.

The sirocco is known as "guebli" (southern) in Tunisia and Algeria, and as sherqui (eastern) in Morocco. Its frequency varies greatly and is greatest in zones accessible from the Sahara. Thus in Algeria the number of days with sirocco amount to over 40 on the High Plateau but seldom exceed 20 near the coast. In Tunisia, the sirocco blows 30-40 days a year east of a line joining Tunis and Gafsa while westwards, the frequency is 20 to 30. The duration of the sirocco varies from an hour to several days and there is no factual foundation for the belief that the
sirocco blows for 3, 6 or 9 days. It has been noticed that among neighbouring stations, the lower ones have a higher frequency of days with sirocco.

WEST PUNJAB

The climate of West Punjab is determined by its special position in the Indian sub-continent far removed from the oceanic influence and results from the monsoonal circulation of the entire landmass south of the Himalayas.

The mechanism of the Indian monsoon has usually been explained as a gigantic land and sea breeze. Although this analogy has an illustrative value it over-simplifies the problem. Far from being the result of a single physical condition, the monsoon is "produced by a combination of circumstances involving considerations of temperature, pressure, humidity, geographical relationships between land and sea, the rotation of the earth and lastly but probably the most important, the distribution of mountain ranges". (i) The development and the change of the monsoon may now be taken up briefly. We may adopt a slightly modified version of the seasonal division adopted by the Meteorological Department of India.

1. The Season of the North-East Monsoon
   (a) Cold Weather Season - January to March
   (b) Hot Weather Season - April to June

2. The Season of the South-West Monsoon
   (c) Rainy Season - July to September
   (d) Season of the Transition from

A. Cold Weather Season: - The highest pressure of the year is established over north-western India (including West Punjab) from which pressure decreases slowly towards the south. The winter (north-east) monsoon is fully established though the winds are generally slight. The weather is clear and sunny but for periodic shallow depressions which appear from the north-west. Most of these have been traced back to the Mediterranean while others are probably formed as secondaries over Persia and Arabia under the influence of primaries further west. (i) These depressions bring about some rainfall which although not of any considerable amount constitutes a boon for the winter cereals, and determines the nature of their yields. These rains occur in light showers which make their agricultural utility much greater than if they were to come down as heavy downpours most of which would be lost as immediate run-off. West Punjab benefits particularly from these cyclones being among the first regions in their path. Murree receives 6" of rainfall in January and February and here are some more figures:-

(i) "The examination of available evidence shows that on an average, about seven out of every ten disturbances which affect North-west India in the winter months, December to April, are continuations of depressions from southern Europe". Walker G.L. and Hem Raj, "Cold Weather Storms of Northern India" M.I.M.D., Vol.XXI, Part III, 1913, P.11. This is important evidence of the influence of the Mediterranean on the climate of West Punjab.
Rainfall - January to March

<table>
<thead>
<tr>
<th>Location</th>
<th>Rainfall</th>
<th>No. of Rainy Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lahore</td>
<td>2.85&quot;</td>
<td>6.4</td>
</tr>
<tr>
<td>Rawalpindi</td>
<td>7.12&quot;</td>
<td>12.1</td>
</tr>
<tr>
<td>Lyallpur</td>
<td>1.27&quot;</td>
<td>3.4</td>
</tr>
<tr>
<td>Multan</td>
<td>1.21&quot;</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Rainfall is highest in the north-west and along the foot of the mountains while S.W. Punjab gets the least. Heavy snowfalls over the mountains add to the reserves of snow for the rivers and provide irrigation water at the commencement of the hot season.

The sudden falls of temperature associated with the rear (the cold front) of the depressions are very often harmful to the crops. The number of these depressions recorded during the cold season in three consecutive years and their monthly distribution is as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>January</th>
<th>February</th>
<th>March</th>
</tr>
</thead>
<tbody>
<tr>
<td>1940</td>
<td>10</td>
<td>9</td>
<td>9</td>
</tr>
<tr>
<td>1941</td>
<td>11</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>1942</td>
<td>9</td>
<td>9</td>
<td>6</td>
</tr>
</tbody>
</table>

They vary greatly in their intensity and the consequent weather conditions.

Mean temperature is roundabout 50° in West Punjab during January but rises continuously towards March. Under the free insolation of a predominantly anticyclonic regime,

(i) Indian Weather Review, Annual Summary, 1940-1942
great diurnal ranges are recorded - from 25° to 30°. Night frosts are common in January and early February and are the severest in the Potwar Plateau. The lowest temperatures recorded are everywhere below 30°.

B. Hot Weather Season:— By April, when temperature reaches 30°, the hot weather has already begun. There is a steady fall in pressure and in May, the high pressure disappears altogether, replaced by a deep low centring around Multan. (i) Winds which are northerly or north-easterly in April, become variable till the S.W. Monsoon sets in. The main reason for this variability in wind direction is the importance that local pressure conditions assume, resulting in a large number of storm phenomena. These are caused by the occurrence of local fronts between "the surface-heated continental air... and the monsoon air"(ii) which is being drawn in by the low pressure. The most usual form they take is that of thunderstorms which bring rainbursts of short duration over a region. The same atmospheric phenomenon gives rise to hailstorms earlier on in the year (from January to April) with maximum frequency in March and the severe dust-storms which characterise the pre-monsoon period. Besides these, local whirlwinds are of common occurrence on days with uninterrupted insolation. Ascending currents of air catch up dust and give the impression

(i) Miller, A.A., Climatology, London, 1944, P.139

of whirling pillars of sand. These are known as dust-devils. (1) All of these phenomena have a considerable influence on the crops of the areas affected.

This season is one of small rainfall which, in view of the very high evaporation associated with continuous heat, does not mitigate the general conditions of drought and the parched appearance of the land. Rainfall occurs in any considerable quantity only in the sub-montane tract.

Rainfall - April to June

<table>
<thead>
<tr>
<th>City</th>
<th>Rainfall (&quot;”)</th>
<th>No. of rainy days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lahore</td>
<td>2.92&quot;</td>
<td>5.9</td>
</tr>
<tr>
<td>Rawalpindi</td>
<td>5.32&quot;</td>
<td>10.2</td>
</tr>
<tr>
<td>Lyallpur</td>
<td>2.23&quot;</td>
<td>5.2</td>
</tr>
<tr>
<td>Multan</td>
<td>1.24&quot;</td>
<td>3.1</td>
</tr>
</tbody>
</table>

The rainfall is due to western disturbances and local thunderstorms. The monthly total of western disturbances recorded in the years 1940-42 is as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>April</th>
<th>May</th>
<th>June</th>
</tr>
</thead>
<tbody>
<tr>
<td>1940</td>
<td>10</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>1941</td>
<td>9</td>
<td>7</td>
<td>0</td>
</tr>
<tr>
<td>1942</td>
<td>6</td>
<td>9</td>
<td>1</td>
</tr>
</tbody>
</table>

The temperature rises rapidly through April and May to reach a maximum of over 92.5°F everywhere in June. S.W. Punjab forms a segment of one of the hottest regions in the

(1) For further treatment of the storms and frequency figures see end of chapter
world and records a temperature of over $95^\circ F$. The diurnal range continues to be high, being $20^\circ-30^\circ F$. The mean minimum temperatures are generally over $80^\circ$, the mean maximum temperatures around $105^\circ$ while the highest temperatures recorded in any year are between $110^\circ$ and $125^\circ F$.

For all vegetative life, this is a difficult period. Hot winds during the day, locally termed "loco" have a withering effect on the vegetation. Clay soils become hardened and weather conditions sap human energy and enterprise. Both earth and man mark time waiting for the summer monsoon.

C. The Rainy Season: Even as the heat reaches its climax and assumes an intensity which becomes intolerable, the monsoon bursts. There is a slight divergence of opinion as to the exact circulation of air connected with the south-west monsoon. It has been consistently associated with the existence of a highly developed low pressure in north-western India which draws in the oceanic winds including the trades winds south of the equator. The latter undergo a rotational deflection towards the north and take the south-west direction. The actual direction of these monsoon currents is controlled by relief so that most of them come as south-east winds in West Punjab, the Arabian Sea branch being much less effective as a rain-making agency.

Wagner, a German meteorologist, has emphasised in view that "the south-west monsoon represents a stationary system of cyclonic disturbances reaching up to the average
height of the Himalayas between two air masses, one continental belonging to the westerly winds of the middle latitudes, and the other maritime. He considers that the continental air is warmer than the monsoon air at the surface and up to 1 km. but colder above and that a considerable part of the rainfall in the Gangetic plain is due to cyclonic convergence\(^{(i)}\). The observations of upper air movements on which this view is based give it a stamp of authenticity. On the other hand, the prevailing pressure conditions and the winds associated with them during most of the season point obviously to the traditional explanation of the monsoon.

The weather observation data recorded by the Indian Meteorological Department provides the conclusive evidence and it is noticed that the two conceptions are not in conflict. The general seasonal circulation of the surface winds conforms to the popular idea of a gigantic sea breeze modified by relief and other physical factors. But the pulsatory character of the rains with intervals of hot dry weather is associated with the activity of depressions generated along the "monsoon front".

Most of West Punjab is included in a part of the Indian sub-continent which has the lowest pressure in the world in July and is not too far from the sea. On the theory of pure indraft, this region should receive the heaviest rainfall.

and yet it is the driest part of India. Simpson\(^{(1)}\) vouchsafes
the following explanation for this aridity:

(a) The small amount of moist maritime air reaching this part.

(b) The hot dry upper air current flowing from the west which prevents condensation.

(c) The low humidity at the ground caused by the high temperatures, the high temperature itself being a result of clear skies and uninterrupted insolation.

Dr. Ahmad\(^{(ii)}\) has put one of these points to a statistical test - the one dealing with the low humidity of the winds in this region. He has proved that the mean precipitation per rainy day in the Punjab is 0.94" as against 0.89" in Bengal and 0.88" in Bombay. This would appear to disprove the above assertion. But calculating rainfall per day during the monsoon for the drier part of the Punjab, Simpson's contention is undoubtedly correct when applied to the region it is really meant for:

Rainfall per rainy day
(July to September)

<table>
<thead>
<tr>
<th>Location</th>
<th>Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyallpur</td>
<td>.78&quot;</td>
</tr>
<tr>
<td>Multan</td>
<td>.70&quot;</td>
</tr>
</tbody>
</table>

Furthermore, heavy rainfalls during short periods are characteristic of the semi-arid and arid parts of northwestern India, a feature which reduces still further the agricultural utility of the monsoon in these regions.

\(^{(ii)}\) K.S. Ahmad, Op.Cit. P.92
Rainfall (July to September)

<table>
<thead>
<tr>
<th>Location</th>
<th>Rainfall (inches)</th>
<th>No. of rainy days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lahore</td>
<td>14.19</td>
<td>14.2</td>
</tr>
<tr>
<td>Rawalpindi</td>
<td>18.11</td>
<td>22.4</td>
</tr>
<tr>
<td>Lyallpur</td>
<td>8.3</td>
<td>11.2</td>
</tr>
<tr>
<td>Multan</td>
<td>4.1</td>
<td>5.5</td>
</tr>
</tbody>
</table>

The normal rainfall for this season constitutes two-thirds of the annual rainfall, the principal rainy months being July and August.

Correlation of Rainfall:— Various meteorologists have worked out statistical correlations between the monsoon rainfall of a year and the preceding conditions of pressure, temperature and rainfall (notably Unakar, Blanford, Walker and Eliot). The purpose of these is to establish a basis for forecasts of rainfall which is so vitally important for agriculture. Some of these suggested relationships may be mentioned in passing.

Large snow accumulations on the Himalayas have an adverse effect upon the monsoon. (i)

Walker (ii) has discovered that well-developed high pressure in the preceding winter is followed by a good monsoon. He also established that high pressure in South America has the same influence!

Eliot (iii) has proved that if south-east trades bring heavy rainfall in their region, the Indian monsoon is also very

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(iii) Imperial Gazetteer of India, Vol. I, 126-127
fruitful.

Despite these established relationships, one may add, it has been found exceedingly difficult to determine the nature of the south-west monsoon in advance. In any case most of West Punjab belongs to a critical region in which even a good monsoon seldom causes enough rain to mature crops without irrigation.

Both the date of the commencement of the monsoon and the amount of rainfall associated with it vary a great deal from year to year. In general, the monsoon sets in around the 1st of July in the eastern section and a fortnight later in the western districts.

The effect of the monsoon on temperatures is to bring them down though they rise again towards the end of September. At Lahore, for example, the mean maximum temperature falls from 106.7° in June to 99.9° and similar falls are recorded everywhere. Temperature is higher towards the south-west where rainfall is less. The intervals of damp heat in between spells of rain are found most uncomfortable by man and beast. The general effect of the rain on the countryside is to bring it to life.

D. The Season of the Retreating Monsoon

This quarter of the year has the "most settled weather of the year.... The serenity of the climate is seldom disturbed". (1) The low pressure conditions are replaced by

(1) H.F. Blanford, The Climates and Weather of India, Ceylon and Burma. London 1889 P.
a weak high pressure in October which becomes intensified as the season proceeds. North-easterly and north-westerly winds prevail. The activity of the monsoon had already begun to subside in September and later ceases to cause rainfall altogether so that October and November are about the driest months in the year. The western depressions commence their activity about this time, reaching their highest intensity in December which is also the wettest month of this season.

Rainfall (October to December)

<table>
<thead>
<tr>
<th>City</th>
<th>Rainfall</th>
<th>No of rainy days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lahore</td>
<td>.63&quot;</td>
<td>1.8</td>
</tr>
<tr>
<td>Rawalpindi</td>
<td>1.87&quot;</td>
<td>3.5</td>
</tr>
<tr>
<td>Lyallpur</td>
<td>.73&quot;</td>
<td>1.9</td>
</tr>
<tr>
<td>Multan</td>
<td>.34&quot;</td>
<td>1.1</td>
</tr>
</tbody>
</table>

The number of western depressions recorded during this season is as follows:

<table>
<thead>
<tr>
<th></th>
<th>1940</th>
<th>1941</th>
<th>1942</th>
</tr>
</thead>
<tbody>
<tr>
<td>October</td>
<td>5</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>November</td>
<td>6</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>December</td>
<td>8</td>
<td>8</td>
<td>6</td>
</tr>
</tbody>
</table>

The temperature falls steadily through October, November and December to come down to the conditions that prevail in the cold season. The diurnal range is high, 30-35° and the temperature decreases latitudinally towards the north.
The date of commencement of winter frost has a great agricultural significance as it determines the distribution of American cotton. (i) The usual date is after the end of December but frosts have been recorded as early as the 8th of December (at Rawalpindi, 1932). On the whole the frost sets in sooner and is most frequent on the Potwar plateau and the sub-montane tract.

Annual Rainfall:— The annual rainfall map (No. 64) shows that rainfall decreases from the north-east to the south-west, the isohyets following the strike of the mountains. The highest rainfall is recorded at Murree which is situated at a height of about 7,000 feet. The sub-montane tract has central Punjab from 10-20" whereas the arid south-west and the tract to the south of the Salt Range records less than 10" of rainfall. Modest as these figures are, they do not show the other hazards of rainfall which makes it so much less useful for crop-production.

The most serious drawback is, as in the case of Barbary, the variability of rainfall. The same features, i.e. the lower the rainfall the higher the variability and also the concentration of rain in a few rainy days are again noticed prominently. Map (ii) shows the highest percentage of variability in the south-western districts, over 30%. Regions of higher rainfall also have more dependable rains, the

(i) Dr. Ahmad, Op.Cit.
percentage of variability here being less than 20%.

The relationship of variability to optimum crop conditions is not easy to establish for the biological effectiveness of the rain is dependent upon "the configuration and vegetational covering of the land upon which it falls, the rate of evaporation obtaining and the capacity of the soil to receive and accommodate moisture to the advantage of the plant" (i) Given the predominantly uniform conditions over the alluvial plain of the Punjab, rainfall is the supreme factor from the agricultural viewpoint and over a greater part of the province variability combines with rainfall deficiency to make irrigation more or less essential.

Cyclical Variation of Rainfall:— Dr. K.S. Ahmad has come to the conclusion (ii) that there is some statistical proof for the general belief that the quantity of rainfall in the province is subject to a triennial rotation. Years of markedly low or heavy rainfall tend to occur at intervals that vary from 2 to 8 years but more frequently at shorter interval of 3 years.

Thunderstorms and Hailstorms:— Both these phenomena originate in a similar manner and the essential condition for their formation is the production of rising currents of moist air on a sufficient scale to make the air unstable. This may happen by strong surface-heating by contact with the heated ground which gives rise to convection currents

(i) Ibid, P.44
in the hot summer afternoons. Thunderstorms that occur in this manner are very localised in character. Distinct from these "heat thunderstorms are the 'depression thunderstorms' caused by mechanical uplift of moist warm air by the undercutting of cold heavy air. These are usually associated with western disturbances."  

Frequency of Thunderstorms

<table>
<thead>
<tr>
<th></th>
<th>Lahore</th>
<th>Rawalpindi</th>
<th>Murree</th>
<th>Khusheb</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>0.5</td>
<td>0.3</td>
<td>0.7</td>
<td>0</td>
</tr>
<tr>
<td>February</td>
<td>0.8</td>
<td>0.9</td>
<td>0.8</td>
<td>0.3</td>
</tr>
<tr>
<td>March</td>
<td>2.7</td>
<td>1.9</td>
<td>3.2</td>
<td>1.6</td>
</tr>
<tr>
<td>April</td>
<td>3.3</td>
<td>3.7</td>
<td>5.3</td>
<td>2.3</td>
</tr>
<tr>
<td>May</td>
<td>3.4</td>
<td>2.7</td>
<td>4.3</td>
<td>1.9</td>
</tr>
<tr>
<td>June</td>
<td>3.5</td>
<td>3.3</td>
<td>7.1</td>
<td>1.5</td>
</tr>
<tr>
<td>July</td>
<td>4.2</td>
<td>6.2</td>
<td>7.1</td>
<td>2.3</td>
</tr>
<tr>
<td>August</td>
<td>4.0</td>
<td>6.0</td>
<td>7.4</td>
<td>1.2</td>
</tr>
<tr>
<td>September</td>
<td>2.4</td>
<td>6.3</td>
<td>5.4</td>
<td>1.6</td>
</tr>
<tr>
<td>October</td>
<td>1.4</td>
<td>2.6</td>
<td>3.3</td>
<td>1.1</td>
</tr>
<tr>
<td>November</td>
<td>0.3</td>
<td>0.3</td>
<td>0.9</td>
<td>0.1</td>
</tr>
<tr>
<td>December</td>
<td>0.5</td>
<td>0.1</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>Total</td>
<td>27</td>
<td>35</td>
<td>46</td>
<td>14</td>
</tr>
</tbody>
</table>

It will be noticed that the highest annual frequency is recorded in the Potwar Plateau where the two maxima in April and June—July are connected with "depression thunderstorms"

(i) Frequency of Thunderstorms in India, I.M. Department, Scientific Notes, Vol.1 No.5
and "heat thunderstorms" respectively.

Hailstorms occur when vertical air currents in a thundercloud have sufficient velocity and extent to bring about a freezing of the moisture and its precipitation as hail or ice. Hailstorms are most common between January and June with the maximum frequency in March. They are encountered more often at the elevated stations such as Murree and Rawalpindi.

Dust storms:- They resemble the thunderstorms in their origin and are a consequence of the strong convection currents set-up after the intense heating of the summer mid-day. Large quantities of dust are raised up and carried over long distances to be deposited over land with a stifling effect on the vegetation. Their frequency is on the whole greater towards the west than the east. They are most common from April to August.
Chapter 4

HYDROGRAPHY

The water resources of a semi-arid region whether in the shape of surface drainage or of underground reserves play a decisive role in its agricultural prosperity. These resources are determined by climate, relief, the natural vegetation as well as by the nature of the geological strata. In reflecting these conditions the rivers and the distribution of sub-soil reserves in West Punjab and Barbary show a contrasted aspect. We shall first consider the rivers and other features of surface drainage and then study the sub-soil reserves of water.

SURFACE DRAINAGE

By virtue of its mountainous relief and a general absence of extensive lowlands, Barbary is naturally unsuited to the development of large rivers. West Punjab on the other hand possesses a celebrated system of rivers which draw their never-failing supplies of water from the Himalayan snows and glaciers. The general aspect of the West Punjab drainage is essentially uniform, all the waters flowing across the alluvial plain into the Indus. The cardinal fact about Barbary, however, is its diversity and one comes across water features varying from the perennial Atlantic rivers through the shorter and torrential Mediterranean streams to the large interior basins of inland drainage. Finally, whereas consequent upon their having considerable catchment areas and a large volume
of water, the West Punjab rivers are well-developed and mature streams, the shorter rivers of Barbary are still characterised by youthful features and an irregular profile.

As regards the water regime of the rivers, the contrasted effect of the Mediterranean and the Monsoon climates may be noted. The combination of great summer heat with complete drought produces a negative season for the rivers in Barbary when they run dry. A similar regime subsists in West Punjab in the hot season but is ameliorated by the melting of the Himalayan snows. As for the winter season, reduced evaporation and a high percentage of run-off makes the low precipitation more effective than it would be on parched lands during the summer. From the point of view of river flow, therefore, West Punjab enjoys a great advantage over Barbary, an advantage that is reflected in the type and development of irrigation works. We may now take up the two regions one by one:

BARBARY

Apart from those features of the drainage of Barbary that have already been pointed out, the important role of geological structure should be specially noted. In the absence of permanent glaciers and the comparatively minor role of snow-cover, the moisture-retaining capacity of the rocks has a great influence over the periodic fluctuations in the water-regime. Limestones at the headwaters of a stream tend to
regulate the flow as for instance the Summam in Algeria draws a constant supply of water from the massive Jurassic limestones of the Jurjura range. The Sebu in Morocco presents an interesting contrast in the water regime of its northern and southern tributaries. The Rif slopes drained by the Wargha consist of clays and marls from which run-off is immediate and the heavy winter rains cause disastrous floods. Summer finds this part of the basin completely dry. The Middle Atlas limestones, the source of the southern tributaries of the Sebu, provide a more regulated supply so that these, notably the Rdom and Beth are less liable to floods and maintain a constant flow. (i)

As the study of the long profiles (see diagrams (ii)) will indicate, most rivers in Barbary are characterised by the occurrence of definite "steps" in their courses, marking the points where a formerly closed basin was captured by the stream. These are a testimony to the youth of the rivers that have not attained to profiles of equilibrium.

One climatic factor, not measured quantitatively so far, as the greatest significance from the point of view of river volume in Barbary and this evaporation. It "accounts for much the greater part of the precipitation which falls on the rivers ... and the average volume of rivers equals at the most a twentieth or thirtieth part of the total volume of rainfall." (ii)

(i) W. Fogg, "The Sebu Basin" Scottish Geog. Mag. 1931, P. 80
(ii) A. Bernard, Op. Cit. P. 52
The nomenclature of the surface-drainage of Barbary presents quite a problem. The local inhabitants call them "wadis" which literally means a valley. This is apparently a result of the water regime under which the majority of the streams flow only periodically during rains and are dry valleys for the rest of the year. But even the native inhabitants make a distinction between perennial and seasonal streams as one of the main tributaries of the Shelli is called "Nahr" or River Wassel in distinction from Wadi Twil, the other major source. This difference is unfortunately not brought out in the naming of many other rivers that, in addition, carry different names in different sections - a result of the isolation of different communities due to the complex relief. The writer has therefore raised those wadis that have a perennial flow and large catchment areas to the dignity of rivers while the seasonal streams have been termed wadis. (1) This is also uniform with the nomenclature in West Punjab where a similar distinction exists between rivers and "nalas".

We may study the surface hydrographical features of Barbary in four groups:

1. The Atlantic Rivers
2. The Mediterranean Drainage

(1)French geographers i.e. Bernard, Despois, etc, tend to accept the local nomenclature to distinguish the drainage with great seasonal contrasts from the European rivers. The writer believes however that perennial flow with some volume puts a river into a separate category from the torrential streams and is reflected in its utility for irrigation. Most barrage reservoirs have been constructed across "rivers" and not wadis.
3. The Closed Basins.

4. Saharan Water-Courses.

I. The Atlantic Rivers

These constitute the best-developed river systems of Barbary drawing their waters from the highest mountains in Barbary - the High and the Middle Atlas on which snow lies for six to nine months. The existence of alluvial plains of considerable dimensions is a testimony to the importance of deposition. The chief systems are those of the Sebu, the Bu Regreg, the Um-er-Rbia and the Tensift.

(a) The Sebu

This is the only river in Barbary approaching a profile of equilibrium. Originating in the Middle Atlas and after receiving the drainage of the Taza Gap, it flows through alluvial terraces in the Fes-Meknes plain. Further down it is joined by its larger tributaries form the north and south, named previously. At its confluence with the Wargha it is only 45 feet above the level of the sea and has 180 miles to run. Here it flows in tortuous meanders above the general level of the plain so that periodic floods inundate the lowlands on both sides.

The merjas of the plain of Sebu are a feature peculiar to it and constitute unhealthy marshes in winter and a valuable grazing ground in the summer. The typical merja consists of two parts, the "hydra" and the "beach" (1) The hydra

Profile of the Sebu, according to J.Clerier and A. Charton.

Regime of the Sebu.
Profile of the Um-er-Rbia.

Outflow of the Um-er-Rbia after Y. Le Moigne and J. Bourcart.
is the depressed part wherein the depth of the water may be as much as 9-12 feet in winter and some water may persist even through the dry summer. The beach is completely dry in summer-time but may be inundated to a depth of three or four feet in winter. It is covered with a variety of forage plants providing extensive pasturelands to transhuming tribes.

The main causes for the formation of the merjas are the impermeability of the clayey silt that covers these regions; the barriers to natural drainage in the natural levees of the Sebu and the coastal dunes; and lastly the inability of the intermittently flowing tributaries of the Sebu to maintain a constant base-level. They cover over 220,000 acres in the lower Sebu plain and the largest of them is the Merja of Beni Ahsen.

The volume of water in the Sebu averages between 1050 and 1400 cusecs, the minimum being 360 cusecs while at flood time it may exceed 70,000! (i)

The Bu Regreg:— is a much smaller river with a length of only 110 miles and a very small and irregular volume of water. Along with its tributaries it drains the Zaer-Zaian plateau. The headwaters of this stream are supposed to have extended much further up but were probably captured by the Um-er-Rbia. (ii)

The Um-er-Rbia:— With a length of 355 miles and a large and rich catchment area, the Um-er-Rbia is the most

powerful of the rivers of Barbary. Rising high in the Middle Atlas, it traverses the Tadla plain flowing East-west but changes its direction to N.E.-S.W. After receiving its largest affluents, the El-Abid and the Tessawt, it cleaves through the Rehamna massif and meanders its way through the Abda-Dukkala plain to the sea. It is a very heterogeneous stream with two steps in its profile to mark local base-levels of captured basins. The river which along with its tributaries drains the larger part of the southern Middle Atlas and the eastern High Atlas, maintains a constantly high volume which varies from 1400 cusecs in July to over 7,500 cusecs in April. The river is less liable to the violent floods that characterise the Sebu.

The Tensift has a total length of 140 miles and drains the Marrakesh region and the northern slopes of the High Atlas.

II. The Mediterranean Drainage

This group comprises a large number of streams stretching from the Muluya in eastern Morocco to the Mejerda in Tunisia. Even the longest rivers like the Sheliff and Sebouse are "more of torrents than of rivers"(1) full only in times of floods and discontinuity of surface drainage is a general characteristic. Gautier(11) has divided them into two groups:

(1) Those which have their whole course in the Tell.

(2) Those whose sources are in the High Plateau.

(1) The Rivers of the Tell Atlas

The important rivers in this group are the Mejerda, the Sahel (Summam), Isser, Habra, Sig and Tafna.

The Mejerda is the longest of the Tellian rivers with a length of 260 miles and is also the principal river of Tunisia draining most of the country between the coastal ranges and the Dorsal. Its source lies in the eastern Algerian High Plains and after a deeply-entrenched course it enters into its lowland valley below Ghardimaou. It receives tributaries from north to south, the most notable being the Mellegue which also rises in the Algerian High Plains. Mejez-el-Bab is the gateway to the plain of Tunis across which the river meanders on to the sea, and has built up a large delta, the only one in Barbary.

The Sahel (or Summam) and the Isser are two small rivers rising south of the Jurjura range and are 125 and 142 miles long respectively. Gautier has called the Isser the "heroic type" (1) of river which crosses successively all the chains of the Atlas at right angles and debouches towards the coast by the celebrated gorge of Palestro.

The rivers of the Mitija plain, Mazafran and Harash show antecedent features when they cut through the Sahel in gorges.

The Sig and Habra, chief rivers of the Sahel of Oran,

(1) Ibid P.355
11 The Um-er-Rbia south of the plain of Beni Amir. Photograph taken in mid June when volume of water is approaching its summer minimum. Notice the hydro-electric plant on the left bank with some associated buildings further to the left. Bushy natural vegetation on the right.

Gorge of the Tafna river below the Beni Bahdel dam in Algeria. Stratification is clearly exposed. Scattered low scrub on the sides of the gorge as well as the heights in the distance.
Wadi el Kebir north of Blida.
It is on the alluvial fan of this stream that Blida has developed.
Photograph taken on a rainy day in late May. On the slopes of Blida Atlas vegetation is luxuriant and some conifers can be seen on the right. Valley slopes are steep as the stream just emerges here from its mountain course.

The Isser and the Jurjura range seen faintly in the distance. The river flows in a broad flood-plain with steep valley sides covered with scattered brush. There are no signs of cultivation in the flood-plain because of the shifting bed of the stream as well as its liability to floods.
are different from all other Tellian streams. They have a very youthful profile in which the plains of Mascara and Sidi Bel Abbes respectively introduce steps of regular slope. The Macta marshes into which both rivers empty lie at the centre of a vast stretch of interior drainage extending from Rio Salado to the Sheliff. There are several inland basins of sizes ranging from insignificant "dayas" to the large Sebkha of Oran is 40 miles long.

The Tafna with a length of 110 miles is the fastest of the Tellian rivers and the one with the steepest gradient. Below Beni Bahdel where a barrage has been constructed it cleaves the interior Tell Range through a deep gorge.

Several of the coastal streams are saline (hence the frequent occurrence of the name Mellah, meaning salty) The salinity of these has been ascribed to the outcrop of triassic rocks which abound in salt and gypsum. The presence of a soluble sub-soil may also be a reason for the general depressed nature of the Oran region.

(2) Rivers of the High Plateau

With the exception of the Muluya, the rivers of this group show a marked step in their profiles where the river leaves the high plateau (See profile of the Shelif) The most important rivers are the Sheliff and the Muluya.

(1) Ibid P.362
PROFILE of the SHELIF after Gautier.

REGIME of the SHELIF at CHARON, [after Yacono.] mean of 1927-1935.
Profile of the Mejarda.
After Gautier.
The Shelif with a length of 434 miles is the longest river of Barbary. Of its two main head-streams, the Twil ("long") rises in the Saharan Atlas to that the Shelif is the only river rising in this range to reach the sea. Below Boghari, the river which had a north-south direction so far takes a sudden turn and flows east-west through an ancient depression which it has filled with its sediments. Despite its great length, the Shelif has a volume comparable to that of the smaller Mejerda, averaging 630 cusecs but rising to over 350,000 cusecs during the highest floods.\(^1\) In the dry season it consists of a series of marshes joined by tiny trickles.

The Muluya connects three basins in its course marking the sites of Pliocene lakes and after a deeply entrenched course through the mountains of Beni Snassen, enters the sea through a coastal plain.

**III. The Closed Basins**

Most of the high plateau is a region of closed basins which are known by several names, i.e. shotts, sebkras, zahrez and gueraa.\(^2\) They owe their origin to the lack of dominant slope towards the plains, the nature of rocks and their arrangement which favours absorption, evaporation and stagnation, and above all to the arid climate. Masses of debris brought down by the torrents after downpours only help

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\(^1\) M.R. Martin "Les Grands Barrages et les Irrigations en Algerie", 1947, P.9

\(^2\) A.Bernard Op.Cit. P.54
The Mejerda above its delta. The river flows between high well-defined banks fringed here on the right by the wind-breaks of a fruit plantation. The beginning of a gentle undulation in the landscape is seen on the left in the distance. Photograph taken in early May when volume of water is fairly high.

A tributary of the Mejerda photographed from the train in the Mejerda valley. Notice the low bare hills in the background. Land on the right is cultivated in the distance and fallow in the foreground. The stream flows between high vertical banks and is incised below the surface of the valley.
The Sebkra Kelbia in Tunisia north-east of Kairwan. It is a shallow depression filled with water. The white glistening salt can be noticed at the edges. In the centre the beginning of a path used in summer when it is completely dry to collect salt. Outline of low hills in the background.
to choke the plateau up with deposits. The Sebkhas or shotts which are full of water only for a short period in winter consist usually of a saline crust or reddish mud.

IV. The Saharan Water-Courses

These are the usual ephemeral streams of the desert type bringing down a mass of sediments after a shower but losing themselves in the sands.

WEST PUNJAB

The water regime of the rivers of the Punjab has been subjected to a detailed and comprehensive analysis in relation to the Himalayan snows and glaciers by K. Sain. The relative proportion of the glacier areas in the river catchments can be gauged from the following table.

<table>
<thead>
<tr>
<th>Name of river</th>
<th>Glacier area in square miles</th>
<th>Percentage of glacier area to total catchment area</th>
<th>Mean elevation of glacier area above mean sea level in feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indus</td>
<td>14,415</td>
<td>12</td>
<td>20,500</td>
</tr>
<tr>
<td>Jhelum</td>
<td>142</td>
<td>1</td>
<td>18,000</td>
</tr>
<tr>
<td>Chenab</td>
<td>1,475</td>
<td>13</td>
<td>19,000</td>
</tr>
<tr>
<td>Ravi</td>
<td>100</td>
<td>3</td>
<td>17,000</td>
</tr>
<tr>
<td>Beas</td>
<td>277</td>
<td>5</td>
<td>19,000</td>
</tr>
<tr>
<td>Sutlej</td>
<td>2,468</td>
<td>11</td>
<td>20,000</td>
</tr>
</tbody>
</table>

(i) The Role of Glaciers and Snow in the Hydrology of Punjab Rivers, Kanwar Sain, Central Board of Irrigation, Pub. No. 36, 1946

(ii) This does not include the areas covered by seasonal snows
Putting it in another way "so enormous is the aggregate amount of water locked up in the crystalline state in the glaciers and ice caps on the Himalayas that if it were all released by melting and flowed down the Punjab rivers, most of the Punjab and Sind plains would be submerged". (1)

The science of snow-surveying as well as the study of the run-off in the rivers in relation to the rainfall are still in their infancy in this part of the world. One river, the Chenab, has however been studied carefully over a period of 20 years (1923-42) with the help of 12 rain-gauge stations and the discharges measured regularly. The results obtained from this study are shown in diagram . The run-off from May to October is appreciably greater than the total precipitation and even the total annual run-off exceeds the annual rainfall. When the losses of rain-water by absorption and evaporation are taken into consideration, it becomes obvious that the glaciers are responsible for a material contribution to the run-off.

K. Sain rejects the prevalent belief that snow-cover is an important factor in flood causation and holds the reverse to be true. Snow cover acts as a flood deterrent in two ways; by the "sponge effect" by which water is absorbed and held and the "surface detention effect", by which deep snow

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(i) Ibid Page 1
regulates the water-supply by acting as a restraining obstacle. He advocates large-scale snow-surveys to make stream-flow forecasts more accurate.

The volume of water in the rivers is subject to very great variations (see graph) and the proportion of maximum recorded discharges at floods to minimum discharge is remarkably high as can be noticed on the following table. (i)

<table>
<thead>
<tr>
<th>River</th>
<th>Site</th>
<th>Minimum Cusecs</th>
<th>Maximum Cusecs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sutlej</td>
<td>Rupar</td>
<td>2,818</td>
<td>250,000</td>
</tr>
<tr>
<td>Beas</td>
<td>Nowshera</td>
<td>2,300</td>
<td>325,000</td>
</tr>
<tr>
<td>Ravi</td>
<td>Madhopur</td>
<td>1,300</td>
<td>200,000</td>
</tr>
<tr>
<td>Chenab</td>
<td>Khanki</td>
<td>3,884</td>
<td>600,000</td>
</tr>
<tr>
<td>Jhelum</td>
<td>Rasul</td>
<td>4,500</td>
<td>500,000</td>
</tr>
<tr>
<td>Indus</td>
<td>Attock</td>
<td>18,000</td>
<td>1,000,000</td>
</tr>
</tbody>
</table>

The heavy variations in discharges are most disconcerting to the irrigation engineer and if they could be adequately predicted, the task of distributing irrigation supplies would become much easier. Cultivators too could then plan their crops more efficiently. K.Sain draws attention to the fact that from April to June, critical months for water-supply, the main source of run-off is snow which could be forecast much more accurately than the empirical rains. (ii)

The general characteristics of the Punjab rivers are broadly similar. Their general tendency is to hug their right bank. Nearly always, therefore, it is easier to carry irrigation water from the left rather than the right bank. Nearly all the rivers shift their courses and flood their banks over a considerable portion of their course, the area covered gradually increasing towards the sea. So long as these inundations remain within reasonable limits, they do little harm and much good. New silt fertilizes the land and winter crops flourish on the water absorbed during a late summer flood. Crops are sometimes protected by bunds (embankments) particularly in the regions irrigated by inundation canals in the south-west of the province. There is considerable evidence that the intensity of floods in the Punjab rivers has increased. As long ago as 1872 an irrigation engineer pointed this out and gave the same reason as is generally given today; being "centuries and centuries of bad and unsettled government when everyone cut down trees but no man planted any".

The relative size and importance of the Punjab rivers may be observed in the following table:

(1) K.S.Ahmed - Agr. Geog. of the Punjab P. 53
(iii) Hayden and Burrard "Geography & Geology of the Himalayas" P. 175
<table>
<thead>
<tr>
<th>Himalayan area in the basin (Sq.miles)</th>
<th>Total discharge of water (Ravi as unit)</th>
<th>Ratio of discharge to area, taking Ravi as unit.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indus</td>
<td>103,800</td>
<td>9.0</td>
</tr>
<tr>
<td>Sutlej</td>
<td>18,500</td>
<td>3.5</td>
</tr>
<tr>
<td>Jhelum</td>
<td>13,000</td>
<td>5.5</td>
</tr>
<tr>
<td>Chenab</td>
<td>10,500</td>
<td>5.5</td>
</tr>
<tr>
<td>Beas</td>
<td>5,600</td>
<td>2.5</td>
</tr>
<tr>
<td>Ravi</td>
<td>5,600</td>
<td>1</td>
</tr>
</tbody>
</table>

The Indus is the greatest of the Punjab rivers. It rises in Tibet from a ring of lofty mountains near Lake Mansarorar, flows through Kashmir, N.W.F.P., Punjab and Sind into the Arabian sea. The total length is 1800 miles and the basin drained is estimated at 372,700 square miles.

The Indus traverses a mountain course of over 800 miles during which it receives the drainage of several large rivers like the Shyok, Gilgit, Zanskar, Dras and Shigar so that it is a mighty river by the time it enters the province above Attock. Here it receives the Kabul. Flowing through the narrow gorges of the Potwar plateau, it is joined by the Soan at Makhad, bringing the entire drainage of the plateau. The Indus emerges on to the plain at Kalabagh where it has a large alluvial fan.

South of Kalabagh the river flows through almost desert country where cultivation is almost entirely dependent upon irrigation. The Indus is, however, a turbulent and unmanageable river which shifts its course frequently, the only
permanent banks it possesses being those at Kalabagh. It is a braided stream with a network of shifting channels and, as is characteristic of Punjab rivers, has a steep right bank. Just above Mithankot, it receives the waters of all the Punjab rivers. The lower course lies in Sind.

The Jhelum rises in Kashmir and flows for about 250 miles as a rapid torrent hemmed in by precipitous gorges. It emerges on to the plain eight miles above the town of Jhelum and flows as a braided river. Sandy islands know as "bels" stud its wide bed. The Jhelum is subject to destructive floods but usually subsides in good time for the riverain land to be sown with winter wheat. Dr. Ahmad believes that the Jhelum rises earlier than the other Punjab rivers because it is more dependent on the melting snows and less on the summer rainfall than they are. (i) This is difficult to understand as only 1% of the Jhelum's catchment is permanently covered with glaciers. It is probable, however, that periodic snow, not covered in the glacier area, makes a substantial contribution to its waters.

The Jhelum occasionally has slight winter floods due to the rainfall brought by westerly depressions.

The Chenab Its sources lie in the Lahaul region of the Himalayas. It enters W. Punjab in the Sialkot District.

(i) Dr. K.S. Ahmad - An agricultural Geography of the Punjab, P.51
Regime of the Chenab at Marala in relation to the measured precipitation over the catchment area.
It begins to rise in March but the annual inundation which follows affects only a narrow fringe along the river. Owing to the sandy nature and loose texture of the soil on its banks, the moisture percolates far inland. Water-table is consequently high. The Jhelum joins the Chenab at Trimmu.

The Ravi has its headwaters on the south-western slopes of the Pir Panjal and the northern slopes of the Dhauladhar Mountains. Leaving the Himalayas after 130 miles in the mountains, it flows in the plain in a comparatively narrow flood-plain with a tortuous channel. It begins to rise in May, reaching a maximum in August but is an insignificant stream in winter.

The Sutlej drains a large part of the Punjab Himalayas. After entering the plain and being joined by the Beas at Subraon it follows the characteristic Punjab slope and has different names in different parts, i.e. in Montgomery it is called Nili (blue) while in Multan it is called Ghans. Changes in its bed have been very frequent.

**SUB-SOIL RESERVES**

The underground water-reserves of Barbary and West Punjab play a considerable role in their traditional systems of irrigation particularly through wells. Map shows the water-table of West Punjab as at present. Over a larger part of the riverain tracts, the water-table lies within 15 feet
of the surface. Further away from rivers the depth of the water increases, but due to percolation in the alluvial sandy layers, underlain by impermeable clay ones, water is everywhere present at smaller or greater depths. Water seepage from canals have raised it at several places to such a point where it has become a liability rather than an asset for agriculture. On the whole, however, the existence of underground supplies reasonably close to the surface gives rise to intensive farming rendered possible by well-irrigation. The sub-montane districts and the riverain lands were irrigated long before the present system of canals brought the bar uplands under cultivation.

Due to the mountainous relief and the complex nature of the geological strata, the distribution of underground water reserves in Barbary is uneven. In general low-lying valleys and basins with deep alluvial deposits have sub-soil reserves derived from percolation. The Haouz and Gharb Plains in Morocco; the lower part of the Mejerda Valley, the Cap Bon region and the region of Kairwan in Tunisia are cases in point and here well-irrigation is practised. Existing knowledge of this invaluable water resource is however very imperfect in Barbary and no exact idea of the possibilities of utilising them can therefore be formed. The underground reserves of the closed basins are now being studied in Algeria where even the possibility of doubling the total
irrigated area by tapping the basin of Shott-es-Sherqui has been envisaged.
Chapter 5

SOIL AND VEGETATION

Whereas the role of the soil in crop production is well-known, the natural vegetation of a region does not appear to be related directly to agriculture. In the study of the geographic relationships between environment and crops, however, natural vegetation provides us with an invaluable index of the biological response to natural conditions. It has been said that the "climax vegetation of a region is a better integration of climatic conditions than any numerical data".\(^{(1)}\) For soils, too, vegetation has a deep significance. The more distinct soil types are almost always associated with quite distinct types of vegetation and over limited tracts "this association is often more pronounced than that between soil and climate".\(^{(1)}\)

The study of natural vegetation serves a very practical purpose for agriculture in two ways. Firstly the problem of soil erosion is intimately connected with the nature and history of the vegetation cover of any region. Secondly, in regions of expanding agriculture such as those we are studying, the index value of natural vegetation can serve as a very useful basis for land-use planning.

As Shantz and Zon have observed "The suitability

\(^{(1)}\) H.G. Champion "A Preliminary Survey of the Forest types of India and Burma", Indian Forest Records (New Series) Vol.1, No.1 1936, P.13

\(^{(ii)}\) "Soil, Vegetation and Climate", Imperial Bureau of Soil Science 1934, P.7
of virgin land for various crops is usually indicated very clearly by natural vegetation. After a correlation is established between different forms of natural vegetation and various agricultural and forest crops, it provides a means of dividing the country into natural regions of plant growth which can be used as indicators of the potential capabilities of the virgin land for agriculture and forest production"(1) 

Natural vegetation is determined not only by climate but also by the soil conditions, both past and present. In fact this close inter-relation of soil and vegetation is the basis for their joint consideration. In view of this and the primary importance of the soil for agriculture, it is only fair that soil should be studied first.

THE SOIL

The soil has been defined as "the uppermost layer of the solid crust of the earth; it consists of rocks that have been reduced to small fragments and have been more or less changed chemically together with the remains of plants and animals that live in it or on it."(ii)

The older concept of the soil which looked upon it as a static body with unchanging physical and chemical properties has given place in recent years to the view which regards it as a living and highly dynamic entity evolving continuously under the influence of climate, vegetation, relief

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(1) "Atlas of American Agriculture" Washington 1924
(ii) Sir A.D. Hall, "The Soil" P.1
and the parent material. In the early stages of its development, the character of the soil is determined largely by the character of the parent rock. Hence many mountain soils approximate closely to the nature of the surface rocks. As the development of the soil proceeds, climate and vegetation become the dominating influence and mature soils often show striking uniformity within the same climatic province even if there is a wide diversity of geological features.

The Properties of Soil and their Importance: The two important physical properties are soil texture and soil structure. Soil texture refers to the mechanical constitution of the soil with reference to the size of the soil particles which range from gravel and coarse sand to fine clay. Although this attribute has an important bearing on the capacity of the soil to hold moisture and on drainage, a property of greater importance from the agricultural point of view is the structure of the soil which determines the condition of tilth and aeration.

Of the nine chemical constituents of the soil essential to the plant (hydrogen, oxygen, nitrogen, sulphur, phosphorus, potassium, magnesium, calcium and iron) nitrogen, phosphorus and potash are the most important as they vary considerably in quantity from soil to soil. Semi-arid regions like West Punjab and Barbary are capable of fixing nitrogen
very rapidly from the air. The role of leguminous crops is particularly significant in restoring nitrogen because of the bacteria which flourish in their roots. The soils of Barbary and West Punjab are fairly rich in phosphorus and potassium. The former region has great reserves of mineral phosphates.

THE SOIL TYPES OF BARBARY

(See Map 66)

Despite its predominantly agricultural economy, Barbary has not so far been subjected to a comprehensive soil survey. Most of the existing literature on soil types is fragmentary and gives an incomplete picture of the characteristic of the soil in relation to crop production. The one notable exception is V. Agafonoff's work on the "Soil Types of Tunisia" (1) based on an extensive field study and analysis, the classification adopted being the modern genetic one. In view of the regional unity of Barbary and the essential similarity of natural conditions, an attempt has been made to state a possible distribution of soils in other regions in the light of the Tunisian analogues as well as any local studies.

It is always interesting to refer to the local "classification" of soils for the peasant possesses an intimate knowledge of their qualities through his own

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experience as well as that of his forbears. Most peasants are also able to give a broad distribution of these soils over the countryside and know what crops can be grown most advantageously on them. They make a clear distinction between heavy clay soils or "tin" and light sandy soils or "remli". In the regions with an adequate rainfall, the cultivable soils with a dark colour are called "tell" in Algeria and Tunisia and "tirs" in Morocco. These soils are ideal for wheat and conserve water so well as to yield good crops even in years of drought. The mountain soils, stony and difficult to plough are referred to as "jebel" (the word also meaning mountain). The reddish soils of the semi-arid regions are termed "hamri", soils which yield good crops of barley in years of good rainfall but which do not retain moisture very well and provide very meagre pasturage. When they are not deep and are mixed with gravel they are called "haroucha". (i)

When later on this native classification of soil types is compared with the genetic types, some striking points of similarity stand out to which attention shall be drawn at appropriate places. This is ample proof that modern scientific studies are only a more exact and precise amplification of facts long since known and appreciated by "ignorant" people through their practical experience.

Numerous geological classifications of soil types exist which do not commend themselves from the practical

(i) J. Despöis "L' Afrique du Nord" Paris, 1949, P. 74
standpoint except possibly in the case of young mountain soils of regions of deficient rainfall. These have been left unclassified by Agafonoff in the case of Tunisia thus, acknowledging in a way, the predominance of geological factors. Most young mountain soils are skeletal and vary with the geological formation. Others show semi-developed types approximating to the soil associated with the rainfall conditions that prevail.

The low valleys and plains are covered with alluvium brought down from the mountain slopes by streams. These soils become progressively fine-grained away from the mountains and if the slope is insufficient, they tend to occur as marshy expanses along the lower courses of streams (i.e. near Oran and the now drained marshes of Mitidja and the plain of Bone in Algeria and those of Sebu in Morocco) Where there is an excess of evaporation over precipitation, alkaline salts, mostly those of sodium, rise to the surface and render them unproductive. The reclamation of such soils constitutes one of the main problems of agriculture and shall be taken up in detail in a later chapter. Alluvial soils are found along the valleys of the principal streams as well as in ancient lakes which during the hydrographic evolution of the region, became filled up with silt. The distribution of such basins has been described under hydrography. These soils are rich

(1) See Soil Map of Tunisia based on "Carte Pédologique de la Tunisie" by V. Agafonoff and L. Yankovitch, scale 1:800,000
in the mineral ingredients of plant food and are generally cultivated.

We may now proceed to study the distribution of "sedentary" soils or soils which have developed under the natural conditions in situ and hence come properly under the genetic classification.

**Podzols:** These soils occur in regions where percolation is in excess of evaporation, i.e. where annual precipitation exceeds 24". They are leached of the bases in the upper layer so that the humus is acidic in reaction. Most of this region is covered with coniferous forest. "The soil profile of the Tunisian podzol corresponds fairly exactly to the typical Polzol of Russia" (1) The thin top layer rich in humus is underlain by a greyish yellow horizon leached by the percolating water. The salts accumulate in a lower layer with a darker colour acquired from the hydrated oxides of iron. One then passes to the C horizon of the parent rock.

The podzols are found in northern Tunisia, northeastern Algeria and in parts of the Rif and western High Atlas. Soils of the western part of Cap Bon in Tunisia and the northern Moroccan littoral have a tendency towards polsolation although the rainfall here is generally between 16 and 20". This is due to the high atmospheric humidity.

The podzols proper are not very rich from the point of view of agriculture and only those plants which are adapted to humid soils poor in lime can succeed. With the help of

fertilizers however, vegetables (haricot beans, potatoes, beet-root) and citrus fruits can be grown in those regions which are free from frost while the mountainous tracts can produce apples, pears, cherries and late vegetables. The drier podzols can be cultivated with cereals, fruits and vegetables with the application of fertilizers.

**Rendzinas:** They result from the influence of a calcareous parent-rock on the soils of the podzol zone. These soils have a dark brown or black colour, the decalcified A and B horizons have together an average thickness of 16" and rest directly on the parent rock without any intermediate substratum or C Horizon. These soils are very rich in humus and in Tunisia, they have the highest humic content of all soils. The rocky fragments of limestone increase in quantity with depth. This soil type is to be distinguished from the "terra-rosa" which is typically associated with the Mediterranean and is similarly associated with limestone rocks because the latter are much poorer in humus. (i)

The north of Tunisia south of the podzol zone, the eastern tell Atlas and most of the soils called "tirs" in Morocco particularly those to the south of the Bô Regreg are of this variety. Towards the south where rainfall is below 20" a thin superficial crust of limestone is observed to prove that evaporation is higher in this region.

(i) L.Yankovitch, Op.Cit. 101
(ii) J.Despois, Op.Cit. P.78
These soils vary in texture from the light variety formed over hard limestones to the heavier soils over marly strata and are rich in nitrates, potassium and phosphoric acid. They are cereal-growing soils par excellence and rotations are practised with leguminous plants. Forage crops such as lucerne, maize and sorghum are also grown. Deeper soils can be utilized for fruit cultivation.

A drier rendzina occurs in regions with a rainfall of 16-20" but the decalcification of A and B horizons is less marked and they have a smaller quantity of humus and clay. These soils are well-suited to cereals with a rotation of fallow every alternate year.

Soils with a crust

Wherever annual precipitation is less than 20", evaporation tends to be in excess of percolation. The vegetation is poorer and thinner than in the more rainy tracts and produces less humus. The salts and lime of the sub-soil move upwards and tend to form a crust of varying thickness. These soils are either red or brown in colour being progressively browner with increasing quantities of lime. The top layer is clayey with some gravel in it and rests directly on the crust which is harder towards the top. The origin of the crust is a subject of controversy, some contending it was formed by the upward movement of lime which was then covered by deposits brought by wind and water, others holding it was formed by downward movement at the foot of the roots.
of plants.

The northern (i.e. wetter) parts of this soil zone have their crust at considerable depth, the top layers are largely decalcified and the soil colour is red. As the rainfall decreases towards the south, the soil becomes greyish-brown or brown with a thicker, harder and shallower limestone crust. As a group these soils are of good quality, somewhat lacking in nitrogen and phosphates, they are rich in potash. Wherever the crust is too near the surface, the roots cannot penetrate easily. They are found between the Mejerdia and the Dorsal proper in Tunisia; in Algeria on the southern side of eastern Tell Atlas and in the High Plains of Constantine as well as in the plateau of Sersou; in Morocco in the major part of the Atlantic plateaux and plain south of Rabat. These soils are well-suited to the production of cereals.

The Soils of the Steppes:— Rainfall here is below 15" and the vegetation a poor grassland so that soils show a light colour, indicative of poverty in humus. The distinction between the soil and the sub-soil becomes difficult. These soils are generally rich in the mineral content of plant food and reveal their fertility when cultivated under irrigation. They all include wind-blown materials, dust and sand. Fine loessic sand occur extensively while in basins, deep deposits of fine alluvium are to be found although they tend to be over-rich in chlorides. The soils round the sebkhas,

(1) L.Yankovitch Op.Cit. P.103
MAP OF THE SOIL TYPES OF TUNISIA
(From Désbré's simplification of Agafonoff)
known as chotts contain too much salt to be cultivable. This group of soils occurs in South Tunisia, the region south of the High Plains of Constantine and in the High Plains of Western Algeria and eastern Morocco; and finally in the Sous and the part of Morocco south of the High Atlas.

THE SOILS OF THE WEST PUNJAB

Except in some part of the Potwar Plateau, the soils of West Punjab are alluvial and show no relation to the underlying geological structure. This similarity of origin under more or less uniform conditions of climate leaves only one basis for their classification - that of mechanical constitution, depending on the size of particles. This feature is of fundamental importance for the agriculture of a semi-arid region as it determines the behaviour of the soil with regard to water supply for the crops. The characteristics of different groups have already been stated and the nomenclature of various combinations indicated on Diagram 17 which also shows the physical nature of the soils of West Punjab.

It will be noticed that there is a predominance of sandy and medium loams in the province. Most of these are excellent soils for cultivation, sufficiently retentive of moisture and not difficult to work. Sandy soils dominate in the Thal. But even soils with a high content of sand can become very productive if a sufficient supply of water is available. The correct estimate of the mechanical texture of soil in terms of productivity can only be made in the light of
rainfall; water supply and other factors. "A soil of a certain texture behaving as a loose sandy soil in a district with deficient rainfall may behave as a loam in another area with a medium rainfall and as a heavy loam in heavy rainfall" (1)

The following generalisations may be made with regard to the distribution of West Punjab soils:

(a) The soil is more sandy near the hills and gets progressively clayey further away.

(b) In the "doabs" of Central Punjab considerable variations occur from the lee or riverain tract where sand predominates to the bar uplands where the quantity of sand diminishes to such an extent that even patches of stiff clay may be encountered. On the Ganji Bar, extensive tracts of hard stiff clay give place towards Multan to low sand dunes and the soil is less cultivable.

(c) The Thal consists of sand-hills (tibbas) with occasional patches of hard level clayey soils and tracts of ground impregnated with salt.

(d) In the Derajat region, soil varies from a rich loam to an alluvial clay as we pass from the mountains to the Indus.

In the Potwar Plateau, a mantle of fine loessic silt occurs in certain parts to the east of Rawalpindi, the angular particles of which suggest violent wind transport.

It is confined to the northern half of the plateau.

The soils of the alluvial plain of West Punjab were studied in relation to their natural vegetation in a monograph under the auspices of the Punjab Irrigation Research Institute. (1) This study undertaken to determine the suitability of different types of soil for irrigated cultivation has yielded some very useful results. The following features are noticed to start with:

a. The occurrence of Kankar (an accumulation of calcium carbonate in nodular form) is an important feature of the alluvial soils of the Punjab. It occurs in those tracts where a highly alkaline surface soil (another common feature in the province) is underlain by a fluctuating water-table containing calcium bicarbonate.

b. While the podzol profile is fairly well-developed in the wetter hills, the alluvial soils of the plains are of so recent an origin that a well-developed soil-profile is not present. However, due to the arid climatic conditions, certain characteristics are developed, chief of them being a high content of soluble salts, alkalinity and zones of deposition of calcium carbonate (kankar)

c. Last but most significant of all, the soils of many parts of West Punjab tend to contain sodium salts or are alkaline. The saline soil type, locally known as "Thur" is

(1) R.C.Hvon and M.L.Mehta "A Study of the Soil Profiles of the Punjab Plains with reference to their Natural Flora" Lahore, 1937
characterised by a high percentage of sodium salts and is permeable to water. In winter, a white efflorescence consisting of sodium sulphate, sodium chloride and small quantities of sodium carbonate appears at the surface over large areas. The alkaline soil, locally known as "Rakkar", is impermeable to water. Both these types are useless for agriculture unless specially treated and reclaimed.

Soil profiles of areas under Jand, Wan, Okan, Karai and grass (the principal vegetational species) were studied, the soil samples analysed physically and chemically and the following conclusion arrived at:

Soils where Jand is the principal natural flora growing under Doab conditions are good soils for cultivation although they are high in sodium salts and the water-table may rise too high. Kankar is generally present.

Wan soils are lighter than those under Jand and are apt to feel the shortage of water supply more severely, i.e. water-retentive capacity is low. They are suitable for general cropping.

Okan flourishes as well on saline soils as on others. The presence of this type should therefore indicate the necessity for the analysis of samples to determine salinity before any opinion can be given on agricultural possibilities. Even on a soil that is not excessively salty, it indicates a type less productive than that under Jand or Wan.
Karai is a common tree in "rakhs" (open plain forests) and generally indicates a soil that will produce indifferent crops when brought under irrigation on account of large sections of sand in the soil profile precluding normal movement of moisture.

Grass grows under a wide range of conditions so that it cannot be considered as a reliable indication of soil quality.

There are still large tracts under one or other type of vegetation and these conclusions can be a useful guide whenever their utilization is contemplated. This study also reveals the value of vegetation as an index of the quality of soil.

The problem of alkaline and salty lands is a fundamental one from the viewpoint of agriculture and will be treated in a later chapter.

**VEGETATION**

In the regions we are studying, the vegetation changes with climate from forest associations through transition zones of brush and small trees to grassland associations. It is proposed to establish types of vegetation from the ecological point of view as such a classification shall be useful in indicating the potentiality of land for crop production. The groupings adopted have been verified by personal observations.
and the principal species in each vegetation type have been mentioned mainly to facilitate their identification by a layman in the field.

The Role of Forests:-

The role of forests is mainly protective: they conserve soil and moisture. In climates marked by periods of intense drought and where torrential rains tend to strip the land of its productive top layer, their value to agriculture cannot be exaggerated. For irrigation works, they act as regulators of water supply. They have a beneficial influence on the water table which is kept fairly high under forest cover. In recent years there has been increasing realisation of their salutary effect on the climate and the following experiment in Algeria gives convincing proof that they help to improve the rainfall:-

"The Algerian Forest Research Service created 12 meteorological stations in 1915 in forested regions to study the climatology of forests as well as of special varieties of trees. Over a period of twenty years (1915-1935) comparisons were made with other stations situated in identical regions but away from forests. It was proved that the presence of an important forest cover tends to increase the average rainfall by a proportion which is of the order of 8%" (1)

Forests supply the domestic wants of human beings and in Barbary, many tribes subsist to a considerable extent

(1) E.C.M. "Algerie", "Les Forets" P.368
on the reserves of vegetation existing in forests. In West Punjab, more forests would make large amounts of cattle-dung which is burnt now as fuel, available as manure.

**The Role of Brush and Grasslands:**

They possess some of the valuable attributes of forests like the protection of soil from erosion and a more limited regulating influence on water supply. They have played a more important role as the habitat for large sections of the population which subsisted on them before the coming of irrigation. Vast tracts of such vegetation in the West Punjab doabs and the steppes and plains of Barbary supported nomadic tribes. The persistence of their tendency to clear the forests for an increasing population both of men and herds is at the root of soil erosion. Furthermore the whole outlook of these people, now practising irrigation agriculture in large tracts has been shaped by the grassland habitat the study of which is consequently of great interest.

**BARBARY**

The general impression one gets in travelling over the region is one of bareness, of the absence of well-preserved natural vegetation. This impression is somewhat misleading as there are still large reserves of forests particularly in the well-watered sections of the Atlas regions. Deforestation over several centuries, however, has reduced the vegetation
cover to a point where it is no longer adequate enough to preserve an equilibrium with agriculture. Before going into the human destruction of forests, it will be well to study their distribution in the light of natural conditions.

Apart from the principal factors affecting vegetation like relief, exposure, climate and soils, the nature of geological strata has a considerable influence on the distribution of forests. This influence is most noticeable in the Tell Atlas which has the typical immature mountain soils with the parent rock exercising its effect in a marked degree. As Semple has observed "Ancient forests have been more likely to persist on soils of disintegrated limestone and crystalline rocks especially when mingled with clay and on volcanic soils because they are retentive of moisture. The porous limestone soils which are very arid, when once deforested, never recover in the dry sections of the Mediterranean lands but deteriorate into a maquis".

The vegetation types adopted follow those of Shantz and Marbut (i) but have been modified greatly on the basis of more recent studies and observations in the field. On the whole, excepting the Middle and High Atlas ranges in Morocco, the vegetation decreases in quality from north to south and from east to west. This coincides with the distribution of rainfall. The principal forest types are as follows:-

(i) "The Vegetation and Soils of Africa", American Geographical Society, Research Series, No.13, 1923
1. The Wet Mediterranean Forest or Oak-Conifer Forest.
2. Mediterranean Scrub Forest or Temperate Brush
3. Dwarf-palm - Temperate grass
4. The Steppes

1. The Wet Mediterranean Forest or the Oak Conifer Forest

These forests occur on high land in those parts of the Atlas mountains which receive a rainfall of more than 20" and have a short drought period of 3-5 months. The principal varieties found are the lebanese cedar and the juniper trees at greater heights and the cork-oak, evergreen oak, the Portuguese oak and the Aleppo pine lower down. The distribution of individual species in gregarious stands depends upon soil, rainfall, temperature and altitude. It should be of interest to relate their occurrence to the natural environment.

The cork-oak forests are amongst the best defined, being limited to the regions of siliceous rocks (sandstone, gneiss etc.) with abundant rainfall and temperatures not subject to extremes. The soil type usually found associated with them is the podzol. They occur principally in the Numidian chain in eastern Algeria, and in northern Tunisia and northern Morocco. These forests are often dense with an impenetrable undergrowth. There are also some "drier" cork-oak forests of a less luxuriant nature in the Oran Tell and in the forest of Mamora in Morocco.
The humid plains of the Tell region contain ashes and elms while the mountain valleys exposed to fogs and oriented toward the sea support deciduous oaks (the Portuguese and Afaires oaks).

The evergreen oak is the most common species in Barbary excepting Tunisia. It occurs in Morocco in the Riff and in the Middle and High Atlas, between 2000 and 9000 feet occupying a third of forested land. Its occurrence and persistence over large areas here and in Algeria is due to its adaptability, its resistance to drought and to mutilation. A gnarled and more resistant species of it is found in the mountains of Aures and Hodna and the southern slope of the High Atlas, mixed with juniper trees in the more arid parts.

The Aleppo pine resists drought and heat to a still greater extent and covers the Biban chain, the Tablat Massif, the foot of Warsenis in Algeria, occurs in the Saharan Atlas, particularly in the Aures, as well as in the Tunisian dorsale but is rare in Morocco. This is the only tree in Barbary which is still expanding its area and is often used for afforestation. The "thuya" is a conifer which is resistant to drought but succumbs to cold. Hence it is restricted to the lower heights and is found widely in Morocco, Algeria and Tunisia. The junipers (particularly the red juniper) are the hardiest species of the lot and are found at both the extremes, in the hotter and drier parts of the Saharan and High Atlas as well as
Low coniferous forest in the mountains of Eastern Algeria. The land to the left has been cleared and cultivated.
Chir pines (Pinus Longifolia) in the Murree Hills. The Younger trees have been planted by the Soil Conservation Service. Mountainous landscape is dimly seen through the trees.
at greater heights.

Agricultural potential:- The principal crops which can flourish in this vegetation zone are olives and vine, especially at lower altitudes, temperate cereals - wheat, barley, oats; also maize, sorghum, tobacco and alfalfa.

The Mediterranean Scrub Forest or Temperate Brush

Occurring between the oak-conifer forest and the Mediterranean grasslands, it covers generally hilly land with a rainfall of 16" and over and a long drought period of 3 to 5 months. It is characterised by a dense growth of bushes and small trees which go under the popular name of maquis. The soils are brown with reddish sub-soils and although usually deficient in lime, are still productive of good cereal and fruit crops. This type of scrub forest covers a larger area than the forest proper, one reason for this being that this is the vegetation which replaces the climax vegetation once it has been destroyed. The trees found most often associated with these transitional associations are wild olive and lentick although where this type of vegetation becomes degraded, the jujube tree is found extensively.

Agricultural Potential:- This area has been used by man for grazing domestic animals although the brush is often too thick and the grasses too insignificant for good grazing land.

Under cultivation with or without irrigation, this region has become most productive. Vine, olives and temperate fruits - citrus, apricots, pears, peaches, plums and apples: vegetables and cereals are grown with success. Other potential crops include alfalfa and tobacco.

3. Dwarf-palm - Temperate Grass

This open grassland, often thickly overgrown with dwarf palm or with shrubs, occupies the low hills, valleys and plains of Barbary with a rainfall of 12-30" and a drought period lasting from 2-6 months. The soils are brown to red in colour with a calcareous sub-soil. Most of this region is now given over to agriculture. This vegetation region usually looks bare during the rest of the year but in spring there is a luxuriant growth of herbaceous plants. The jujube tree occurs fairly extensively over the region. These grasslands have long since formed the habitat for transhumant tribes but have now largely come under the plough through irrigation or dry-farming.

Agricultural potential:-

These regions are specially suitable for the production of cereals - wheat, barley, oats, rye, maize and sorghum. Commercial crops like tobacco and alfalfa can also be grown. Temperate fruits and vegetables flourish under irrigation.

4. The Steppes

This region includes most of the dry mountains and plateaux in Barbary with a rainfall of 8" to 16" and varies in
the aspect of its vegetation cover from the characteristic alfa cover of the High Plateaux to the argan forest of southwestern Morocco which is unique in the world. The alfa is a perennial grass which is remarkably resistant to drought. It grows in tufts and is useful for grazing camels, though it does not appear to please cattle. Sandy soils are occupied by a grass known as drinn which also forms excellent pasture for camels. The large salty expanses around the shotts support halophytic vegetation.

The largest area of steppes occurs in Algeria. Some of the alfa areas here represent the final stages of degradation of red juniper or Aleppo pine forests but others are true climatic communities. (1)

The argan tree covers over a million acres in Morocco and flourishes on the most inhospitable soils under conditions of extreme heat and drought in veritable communities. Apart from this, other trees are rare in the steppes, jujube being one which occurs sporadically.

Agricultural potential:- This region is essentially grazing land which can support a thin density of domestic animals. As the grasses persist even through the drought period, it is possible to graze animals throughout the year. Agriculture is impossible without irrigation.

Area covered by Forests:-

The forests cover a total area of about 20 million

(1) G.H.N.I.D. "Algeria" P.148
acres distributed as follows: Morocco 10 million acres
Algeria 7½ " "
Tunisia 2½ " "

In Morocco they occupy 16% of the non-desertic area. The lowest percentage of forest area is in Tunisia being 8% of the total and a much larger percentage is desirable as forests are essentially complementary to agriculture in terms of their influence on soil and water conservation. In Morocco too it has been advocated that the best advantage of the climate and hydrology of the country can be taken only if forests occupy up to 45 million acres\(^{(1)}\)(more than four and a half times their present area)

The Destruction of Forests:-

The vegetational cover of Barbary has been profoundly modified by man and extensive areas have been deforested with the passage of time. Viewing the signs of destruction and reading about past luxuriance of vegetation, French writers have often expanded on what they call "the Arab's hate of trees" and attributed the present bare landscape to the "atavism" of the Arab invaders and nomads. Present opinion is, however, becoming modified towards the conclusion that the large scale clearance of forest cover through the ages was a natural development under the existing mode of life - which was predominantly pastoral. The nomad's herds of animals, his need for fuel and shelter naturally used up reserves of forests

\(^{(1)}\) J.P. Challot "L'Homme et La Foret Marocaine" Revue des Eaux et Forêts. May 1946 P.238
in a region where "vegetation does not regenerate easily"(i) Forest fires must have been frequent in a land where the long summer drought renders vegetation easily combustible.

If we pursue the history of the destruction of the forest cover, the Roman epoch must have been the first period of large-scale deforestation to construct ships, to meet exports of timber as well as the requirement of colonists and townsmen. The time of Arab invasions and the subsequent centuries saw a steady reduction of forested land through the needs of a nomadic population, extension of cultivation as well as to meet the increasing consumption by large towns. Finally, even during French rule the destruction of forests has continued at an accelerated pace. "No region of North Africa has seen its forests retreat and its natural vegetation degraded as much as the Tell Atlas in Oran where colonisation has been most successful".(ii) And indeed the figures of the extent of forests in Algeria(iii) through the ages as recently calculated leave no doubt that the recent generations should have known better than to blame their predecessors - there were about 13,600,000 acres of forests before Muslim times, 9,880,000 acres in 1830 as compared to 7,400,000 acres today.

WEST PUNJAB

Except for parts of its wetter northern fringe, West Punjab is without any extensive forests and indeed, in the plain, hardly any vestige of natural vegetation has survived.

(i) Despois Op.Cit. 86
(ii) E.C.M. "Algerie" P.368
(iii) Ibid, P.85
The vast expanses of scrub-forest which used to cover the "bar" uplands between the rivers have been cleared for irrigated cultivation. In the Potwar plateau, the destruction of natural vegetation through deforestation and over-grazing has brought on the evil of soil erosion in its severest form. In general, the low percentage of forested land has rendered it necessary for peasants to burn dung as fuel rather than to utilize it as the valuable manure that it is. Thus of vegetation destroys the soil in some regions, deprives it of much-needed organic fertilizers in others.

The following forest types may be distinguished in West Punjab in relation to rainfall and other natural conditions:—

1. Himalayan Moist Temperate Forest
2. Himalayan Sub-Tropical Pine Forest
3. Sub-Tropical Dry Evergreen Forest
4. The Tropical Dry Deciduous Forest
5. The Semi-Arid Thorn Forest

Of these the first four are confined to the comparatively rainier and hilly northern mountains and sub-montane zone, including the Potwar Plateau while the plain has a single type of vegetation conforming to the monotony of the environment.

(1) This study of forest types is based largely on H.G.Champion Op.Cit.
Himalayan Chain known as the Murree Hills. Their distribution is a matter of altitude and rainfall. The moist temperate forest occurs above 5000 feet in a zone where rainfall exceeds 50" and consists predominantly of a tall coniferous forest with a rich evergreen undergrowth, mostly oaks. The forest is practically impassable due to the growth of luxurious herbaceous vegetation during the summer which provides good grazing. Podzolic soils occur in this zone. Pines and deodars are the principal species.

The Sub-tropical Pine Forest is an almost pure association of pine (generally pinis longifolia) occurring between 3000 and 6000 feet in a zone receiving a rainfall in excess of 35". There is practically no underwood and shrubs too are few, except when moisture conditions are favourable. A grassy cover is usual and provides a fairly good pastureland. From the agricultural point of view, rich crops of maize, wheat and even hill rice at lower slopes can be obtained with terracing. Temperate fruits flourish very well.

3. **Sub-Tropical Dry Evergreen Forest**

This is low forest of small-leaved evergreen trees and shrubs including thorny species, the latter becoming prevalent with drier conditions. This type of forest is usually associated with a rainfall of over 20" with some winter incidence of precipitation. During the monsoon there is a development of herbs and grass. This type of vegetation
occurs in the more elevated parts of the Potwar Plateau and on the Salt Range and bears a "fairly marked resemblance to the dry evergreen types of the Mediterranean".\(^{(1)}\)

The principal species are olive and phulai (acacia modesta). This vegetation zone has been largely deforested with consequent denudation of the soil.

4. Northern Tropical Dry Deciduous Forest

This type does not occur anywhere in the West Punjab as a continuous canopy as it has largely been cleared for cultivation. It now occurs in patches as riverain "shosham" forests or scrub and consists of deciduous trees with a thin shrubby undergrowth including some evergreen xerophytic species. The region of its occurrence has a rainfall of 30" or more and the contrast between the bare, leafless trees in the dry summer and the luxurious growth during the monsoon is a striking feature. The principal botanic species are Acacia catechu and Shorea robusta. This zone provides some of the finest agricultural lands of the province.

5. The Semi-Arid Thorn Forest

Occurring in the zone receiving 10" to 30" of rain, this is an open low forest in which thorny hardwood predominate, acacia being particularly characteristic. There is a thorny bushy undergrowth while climbers are numerous, all displaying xerophytic adaptations. There is a thin grass growth which

\(^{(1)}\) Ibid P.211
may be considerable in inundated tracts. The forest covers the larger part of the West Punjab plain and the lower hills of the Salt range.

The type prevalent in the arid tract in the south-west and in the Thal may be called the "desert thorn forest" with a still more widely spaced tree cover. The principal tree-types found in those two thorn-forest zones are Jand (Prosopis spiligera), Wan (Salvadore Oleoides), Okan (Tamarix Articulata) and Karai (Capparis aphylla).

It is in these zones that irrigated forest plantations have been set up, the best known being those of Chhanga Manga and Chirchawatni. Their object is to satisfy the fuel requirements of the population.

Extent of Forests:

Nominally, the area classified as forests covers over 1,150,000 acres in West Punjab but the majority of the "forest reserves" in the plains are nothing more than wasteland covered with stunted trees and bushes or merely coarse grasses. The best-preserved forests occur in the north-western hilly tracts and in the government plantations. The destruction of the West Punjab forests is a sad story inscribed in the countless bleak gullies and ravines in the Potwar region as well as elsewhere and will be treated in detail on the chapter on Erosion.
Chapter 6

THE CORRELATION OF PHYSICAL FACTORS

The several physical factors considered so far may now be integrated and some conclusions may be drawn in relation to cultivation. The most fundamental relationship is the one between aridity on one hand and natural vegetation and agriculture on the other. The aridity line of 5 in both regions approximates to the limit of desert vegetation - desert shrub in Barbary and desert thorn forest in West Punjab. Making an allowance for areas with high coastal humidity, the distribution of dwarf palm - temperate grass in Barbary agrees with the limits of the indices of 10 and 20. Wherever the index of aridity exceeds 20, temperate brush predominates. The productive capacity of these various zones of vegetation was indicated earlier. In West Punjab too, the distribution of vegetation zones approximates closely to the various indices of aridity. Thus Himalayan coniferous forests occur where the index exceeds 30, while the dry deciduous forest is confined to the sub-montane tract where the index of aridity is more than 20. The Potwar Plateau has its own Mediterranean type of vegetation. The gradations in the vegetation zones of the two regions thus agree closely with the degree of aridity. The relationship between the soil, vegetation and climate was pointed out before.

Index of Aridity and Variability of Rainfall: - In both Barbary and West Punjab, the average variability of rainfall increases with aridity. Thus in Algeria, the percentage variability is below 15 wherever the index of aridity exceeds 30. In the west, over the Shelif valley, where the index is below 15, variability increases to over 25%. The intermediate figures and the figures

* See p. 4 of text.
The Natural Zones of Barbary

Limits of Crops in Barbary

(After Delage, l'Afrique du Nord, 1904)
for the drier parts show the same relationship as a comparison of the Maps of Index of Aridity and Variability of Rainfall show. Except for Rawalpindi district, variability in West Punjab increases towards the south-west exceeding 40% where the index of aridity is round about 5.

**Critical Limits**

With its comparative uniformity of physical conditions, West Punjab does not have many critical limits to the extent of cultivation. The most serious limitation, that of moisture has been largely offset by the development of irrigation. The only uncultivable parts of the province now are:

(a) Regions beyond the reach of irrigation - parts of the Thal and Derajat tracts, the Salt Range.
(b) Eroded, water-logged or saline lands whose distribution is dependent on human factors as much as on natural ones.

**Barbary** on the other hand presents a greater variety of conditions and critical limits based essentially on climate may be applied.

(i) Despois has demonstrated how topographic, climatic, vegetal and even hydrographic features in the region change at the frontier between the Tell zone and the Steppes, a factor reflected in the distribution of cereals and the limits of olives and the date-palm, the last marking the passage to the Sahara. The choice of these old-established crops is significant because they conform much more to the habitat than other crops developed by European colonists.

The following generalisations may be made on the basis of these limits:

1. The isohyet of 16" marks the passage from the Tell to the

(i) Op. Cit. p.97 - 110
steppes and also coincides in Algeria and Tunisia to the Northern limit of inland drainage and of alfa grass. It also forms the limit of the profitable cultivation of cereals in these territories. The only exceptions to the latter rule are the lower plains of western Algeria and the plateau of Sersou. Here cereals do not give good yields without irrigation or dry farming. The lower precipitation of the southern part of the Atlantic plains in Morocco is offset by high humidity as already explained under Climate and the zone of profitable cereal cultivation is extended to the isohyet of 12".

2. The Isohyet of 8" follows very closely the southern edge of the Saharan Atlas and also agrees with the northern limit of the date-palms(1) as well as the southern limit of the olive in Tunisia.

3. The principal areas irrigated in the traditional manner lie in the semi-arid zone receiving a rainfall between 8" and 16". A map of land available for cultivation in Barbary has been drawn, based largely on physical factors.

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(1) The date-palm plantation around Marrakesh is an exception but it was created artificially with the help of khettaras. The quality of the dates is indifferent.
To understand the present it is necessary to make a historical survey of foreign cultural influences. Since prehistoric times the human element in our two regions has been greatly modified by successive migrations and occupation from outside so that the present-day rural life reflects the extent to which these invaders modified the existing civilization. The primary objective of this account is to trace the origins of current agricultural practices and systems of farming. Allied to that and, indeed, inseparable from all practical aspects of life is the mental make-up of the people or their cultural outlook and ideals as determined by the same influences. This is essentially a geographical concept - to trace back the influence of other environments as transported by the conquering peoples.

BARBARY

Belonging to the Mediterranean Basin in which developed some of the earliest and greatest civilizations of the world, Barbary itself has made no outstanding contribution to the progress of culture. It has always depended upon foreign stimuli to keep pace with world developments and even these foreign colonists and empire builders have in the course of time succumbed to the "vast inertia" of the region and fallen back to its own primitive ways. Great cultures - Phoenician,

Greek, Roman - have lighted their torch in its dark and dreary wilderness, shone resplendently for a time and then flickered out leaving very often nothing more than a few imposing ruins. Only the Arab, or strictly speaking the Islamic influence, penetrated the thick hide of Barbary's passivity and continues to this day as the leading light of the region.

It is difficult to explain this local genius in terms of geographical determinism. Greece or Rome, which rose to such heights of culture, had the same rugged relief and difficulty of communications even though their climate was not so arid. Perhaps the proximity of the Sahara close behind the well-watered coastal lands had something to do with this fact but again Arabia with a similar environment produced a dynamic culture which has left a lasting imprint on mankind. We can only regard Barbary's barrenness in human achievement as one of those numerous facts of history which remain at present unexplained.

The pre-historic epoch can be briefly passed over. The most significant period was the Neolithic when a white people, probably a branch of the Mediterranean race occupied the region at the expense of its black negroid inhabitants. (1) This period was marked by the domestication of animals and the cultivation of cereals on a small scale.

The Phoenician occupation of Barbary was the first historical event of which a record exists and lasted approximately from 1200 B.C. to the 2nd century before Christ. The city of

Carthage near the present site of Tunis was the most famous settlement of this epoch. A large part of north-eastern Tunisia was cultivated and irrigation by canals practised. But the Phoenicians, being essentially maritime traders, did not penetrate deeply into the country. The planting of vines and olives grew considerably and some vassal and allied chiefs developed the cultivation of cereals in the interior. The High Plains of Constantine, for example, became a cereal growing region of great importance.

The Romans who followed the Phoenicians after the Punic Wars did not reach their greatest expansion till the first century A.D. and remained in occupation up till the Vandal incursion in early 5th century. It was under them that Barbary acquired its reputation as an agricultural region of importance and came to be known as the granary of Rome. Effective occupation by the Romans was limited to the Tell Atlas although in the eastern section the two provinces of Africa Proconsular and Numidia extended right up to the Sahara. In these latter regions, impressive remains of large and well-planned cities are encountered. Ruins of oil presses and irrigation works occur in regions which are now barren steppes. We make as an example the numerous ancient reservoirs around Tebessa some of which have been cleared of the debris accumulated in centuries and brought into active use again. Sbeitla in southern Tunisia is yet another instance where occur ingenious constructions of stone walls which served the
dual purpose of conserving soil and water. (i) These signs of ancient prosperity led to the widespread assumption that the arid southern steppes of Tunisia and Algeria once had a better climate. This idea has been refuted by most climatologists, however, and the only conclusion we can draw is that irrigation and dry farming reached a high state of perfection during Roman times. These great works of irrigation as well as the advanced agricultural practices did not survive the Vandal onslaughts and Barbary sank back into its primitive ways.

The Arab conquest during the 7th and 8th centuries opened up another epoch of great cultural advance, for these invaders brought with them not only a new faith but also a host of new ideas collected from their rapidly increasing empire. Irrigation practices prevalent in Persia (khettaras - see chapter on Irrigation), Egypt and Mesopotamia were introduced. New crops brought from the East included rice, sugar cane, cotton, oranges, apricot, indigo, henna, saffron, most of them grown with irrigation. Oasis-cultivation and date palm plantations were extended. This was also the epoch when many large cities were founded, later to become the main bulwarks of culture and also to wield a considerable influence on the nature of cultivation and land-utilisation through the

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(ii) Notably Fes, Tlemcen, Kairwan
great demand for garden and vegetable crops. The later invasion by large nomadic Arab tribes, notably the Beni Hilal and Beni Solaym provided a set-back to agriculture and a large part of the Algerian High Plains became a land devoted to pastoral nomadism. The harmful effects of these invasions on agriculture have been over-emphasised for many of the descendants of the Beni Hilal later took to sedentary cultivation notably in Morocco. The Islamic influence penetrated deep into the life of the local inhabitants and Arabic became the leading language. The Arab invaders were different from previous ones in that they were not merely concerned with conquering and exploiting new lands, but came with a missionary spirit, offering equality and brotherhood to all. Hence their culture became the culture of most of the inhabitants of Barbary.

The introduction of Islamic property laws was a significant development, one which has had a far-reaching influence on agriculture up till today. Particularly to be mentioned are the habous lands, dedicated to a religious purpose. The Islamic property regime is discussed in the following chapter.

Later developments during the Islamic epoch included the arrival of a large number of Muslims from Spain where their domination was coming to an end. As they had perfected the art of irrigated cultivation of fruit crops in Spain, they had a significant contribution to make to the make up of the
rural population. They brought with them many of the crops
grown in the New World, chief among them being maize, tobacco,
tomatoes, pumpkins and many types of beans. Their descendants
known as the "Andalous", are considered to be the best market-
gardeners and cultivators in Barbary.

At the beginning of the 16th century, a large part of
Barbary became incorporated in the Turkish Empire. The epoch is
not a memorable one except for the harshness of taxation on
the land, rendered far worse by the practice of "farming" the
revenue through extortionist agents. Lack of security over a
major part of the country resulted in the extension of nomadism.
The struggles between neighbouring chiefs and tribes always had
the effect of impoverishing the countryside, the more mobile
nomadic groups establishing their overlordship over the sedentary
cultivators.

This was the state of affairs when the French conquered
Algeria in 1830. The most notable development during their
domination has been the development of European colonisation.
A large part of the fertile regions of Barbary has gradually
been acquired through official or private enterprise. Marshes
have been cleared notably those in the Mitija and Bone regions
and cultivation extended over formerly untilled land, but the
major part of the lands now owned by Europeans were formerly
occupied by the Muslim peasants (fellahs). The state has backed
and financed the colonists with all its resources so that today
mechanised cultivation has reached as high a standard as anywhere else in the world. Modern scientific research has improved crop varieties. Production has gone up on the whole but its distribution among the population is most unequal, the colonists sharing most of the newly developed prosperity. Cultivation of cash crops like vine, citrus fruits and early vegetables has been greatly extended to meet the requirements of France and other world markets. Among the livestock, pigs have begun to figure. There has been great development of irrigation works and transport services.

The modern techniques used by the colonists have not been copied except by a limited number of large Muslim landlords. The French Government followed a policy of building up the prestige and power of local notables to support their policies. This has further reduced the independent status of the petty fellah. The effects of French colonisation will be further considered in the following chapter as also their modification of Property laws.

The development of transport and commerce has brought about the linking up of Barbary with the world's agricultural economy so that it is no longer a self-contained subsistence unit but adjusts its production to world trends. The French administration has thus introduced into Barbary most of the technological developments of the western world. But their culture has failed to penetrate deeply into the life of a thoroughly Islamised people. Indeed as a French writer has
observed "For all the influence of Europe to which Algeria and Tunisia have been exposed, it would be wrong to imagine that the powers of Islam have considerably weakened in French North Africa"

Our insistence on the lasting influence of Islam would not be relevant unless it had a direct bearing on the agriculture of the region. Islam engenders among its followers an attitude to life that has puzzled Europeans who look upon it as fatalism, hindering, in their opinion, all enterprise or progress. But the attitude of the Muslim is not based on fatalism, rather on fortitude in the face of a capricious climate. That he is not averse to progress will be noticed in a later chapter. The main results of the peasant's being steeped in religion are:

(a) He refuses to cultivate certain crops that are forbidden. Vines were not grown except on a very small scale for eating purposes because wine-drinking is not allowed. Thus the present strides in vine-cultivation would not have been possible but for the Europeans. He would also have nothing to do with keeping pigs.

(b) His attitude to advanced techniques continues to be that of suspicion and even hostility as they have been brought by a conquering race. The Barbary Muslim is proud of his traditions and much of his conservatism is caused by his antipathy to the superior attitude of French administrators and colonists.

Summing up, we may quote the opinion of an enlightened Muslim landowner of Morocco on the nature of foreign cultural influences "It is necessary to enquire as to why all traces of Latin culture disappeared entirely in these regions while the Arab culture has survived and even prospered. The answer to this question is very simple - Rome interested herself in North Africa itself, in its plains, its fertility and its richness without concerning itself with the inhabitants, whereas Mecca appealed directly to the man and his heart" (1) The dynamic spirit of Islam has not survived the centuries though its cultural influence is a basic human factor to be considered with relation to all social and economic activity. This persistence of the Islamic manner of life (though, unhappily, not its spirit of enterprise) prove that unless a foreign power applies its energies to the betterment of the peoples its influence cannot endure for the land soon returns to its natural state once they quit and men continue as before. The present effects of French domination are closely comparable to those of Roman occupation. Land has been colonised, irrigation works developed and transport and communications developed, but, on the social plane, the only opportunity offered to the Muslim inhabitants is to quit their own culture and laws and become French citizens. This they will never do and so it would appear that unless there is a radical change in the French attitude, their influence on

the civilization of Barbary will not prove to be enduring.

WEST PUNJAB

The historical record of the province goes back beyond 2000 B.C. when the Indus Valley civilization flourished, and has left its remains at Harappa, near Montgomery. Since then its peculiar position at the very gateway of the fertile Indian sub-continent made it a battleground on which wave after wave of invaders contended for the riches of the vast land-mass. The remarkable fact is — and here lies the close parallel to Barbary — that although Islam did not appear on the scene till after 700 A.D., its influence alone has proved to be enduring and has ultimately prevailed. The region was introduced to western science and technology and brought into line with the rest of the world by a western power — in this case Great Britain.

The cultivation of cereals was carried on during the days of the Indus Valley civilization and possibly even earlier. The Aryans invaded the country sometimes between 1000 and 500 B.C. and this province was the first to be occupied. The Aryans established a patriarchal system and carried on sedentary cultivation with cereals as the principal crops. The later introduction of the caste-system with its consequent division of society into four classes — priestly, martial, agricultural and trading, and lastly menial — had an influence on the social and economic edifice that is still noticeable today. On one hand it resulted in the development of hereditary skill but on the other
it rendered society inelastic, hindered progress by erecting artificial barriers between men and restricting them to only one occupation. Later vitiation of the caste-system had its repercussions on rural life principally by relegating the actual tillers of the soil to a low social position and developing a large idle aristocracy. A salutary development was the growth of the village into a self-contained unit, governed by the elected group of elders or the panchayat.

We should remember, however, that the cradle of the Aryan civilization lay to the east in the Ganges valley wherein all the institutions associated with the Hindu civilization reached their greatest development. West Punjab lay on the outskirts of the sub-continent and bore the full brunt of a ceaseless stream of invaders— from the 5th century B.C. nomad races from central Asia descended on the province through the north-western passes and settled down in sufficient numbers to occupy large areas. Prominent among them were Scythians (from whom present day Gakhars are descended), Parthians, Kushans, Huns etc. These conquering groups retained their tribal organisation and were hardly affected by Brahmanical Hinduism. Later on, most of their descendants accepted Islam and became its hard core, finding its militant spirit and its simple ritual much to their liking. Most of the great West Punjab tribes of today are descended from these groups and so are the major agricultural classes. Those of these tribes who retained.

(1) H.K. Trevaskis "The Land of Five Rivers" P.76
their pastoral habits longest and, for a long time, continued to graze their cattle in the jungle prairies of the inter-riverain lands acquired or retained the name of Gujars. But the great mass of the tribes who took more readily to agriculture were called Jats (1). The latter became par excellence the peasant of the Punjab and have continued to be the finest cultivators of the province till today.

The first Islamic invasion of the region followed the Arab conquest of Sind early in the 8th century A.D. and an Arab state flourished in Multan for several generations. At the beginning of the 11th century began the Muslim invasions from the north-west which soon resulted in the establishment of Islamic dominion over the province. West Punjab was thus the first region on the Indian sub-continent to be Islamised. There were contacts between the new invaders and the Hindus but never any fusion. Islam was too individualistic, too militant, too well-defined a creed to be absorbed in a philosophy that had hitherto succeeded in incorporating most conquerers into its fold. Subsistance cultivation continued at the same level during the rule of succeeding Muslim dynasties. Cotton was widely grown. Irrigation must have developed early in West Punjab though no records are available. It was a Mughal governor who constructed the Hasli canal from the Ravi River to irrigate the Shalimar Gardens near Lahore - the canal which was the origin of the Upper Bari Doab Canal. A significant irrigation development was the introduction of the Persian

(1) Ibid
wheel. The legacy of Islam cannot be defined in terms of countable items alone. The whole outlook and life of the people was transformed by this creed to such an extent that recently Punjab became the nerve-centre of the Pakistan movement which has resulted in the establishment of a separate Islamic state. Even agriculturally, because of the extensive trade relations of the sub-continent under Muslim emperors, many new varieties of crops must have been imported of which no exact record is yet available. As for the human side of agriculture the village continued to function as a self-contained unit. Land was cultivated by small holders, large capital farmers being absent. The practice of "farming" the revenues which often prevailed discouraged agriculture. The administration of rural areas was in general confined to maintaining peace and collecting land revenue.

The decay of Islamic power during the 18th and 19th centuries resulted in a period of Sikh domination, quite unremarkable in its lasting effects on the agricultural and general life of the area. The British conquest of the province in 1856, however, set into motion those great developments in irrigation, transport and administration which have transformed the rural landscape. Although the introduction of these modern techniques was inevitable at some stage, their growth took place under specially favourable circumstances and was accomplished with remarkable speed and smoothness. The development of internal transport and external trade brought about the growth into importance of commercial crops like cotton, sugar-cane etc.
The total area under crops was extended greatly through irrigation. The organisation of agricultural research, the development of new varieties of crops had the effect of raising yields and total production.

On the human side the control of diseases and of famines both resulted in a great increase in population, further stimulated by the prosperity brought by the canals. Despite the great extension of cultivated area, this has ultimately had the effect of increasing pressure on the land. British policy which encouraged the growth of landlords "set into motion processes which were neither intended nor foreseen" (i) It weakened the autonomous village unit. The landlords became mere rent receivers playing a small part in the agricultural partnership. Furthermore their tendency to move to the towns has resulted in the drain of rural wealth to urban areas.

The development of large-scale industries has had the effect of depriving the village communities of the income they received from cottage industries, thus increasing the pressure on the soil. The total effect of these tendencies has been that "the greater output has to be divided amongst greater numbers and has probably been accompanied by greater inequality of distribution" (ii)

Despite the growth of communications and trade and the development of landlordism "the village, placed in its ancient organic, social setting, is definitely holding its own" (iii)

(i) L.S.S. O'Malley "Modern India and the West" London 1941 P.234
(ii) Ibid P.290
(iii) Radhakamal Mukerjee "Economic Problems of Modern India" Vol. 1 P.103
The strong tribal affiliations still prevalent in many parts of the province have maintained its status as a self-contained agricultural community. Even large scale settlement in the newly irrigated canal colonies had to be based on village or tribal groups unified by strong ancestral ties.

Since the coming of Independence in 1947 and the establishment of a government that is bound to be guided largely by Islamic ideals, great changes have taken place. The mass movement of population on partition has made the former Muslim majority of about 70% into an exclusive element there being only a few thousand Hindus left. This has reduced considerably the extent of the Hindu element in the present social and economic make-up. The arrival of millions of destitute refugees from East Punjab has necessitated the breaking up of many large estates formerly owned by Hindu and Sikh landlords into small allotments. The government has recently announced its intention of nationalising the land with the object of abolishing landlordism altogether though it is doubtful whether this shall be achieved very soon. A vast programme of rural uplift and development is taking shape which, if put into effect, should greatly improve the lot of the peasant. The exclusively Muslim population is increasing very fast however, and no rural planning can ultimately be effective unless this tendency is checked through educating the masses.

In conclusion it is noticeable how the population, its outlook and its ideals have been dominated by Islam. Most present-day planning, even if influenced by western or Soviet
practices, claims to be Islamic in inspiration and it is
certainly true that no projects can succeed among a heterogeneous
people consisting of so many tribal and racial elements unless
they appeal to their strongest and deepest loyalty - the one to
religion. The western influence has been mainly technological
and administrative and has little disturbed the main currents
of rural life or the methods of cultivation.
Chapter 8

THE REGIME OF LANDED PROPERTY, TENURES AND HOLDINGS

After the brief survey of historical influences which have determined the present day farming methods and crops, we may proceed to enquire into the regime of the ownership of land, the prevailing systems of tenures and the size and distribution of holdings. The importance of these aspects of man's relationship to land can hardly be over-emphasised because they integrate on one hand the physical social and historical factors behind the land and on the other exert a far-reaching influence on the amount of human initiative and energy expended on its cultivation.

That ownership of land and the tenancy systems respond to the environment will be noticed subsequently both in Barbary and West Punjab. They are related more directly, however, to the social judicial organisation of the rural population. In this the influence of Islam needs to be considered specially. The history of French modification of property laws in Barbary has been one of continuous conflict with a system which they found to their bewilderment and annoyance to be rooted in religion itself so that interference on their part struck at the very root of the entire social and economic organisation of the population, based as it was, essentially on the Koran. This history will be surveyed in brief at a later stage in this chapter. In West Punjab, the role of Islam as a factor in determining man's relation with land has been equally powerful though several
existing features date back to the pre-Islamic days. The influence of religion in governing the size of individual holdings is even more powerful and is at the root of one of the greatest problems of agriculture in both regions – the problem of the small-holding.

It is proposed in the following account to consider the regime of landownership, land-tenures and agricultural holdings of our two regions side by side, to draw comparisons and contrast between them in relation to the geographical environment and to consider the influence of these socio-economic factors on crop production. The history of French modification of the property regime in Barbary comes in for some discussion as under the influence of a number of conflicting colonial policies, this interference produced a dual regime – one traditional and Islamic, the other western and French. Such an historical survey of the land regime in West Punjab is hardly called for as the British administrators did not affect any considerable changes in the existing regime but only perfected and clarified it.

THE REGIME OF OWNERSHIP OF LAND

An element of collectivity dating back to the days when tribal organisation was still a dominating force persists in Barbary and West Punjab, much more in the former as the change to individual ownership is not complete. For this the importance of pastoral pursuits on the modes of life is
greatly responsible as will be noticed in a later chapter. Collectivity has survived in West Punjab chiefly in the shape of common pastures in villages known as shamilat. This is further indicative of the role of pastoralism in maintaining a collective property regime. Individual ownership is associated with sedentary cultivation, more especially with irrigation. The influence of Islam has been to emphasise the distinction between private ownership and the common (unproductive) lands. The one special institution introduced during the Islamic epoch was "habous" or "waqf" by which landed or other property could be willed to some charitable body in perpetuity. The area of such lands is much greater in Barbary than in West Punjab, less due to a greater devotion to charity than to an anxiety to safeguard property under conditions of greater insecurity and chronic internal chaos than subsisted in West Punjab. The latter land has by no means been peaceful and it is probable that historical or social factors unknown to the present writer have been responsible for the comparatively minor importance of habous or waqf lands in this region.

The last category in Barbary, for which West Punjab does not have an exact counterpart is state or Makhzen lands. The Crown Waste Lands of West Punjab correspond to the undeveloped and, at present, unproductive part of the Makhzen lands and have been used for irrigated settlement with the
extension of the Canal system. They have also been utilised to reward military and civil service to the state of the yeoman grants in the Canal Colonies. The Makhzen lands of Barbary are however more than this. Parts of them constitute the private domains of the Sultan of Morocco and the Bey of Tunis and these figureheads are peculiar to Barbary.

Despite the differences in relative importance of the types of landed property, differences that are in the case of collective lands indicative of the greater degree of aridity and the predominance of mountainous relief in Barbary, the similarity in the fundamental features is striking. This is a parallel that is specially significant for this study as it brings out the thesis that in spite of their great distance from each other and contrasted relief, similarities in the degree of aridity and a comparable cultural background lead to similar features of land-use and give rise to agricultural problems that are basically identical.

BARBARY

We may now proceed to study the traditional modes of landownership as they exist today in their modified form, followed by an historical account of the modifications introduced by the French.

The following types of ownership go back to the

(1) See account of settlement of the Canal Colonies under Irrigation.
pre-French times:

1. The "Melk" lands are those that are owned individually under Islamic law or "Sharia" and are under the jurisdiction of Islamic courts. A peculiar feature about this type in Barbary is that whereas Islamic law upholds the division of property in equal shares among the offspring of a family, "melk" lands have remained indivisible, possibly under the influence of custom. The effect on agriculture is disastrous because on one hand the individual portions of the collective holding become progressively smaller and on the other there is no inducement to apply initiative and energy. The acquisition of additional land by a more efficient landholder is often out of the question as no sales are possible without the consent of the entire family. Cases are not rare where as many as ten families may be depending upon the holding which two generations earlier was supporting only one. A large proportion of lands in the fertile parts of Barbary is included under this category and they will perhaps continue to exist as Islamic law on which they are based is sacrosanct in the eyes of people. The French administration has recognised in essence the validity of this system but have introduced certain features to render it more precise. In Morocco for example, the individual property is confirmed after the proprietor has submitted a statement known
as "Istimrar-el-melk" setting out his title to the lands in question.

2. Collective lands, referred to in local parlance as "arsh" lands are those to which groups like tribes, clans or "dwars" (villages or hamlets) have a collective right. They may be cultivated lands or rough pastures and their boundaries are not demarcated as clearly as those of melk lands being very often small local streams or other natural features like crests etc. They are managed by the representatives (Jemaa) of the group which owns them and are supervised by the government. French colonisation has made deep inroads into this type of collective property because very often there was no written title, only a sort of "gentleman's agreement" between neighbouring tribes. Extensive acquisitions have been made and covered by adequate safeguards to render them secure which in most cases have taken the shape of their being registered under French law. Provision has also been made in Morocco for collective lands being rented out for periods of ten years or in perpetuity at the payment of an annual rent.

3. Makhzen Lands: They exist under this head mainly in Morocco and Tunisia and include all properties which were deemed to belong to the state before the establishment of the

(i) J.Rey, "La Propriété Immobilière", "E.C.M.Maroc"
(ii) Ibid, p.217
Protectorate. The state lands in Algeria (beyliks) were abolished immediately after the establishment of French suzerainty in 1830 along with the habous lands. These lands in the Protectorates include the "dead"(i) or waste lands, the lands acquired by the rulers, the properties falling to the state for the lack of heirs and finally lands confiscated from rebelling subjects or tribes. The rulers considered these lands to be his own personal property and made grants to those who deserved well of him. These grants were of two types in Morocco. One came to an end with the death of the incumbent ("Intifaa") while the other ("Iqta'a") could be transmitted to one's descendants. The latter was the origin of numerous large "melk" holdings to be found today in Morocco.

The Sultans of Morocco also used to allot "guich" lands to certain warlike tribes like the Wdaia, Sherarda etc. collectively in return for military service. These tribes then divided such lands equally among families. Jean Celerier has made a study of the changed régime of property-holding and the progress towards individual ownership due to colonisation in one of these tribes, the Sherarda which we shall study later on when we treat recent developments.

(i) French jurists point out that "dead" lands are those under Islamic law which are unproductive and they become the property of anyone who brings them under the plough.

The French administration has, since its foundation, regulated the affairs of these lands so that the private property of the State has been separated from the public property and the latter organised under the Public Works Department (Administration des Travaux Publics).

Extensive State lands that existed in Tunisia before the establishment of the Protectorate have been similarly divided into the private and public categories. Here as well as in Morocco the right of the enterprising cultivator to own the "dead" land he brings under the plough has been upheld.

4. Habous Lands: "Habous" or "wakf" is an act in Islamic law by which the owner of a property wills it in perpetuity either to a pious or charitable foundation ("habous khairi") or to a family or group of persons ("habous adi or ahili"). It is the perpetual and inalienable nature of this type of lands supported by a strong religious sentiment which is their special feature, a feature which tempted so many persons to put their lands into this category to save them from the unstable political régime as well as from the prodigality of their descendants.

The twofold division of the habous does not affect their judicial position or the validity of the bequest; the distinction is only in manner of their administration. (i)

(i) Mohammad Saadallah "Les Habous". E.C.M. "Tunisie" P.204.
There is only a slight difference in their management in Morocco and Tunisia, the two countries where they exist today. The public habous are looked after in Tunisia by a Director of the Administration of the Habous helped by a Council of Administration consisting of five Muslim notables. The various acts of this administration are subject to the control of the Supreme Council presided over by a Minister of the Bey. Individual habous are supervised by local bodies known as Jemââa. In Morocco the care of public habous is entrusted to Nadirs or failing that, they are managed by the local Qadi, both being ultimately under the administration of the Sultan. The extensive properties of the public habous which consist of olive orchards, cultivable lands etc. are let out to tenants under the prevailing systems of tenures as also some special ones we shall note later on.

The private habous are looked after in Tunisia by a makaddam named by the founder or otherwise by the Qadi. In Morocco they are managed by the beneficiaries themselves under the surveillance of the Qadi.

The exact area of the Habous lands cannot be calculated as statistics are imperfect and also take into account the buildings, shops etc. similarly dedicated. That their extent is considerable may be gauged by the large size of the habous administrations (over 450 officers and subordinates in Tunisia alone.) In Algeria, where the public habous
were abolished by the French immediately after their conquest, "half of the melk lands were habous" (i) at that time. The private habous were later declared alienable and have been reduced to negligible proportions.

Various safeguards exist today in Tunisia and Morocco to protect these properties which cannot be sold or exchanged unless they are replaced by a property of equal or higher value. The habous lands serve a useful purpose in that they help to maintain many social services and charitable institutions, schools, orphanages etc. They are usually cultivated in the manner typical of the the districts in which they are situated, although some collective habous are largely under olives, i.e. in Northern Tunisia.

One great advantage of their legal position has not been exploited fully - the fact that they can be used for experimentation with new crops and techniques which would be more difficult to achieve with individual proprietors. There are sporadic instances of their being managed in conformity with modern agricultural trends. In Tunisia, for instance, over 1400 acres of habous lands were planted with citrus fruits in 1940 in the Cap Bon Region, (ii) an area in which fruit-growing is proving to be the most remunerative mode of cultivation.

(ii) Mohammad Saadallah, Op-Cit. P.206.
THE FRENCH LAND POLICY IN BARBARY

The history of French land policy in Barbary commences with the disastrous handling of the traditional regime in Algeria, first to be conquered. Experience that was gained here through trial and error and with consequences wholly tragic for the local population, later benefitted the two neighbouring territories where the established system received a more sympathetic and imaginative handling. While the contradictions and changes of French colonial theory have much to do with the development of a land policy, it has been the drive for settling European colonists in Barbary which has always dominated its main trends. Algeria was conquered and colonized during a phase when the idea of establishing a new France overseas had become a governing principle.(i) By the time Tunisia and Morocco were incorporated into the French Empire a colonial philosophy based on "colonies d'exploitation" rather than "colonies de peuplement" had emerged so that these territories which were made into Protectorates retained their traditional regime largely unchanged.

Right from 1830, the conflict between the interests of the settlers and the Arabo-Berber population presented the administration with its greatest problems in Algeria. The colonists wanted land with security of possession before they embarked on any work on its cultivation. On the other hand, the native population clung tenaciously to its land whose overweening importance among a primitive society was increased by the sacrosanct dictates of religion (1) which determined the regime of ownership. The root of the difficulty lay in the fact that most of the land was owned collectively by tribes. The administration sought to apply French ideas of individual ownership and legal transfers to the country and in doing so played havoc with the traditional system as well as all those whose lives depended upon it.

The Beginnings: - In 1830, on the eve of conquest, all habous and state lands (beyliks) were expropriated. Apart from this step which caused great resentment among the local population, the government did not feel the necessity of bringing about any modification in the property regime.

(1) Ibid p.196.
Inaction was confined to ensuring security of tenure for the colonists. Thus the Ordinance of 1844 confined itself to regulating the expropriation of land and validating the sale of habous land. The law of 1846 recognised the "anarchical state of rural property" and laid down that unless claims to ownership of land in areas earmarked for colonization were forthcoming within a certain period, all land would be deemed vacant and available for colonization. The law of 1851 guaranteed the right of property to all private owners whether Europeans or natives. It also warned off capitalists from lands not open for colonization. This was a recognition of the difficulties inherent in dealing with tribally held lands.

The policy of "Cantonnement" (restricting tribes to limited areas) 1851 - 1853: About this time the increasing influx of colonists led to new measures for acquiring land from the native population. There were three types of landed property then existing in the country:

(1) **Makhzen** - state lands which had been granted to tribes by the Turkish rulers in return for military service.

(2) **Aròh** or tribal communal lands.

(3) **Melk**.

The first category was expropriated on the ground

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(1) V. Piquet "La Colonisation Francaise dans l'Afrique du Nord" P.150
that it had never ceased to be the domain of the state. The second one was encroached upon because "it was maintained that according to the Koran, such land in Muslim countries belongs entirely to the sovereign and the individual has only the right of occupancy." The policy of restricting tribes to areas necessary for their sustenance and making the rest available for colonization was therefore instituted. This was essentially humane in its application and left the tribes with enough land to carry on their activity without undue difficulty. Thus between 1857 and 1863, the territory of 16 tribes covering 343,000 hectares was divided and of this they retained 282,000 hectares. They were stripped, however, of their best lands.

"The Arab Kingdom episode": With the accession to power of Emperor Napoleon III, a phase of marked liberalism set in. In a celebrated letter to the Governor General of Algeria in 1863 he declared that he wanted to convince the Arabs of the civilizing mission of Europeans by stopping all exploitation and by granting them the right of possession to the land they occupied. The collective lands were, however, to be delimited and partitioned into dwars or villages. Thus between 1863 and 1870 376 tribes had 7 million hectares of land divided into 676 dwars. This was envisaged to be a step prior to the introduction of the regime of individual

(i) Ibid p.162.
(ii) Ibid p.164.
property. The measure was later criticised because it was argued that the law thus wished to consolidate the very regime of collective property it set out to destroy.

The Policy of Assimilation: With the advent of the Third Republic, the notion of applying French institutions in the colonies became the governing policy and in 1873, a law was passed which abruptly stated that the French ideas of land-ownership had to apply in Algeria. Any man in a tribe could apply for his share of the tribal land and the property of the entire tribe would be divided up. Communal land-ownership was thus attacked root and branch. The measure had consequences that might have been foreseen. "The majority of the Arabs affected could not understand the intricate legal process, nor perceive why they should have to pay large costs when they received no obvious advantages." Whether it was the negligence of legal forms or inability to bear the cost of the process, the result of both was expropriation. The speculators made immense gains for it was extremely easy to bribe any tribal renegade to claim his share in order to start a process which culminated in the forced sale of the entire tribal land to meet the heavy cost. The native population lost a large proportion of their lands in this fashion.

The folly of this precipitate individualization was recognised in 1887 but then the government went to the other

extreme and all transfer and alienation were forbidden. A trend towards individualization had set in under however inauspicious circumstances and it was by no means politic to stem it abruptly. The law of 1897 finally established the pattern of the Algerian land policy, the principle being that any individual who wished to have his land separately could get it delimited without upsetting the whole tribe. This law has worked well and is still in operation after some minor modifications. But the legislation till that date has had lasting consequences because by its errors and contradictions, it has engendered enduring and "disillusioned hostility" among the local population which remains opposed to all reform.

According to Pierre Berthault, 4,100,000 hectares are at present registered according to French law (2,300,000 belonging to Europeans, the rest to Muslims) while 7,400,000 hectares are still governed by Islamic law.

**TUNISIA AND MOROCCO** These countries have benefitted from the experience gained in Algeria. A new system known as "Immatriculation" has been introduced in Tunisia since 1885 and in Morocco since 1913. Based on a type developed in Australia, it aims at consolidating private property by establishing undisputed possession to a clearly defined holding or estate which is then entered into a register. Although instances of

(1) Ibid, p.203
(11) E.C.M. "Algerie", Vol.1, p.240 The figures are presumably for 1942.
exploitation of illiterate peasants by unscrupulous persons did occur, registration of property in this manner has steadily gained ground. Above all, it has consolidated the colonists' position. At present the area under this regime is as follows:

Tunisia 1,770,000 hectares.
Morocco 4,000,000 hectares.

**REGIME OF LANDED PROPERTY IN WEST PUNJAB**

The systems of landownership in West Punjab vary from region to region but on the whole one basic distinction is between those of the old-settled districts and the newly-developed canal colonies.

**LAND-OWNERSHIP or OWNERS' TENURES:**

(1) **Old Settled Districts**

The main feature of the regime of land-ownership is the predominance of land-lord or joint types, both based upon tribal or family relationships. Land is held in full proprietary right by a group but an individual or a family claims superior status by virtue of ancestral rights. The proprietary body may consist of twenty or fifty or even more co-sharers, usually of common descent and they attach great importance to their landlord's right over the whole area of the village, arable or waste alike.

The joint or landlord-villages have been subdivided into Zemindari, Pattidari and Bhaiachara. (ii)

The term zemindari is applied to cases where a single

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(ii) Baden-Powell: Land Systems of British India.
landlord had obtained the governing proprietary right. Through
the multiplication of the number of claimants after several
generations, a numerous group would enjoy the right, and the term,
Mushtarka (joint or communal) is applied. Quarrels are bound to
occur at some stage among the joint-owners and the land is then
divided according to the law and custom of inheritance. The
village is then said to be on the Pattidari tenure. If a village
is divided on some principles other than those of the ancestral family
holding, it is known as Bhaiachara and true custom has been to
divide the village artificially with equal lots. The whole area
is divided into grades of various quality and each type is then
sub-divided among the incumbents of the property.

Owners are sometimes found in West Punjab village
communities who do not belong to the brotherhood and are not
sharers in the joint lands (shamilat) and other collective rights.
The title is limited and is known as "Milkiyat Kabza."

Instances are not uncommon where the proprietary right
is divided. The owner with the greater rights is known as
ala Malik or zemindar and the inferior ones with the title as
adna Malik, the latter may or may not have title to the joint
land. The joint nature of these older systems leads to villages
paying their land revenue to the state collectively and in fact
acting as a body in all matters between them and the administrative
authorities.

The Great Landlords  Although, strictly speaking,
there is no counterpart in West Punjab of great landlords of the
Bengali *zemindar* type, the insecurity and arid conditions of the pre-irrigation epoch have handed down a legacy of large holdings and of tribal chiefs. The latter were not in possession of such vast properties as they do now as the members of each tribe had a tradition of independence and equality. During the British rule, however, privileged interests were developed as has already been described under the historical survey of agriculture. Their special role in the agriculture of the province will be discussed later.

(2) The Newly Settled Districts Land is held directly by each holder in the colonies and each holder is bound to pay land revenue by his separate agreement. This system is a comparative innovation and although large grants were made to certain persons for their services to the government and there were large purchases by capitalists, the large majority of peasant grantees were allotted uniform parcels on which they were required to take up residence. Conditions imposed included permanent residence on the land and direct cultivation of the lands granted. Other conditions like keeping brood-mares for horse-breeding, breeding of camels, introduction of scientific methods of cultivation and of improved crop varieties were sometimes additionally enforced. The exact nature of these tenures will stand out when they are described with colonisation in the newly irrigated areas under IRRIGATION.
LAND TENURES

The traditional systems of tenancy in both West Punjab and Barbary are of a rudimentary nature based on the sharing of actual produce. The khamessat and associated tenures in Barbary and the batai (equal sharing) system in Punjab have both remained dominant despite recent developments of irrigation and transport that have opened up the agricultural produce of these areas for international commerce. This is partly due to the local agricultural economy having remained essentially a subsistence one although other factors such as the desirability of having permanent tenants, the general lack of accumulated capital among local landowners may also have played their part. Historically, insecurity in both regions must have made money a scarce commodity as well as a risky one so that kind was preferred to cash. In addition, under the essentially simple socio-economic organization based on autonomous villages and tribes, people did most of their transactions in kind until recently and village menials in West Punjab are still paid in kind on the occasion of the harvest. It may be added that with the extension of European colonization, a capitalistic system of agriculture has become established over large parts of Barbary with the
employment of paid labour, while in West Punjab, even the big landlords continue to cultivate their lands on a system of prolonged tenancy based as often on sharing of produce as on the payment of rent in cash.

**LAND TENURES IN BARBARY**

The most common tenancy contrast in Barbary is known as "khammessat" under which the tenant only provides labour and the plough, the animals, seed etc. are the responsibility of the owner. In return for his work the tenant or "khammes" gets a fifth of the produce. The tenant is provided for by the owner till the harvest but if his share of the produce does not make up for the grain etc. advanced by the owner he is obliged to work with the same owner till he has cleared all his liabilities. Under the capricious climate of Barbary, tenants often find themselves indebted for life and bound to work with the same owner. This practice is native to Barbary and has been a subject of controversy among Muslim jurists on account of the very unstable basis of remuneration.

The basis of this and several other related systems of tenures is the traditional conception of five factors in
agricultural production

1. The seed.
2. The field.
3. Labour.
4. The animals.
5. The plough.

Thus work on the field constitutes one-fifth of the factors involved and earns a corresponding reward. Another contract is the direct opposite of khammessat under which the owner leases only his field and all the other requirements are supplied by the tenant. The owner is then entitled to a fifth of the harvest and this type of association is known as "bel khobza".

Other variations deriving from the above conception are "khammes wa ferrad" by which the tenant supplies a ploughing animal plus his work and is entitled to two-fifths of the total yield and lastly "Shirka bin Nosf" (association with equal sharing) by which the tenant provides his service, half the seed and the animals and can claim half of the produce. The conception of these various factors is known as "sehma".

Khammessat still remains the dominant system of tenure although the increase of work involved on the field in cultivating new crops like fruits etc. and increasing complications accompanying new methods (preparatory tillage, application of fertilizer) have led to modifications in an increasing degree. In the Gharb plain in Morocco, the practice of periodic payments in grain (simama) in anticipation of the harvest has come into vogue and is spreading to neighbouring regions. On the whole the tendency is to work up towards monthly payment

of wages making the khammes into a paid labourer. In this respect the influence of the European farms has been considerable. There are also cases where the share of the tenant under the khammessat contract has been increased to one-fourth (Rubaa).

Apart from these traditional systems native to the region, there are two tenancy practices which derive their basis from the Islamic conception of "dead" and living lands as already defined. **Mukassara** (breaking up) is a practice by which unproductive land becomes the property of the person who brings it under the plough. This is in line with the emphasis placed on increasing agricultural production by Islam: the Prophet Mohammed said "Whosoever plants or sows something and from the fruits of his trees soil would feed men, birds and beasts - all of this will be judged as charity".

The other tenancy contract based on Islamic tradition is "mgharsa" under which the tenant (mogharsi) clears a formerly uncultivated piece of land owned by someone, plants trees and digs wells. Until the trees come into production, the mogharsi may cultivate cereals between the young trees. The owner is entitled to a quarter of the harvest if he does not furnish the seed but he is entitled to one half if he gives all the seed, and one third if half the seed. After the trees come into production, the whole area is shared equally by the mogharsi and the proprietor. This system is especially prevalent in the Sahel region of Tunisia where it has been instrumental in achieving the great expansion of olive orchards.

After the land has been divided between the mogharsi

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(i) J.A. Tournieroux "L'oléiculture en Tunisie", p.271
and the owner, the former may continue to take care of the whole orchard and give only a third of the produce to the owner. This is known as the contract of mousakat. The owner is also entitled to 1/5th of any cereals produced on the land.

The systems enumerated above apply to all types of properties, but there is one system associated specially with the habous lands known as enzel. Land is rented by the governing authority on a perpetual lease at a fixed rent and the enzelist holds it like a proprietor and can pass it on to his descendants. This system has resulted in some extraordinary situations much to the benefit of the tenants many of whom are Europeans. There are large properties in Tunisia which were rented fifty years ago at 2 francs per hectare (2.47 acres) which at that time represented a substantial sum. Today the rent remains the same but the two francs represent less than a half-penny! The system of enzel leases also provides that if such lands lie across the different parcels of land of a neighbouring proprietor, he can purchase enzel lands though habous lands are, in theory at least, inalienable. The practice of enzel is widespread mainly in Tunisia.

The geographical distribution of different types of tenants cannot be demonstrated for the whole of Barbary for the lack of adequate data. The following figures for Algeria give an idea of the relative proportion of ordinary labourers, khammes tenants, owners etc. on native and European farms.
For 1929-30
(Source - First World Agricultural Census)

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<th>Classification</th>
<th>Absolute data</th>
<th>Percentage of group of total</th>
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<td>and khammes:</td>
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</tr>
</tbody>
</table>

Total agricultural population 2,407,442 100

TENANCY IN WEST PUNJAB

"Though the Punjab is 'par excellence' the province of cultivating proprietors, yet about half of the area is cultivated by tenants"(1)

Three types of tenants are in existence:

1. Hereditary tenancy (under Punjab Tenancy Act) Locally known as "maurus".
2. Those held under court decree, lease or other special agreement.
3. Tenancy-at-will.

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(1) K.S.Ahmad, Op.Cit. p.245
Direct cultivation by the proprietor is known as Khudkasht. Several systems of farming by tenants are at present in vogue:

1. "Batai" system - Land is leased on a sharing basis the usual share being half and half between the tenant and the landowner. The expenditure on land and water dues is shared though the cost of the seed has usually to be borne by the tenant. Ultimately the tenant's share is considerably less (1) than that of the owner.

2. Siri System - This is a system of direct cultivation by the owner in which the labourers get a fixed proportion of the produce instead of cash. They also share a corresponding proportion of the land revenue. Their feeding is the landlord's responsibility.

3. Nakdi rents - Farming is done on cash rents irrespective of what crops are grown.

4. Zabti rents - In this case cash rents are fixed at different rates for different crops.

5. Chakota - This is farming on lump grain or cash rents consisting of a fixed amount of money in the autumn (ii) harvest and grain in the spring.

Most of the province is given to the batai system of farming. The system has some manifest disadvantages. Since the landlord ultimately secures the major part of the produce


(ii) Punjab Settlement Manual, 1915, p.159
there is no incentive for improvements or efficiency. On the other hand the system secures natural adjustment of rent to the produce and is thus independent of price fluctuations.

Kind rents have become prevalent during the last few decades. This may be accounted for by the fact that the spread of canal irrigation has given a greater security to crops so that the landlord stands to gain more by the larger yields of irrigated lands than by a fixed areal rent. It may be remarked that cash rents are still prevalent in the precarious barani (Rain-cultivated lands).

H. Calvert conducted an enquiry into the relative merits of kind and cash rents according to its effects on the efficiency of agriculture. His conclusion was that tenants worked harder when paying a fixed cash rent, thus hoping to make something over and above the normal produce. If working under the batai system, the tendency was to concentrate on more remunerative crops like sugar-cane. Batai tenants did not appear to be planting trees or ploughing carefully. These findings were later confirmed in the village surveys made by the Punjab Board of Economic Enquiry.

Regional Tenures: The types of tenures vary over the province. Central Punjab is marked by the prevalence of well-organised village communities in which groups are united by ancestral ties. The type of ownership here has already been described.

(i) "Wealth and Welfare of the Punjab" p. 89-91, Lahore 1927
The Potwar Plateau has a strongly tribal organisation in which several villages may form a unit. Within these are found Ala Malikan or the big landlords, followed by hereditary owners (Malikan), Adna Malikan, the small proprietors and finally outsiders who have purchased land in these villages but do not enjoy a right to common lands (Malikan Kabza).

Tenures in South-west Punjab show the effect of aridity and pastoral pursuits that used to be the rule before canal irrigation. The unit of property is still the well over large areas and is known as chah or patti. Two distinct classes of owners are found, the old established landlords called Malikan ala and outside settlers, formerly called riaya (subjects) but known now as malikan adna.

The system of adhlapi prevalent in the trans-Indus district of Dera Ghazi Khan is similar to the system of mgharsa in Barbary. If a man sinks a well in barren land with the owner's consent, he becomes owner of half the commanded area. The share of a man who cleans an old well is 1/5th. (1)

HOLDINGS

The large majority of cultivators in Barbary and West Punjab are small-holders as will be proved by a study of available statistics. This in itself is a reflection of the pressure of population on the land as well as of the Islamic regime of property under which all members of the family are entitled to a share in the patrimony. Although the latter results in actual

(1) Punjab District Gazetteers, D.G.Khan, page 79
partition of cultivated lands in West Punjab, in Barbary, the family holdings remain indivisible in theory. The fact remains however that the average areas of land cultivated by the individual peasants are very low and are being progressively reduced.

Side by side with the sub-division of holdings, there is the problem of fragmentation i.e. breaking up of individual scattered plots into smaller sections after each sub-division. The process, founded on the laudable object of providing exactly equal shares of various types of land, has been carried too far especially in West Punjab where it has been studied in detail. There are indications that the problem also exists in Barbary as the productive land forms a small proportion of the total area.

Relative position of Barbary and West Punjab The only part of Barbary for which statistics are available is Algeria. The average size of holdings for whole countries while not conveying an exact picture, does present a basis for examining the general position in relation to other countries. The following table indicates average holdings in acres per cultivating worker in several countries (figures for 1921 for all countries except Algeria, 1929-30)

Scotland 56.31  Algeria: European 223.4  
Wales 38.95  Native 33.3  
England 26.95  Punjab 9.2  
Germany 19.25  
France 15.5  

Keeping in view the higher standards of cultivation in European countries the discrepancy is even more considerable than the figures indicate.

The figures for Algeria are relatively high but while the lands of the Europeans are undoubtedly fertile, the native holdings are usually located on steep hill sides so that in terms of productive capacity they approach nearer to the Punjab region figure.

The cultivation of the small-holding presents several disadvantages:

1. The small area of the holding gives insufficient scope for the working capacity of the peasant family. It also gives disproportionately low returns for the amount of effort and money expended on it. As Mukerjee noticed by a comparison of farm accounts in the Canal Colonies of West Punjab, "the costs of cultivation increase in relatively greater proportion with diminution of the area of the holding and that almost similar results are traceable so far as the net income per acre is concerned, which tends to decrease as the area of the holding decreases".

2. The small-holders suffer from a lack of capital on one hand and of technical ability on the other. Their poverty is responsible for both. Indebtedness in bad years is a common happening.

3. The small-holder lacks the knowledge and resources to run his farm commercially. Neither his choice of crops nor his

knowledge of market conditions are designed towards meeting the current requirements. The small-holdings also have some advantages i.e. possibility of intensive cultivation of lucrative and giving close personal care to the farm. For a maximum advantage to be taken of the small-holding, credits, co-operation, vocational training and an adequate marketing organisation are essential. Most of these are inadequate in Barbary and West Punjab.

Details of Holdings in Algeria

While the size of holdings observed personally will be given under the account of Agricultural Regions, the following statistics for Algeria should give a representative picture.

PRIVATE AGRICULTURAL PROPERTIES in 1930 ACCORDING TO SIZE

<table>
<thead>
<tr>
<th>Classification</th>
<th>Number of owners</th>
<th>Total area of land owned absolute data</th>
<th>Percentage of total</th>
<th>Average for owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 25 acres</td>
<td>372,258</td>
<td>4,032,480</td>
<td>16.8</td>
<td>10.8</td>
</tr>
<tr>
<td>From 25 to 124 acres</td>
<td>146,040</td>
<td>6,989,144</td>
<td>29.1</td>
<td>47.9</td>
</tr>
<tr>
<td>From 124 to 247 acres</td>
<td>41,535</td>
<td>4,816,530</td>
<td>20.1</td>
<td>116.0</td>
</tr>
<tr>
<td>Over 247 acres</td>
<td>13,370</td>
<td>8,154,763</td>
<td>34.0</td>
<td>669.9</td>
</tr>
<tr>
<td>TOTAL</td>
<td>573,203</td>
<td>29,992,917</td>
<td>100</td>
<td>41.9</td>
</tr>
</tbody>
</table>

It will be noticed that less than 10% of the owners in the last two categories own 54.1% of the total cultivable area and that almost two-thirds of the owners own only about 10 acres each on the average. The following figures for European and Muslim owners further bring out the differences that exist between one group of owners and the other:

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(i) International Institute of Agriculture, The First World Agricultural Census, No.21 Algeria, 1938
EUROPEANS

<table>
<thead>
<tr>
<th>Classification</th>
<th>No. of owners</th>
<th>Absolute owners area (acres)</th>
<th>Percentage of total</th>
<th>Average (acres) per owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 25 acres</td>
<td>3,643</td>
<td>102,721</td>
<td>1.8</td>
<td>11.9</td>
</tr>
<tr>
<td>From 25 to 124 acres</td>
<td>7,095</td>
<td>533,550</td>
<td>9.2</td>
<td>75.2</td>
</tr>
<tr>
<td>From 124 &quot; 247 &quot;</td>
<td>4,790</td>
<td>395,731</td>
<td>15.5</td>
<td>190.6</td>
</tr>
<tr>
<td>Over 247 acres</td>
<td>5,359</td>
<td>4,238,216</td>
<td>73.5</td>
<td>789.4</td>
</tr>
<tr>
<td></td>
<td>25,807</td>
<td>5,770,218</td>
<td>100</td>
<td>223.4</td>
</tr>
</tbody>
</table>

The number of large holdings is not inconsiderable, 40% of the holdings being over 124 acres. The small proprietors are either those who practice the intensive cultivation of truck crops or cultivate some land as an additional occupation apart from their main profession in business or administration.

The figures for Muslim owners are given as follows:

<table>
<thead>
<tr>
<th>Classification</th>
<th>No. of owners</th>
<th>Absolute owners area (acres)</th>
<th>Percentage of total</th>
<th>Average (acres) per owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 25 acres</td>
<td>364,615</td>
<td>3,929,757</td>
<td>21.6</td>
<td>10.8</td>
</tr>
<tr>
<td>25 acres to 124 &quot;</td>
<td>158,945</td>
<td>6,455,594</td>
<td>35.4</td>
<td>46.5</td>
</tr>
<tr>
<td>124 &quot; 247 &quot;</td>
<td>36,835</td>
<td>3,920,799</td>
<td>21.5</td>
<td>106.4</td>
</tr>
<tr>
<td>Over 247 acres</td>
<td>8,001</td>
<td>3,916,549</td>
<td>21.5</td>
<td>489.5</td>
</tr>
<tr>
<td></td>
<td>547,396</td>
<td>18,222,699</td>
<td>100</td>
<td>33.3</td>
</tr>
</tbody>
</table>

Less than 9% of the Muslim owners have holdings of over 124 acres and the greater mass — over 66% possess parcels of land that average only 10.8 acres. The Muslim small holdings, even though of an area comparable to the European small holdings do not compare in quality for even as Pierre Berthault has observed "As against the European small holdings located in the rich zones, the native small property exists over the high plateaux or over the zones where colonisation cannot be successful except with very large holdings." (1) This discrepancy combined with the age-old methods of the local peasants produces those great contrasts in productivity we shall notice later on.

Size and Distribution of Holdings in West Punjab

The average size of holdings in the various districts of West Punjab for 1931 is indicated on Map 7. It will be noticed that they are smaller in the congested old-settled districts of Rawalpindi, Jhelum, Sialkot, Gujrat and Lahore as well as in the mainly well-irrigated districts in the south-west - below 7.5 acres. In the canal colonies, they range from 7.5 to 10 acres while they exceed 10 acres in the two districts that extend over most of the Thal desert - Mianwali and Shahpur.

H. Calvert made a study of the size and distribution of holdings in the Punjab in the 1920's and arrived at some interesting conclusions as regards the role of various factors in determining their size. He distinguishes between owners' holdings (areas belonging to individual proprietors) and cultivators' holdings (areas cultivated by individual holders whether owners or tenants). For the undivided province, the relative proportion of the owners of various sizes of holdings may be judged from the following table (for 1922-23):

<table>
<thead>
<tr>
<th>Percentage of owners</th>
<th>Percentage of lands held</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1 acre</td>
<td>17.9</td>
</tr>
<tr>
<td>1 to less than 5 acres</td>
<td>40.4</td>
</tr>
<tr>
<td>5 &quot; &quot; 15 &quot;</td>
<td>25.2</td>
</tr>
<tr>
<td>15 &quot; &quot; 50 &quot;</td>
<td>11.8</td>
</tr>
<tr>
<td>More than 50 acres</td>
<td>3.7</td>
</tr>
</tbody>
</table>

Thus while the majority of the peasants (84.5%) own holdings of less than 15 acres, a minority (15.5%) hold 61.3% of the land. The average figure of 7.8 acres per owner applies in reality to less than 18% of the owners. The holdings of below 1 acre belong in most cases to cultivators rather than allotment holders or labourers.

(1) The Size & Distribution of Agricultural Holdings in the Punjab " " Cultivators " 1928
Calvert has established that on the whole, the size of owners' holdings increases as the rainfall decreases. Along the Indus only 33% of the holdings are above 10 acres in Attock with a rainfall of 20.15". At Muzaffargarh which receives 5.95", their percentage increases to 87.8%. The same distribution was noted along the Jhelum and the Sutlej.

Different conditions obtain however in the canal colonies and the following distribution was noticed:

<table>
<thead>
<tr>
<th>Percentage of owners</th>
<th>Percentage of land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 1 acre</td>
<td>10.5</td>
</tr>
<tr>
<td>1 to under 5 acres</td>
<td>24.4</td>
</tr>
<tr>
<td>5 to 15 &quot;</td>
<td>32.3</td>
</tr>
<tr>
<td>15 to 50 &quot;</td>
<td>24.4</td>
</tr>
<tr>
<td>Over 50 acres</td>
<td>8.3</td>
</tr>
</tbody>
</table>

Thus a majority of the cultivators (56.7%) own two thirds of the cultivated land in holdings of 5 to 50 acres. This shows the influence of government supervised settlement and uniform allotments to peasant colonists.

Cultivators' Holdings Calvert's survey revealed that most owners holding less than 15 acres tend to take extra land for cultivation as tenants. About 83% of the cultivators cultivate less than 15 acres so that this may be recognised as the normal size of the cultivators' holding. This also reveals that the Punjab peasant is essentially the man with only one plough. In the congested sub-Montane district of Sialkot 55.6% of the cultivators held less than 2½ acres, most of it well-irrigated.

No connection was noticed between the size of holdings and the type or intensity of cropping. In fact, there appeared to be a tendency among smaller holders to grow a larger proportion of cereals and pulses than the bigger cultivators.
Fragmentation of Holdings and Consolidation

Various surveys in different parts of the province revealed that small-holders held land in numerous scattered plots. In a study of this problem, Calvert estimated that in the congested districts of Jallundar, Hoshiarpur and Guriaspur (a part of the latter is in West Punjab) average holdings of five acres were held in 25 plots. The evils of fragmentation are easily imagined—waste of land in boundaries, waste of time in travelling to and fro between plots, lack of adequate care etc. A legislative solution of the problem was found to be impossible. A system of co-operative consolidation was, however, worked out under which cultivators within the same village exchanged their scattered plots among themselves so as to obtain large compact fields. The work was supervised by the Co-operative Department and cost the government less than 2 rupees (3 shillings) per acre in the 1920's.

The system has since become widespread and its virtues are being realised. Two diagrams show a part of the lands of a village in West Punjab before and after consolidation.
The most significant development in the agriculture of Barbary in recent times has been European land-settlement. The land policy it inspired was outlined earlier; yet so closely interwoven is this development with all aspects of agriculture that it merits treatment in some detail. To the Europeans in Barbary, the establishment of a large number of their compatriots in these territories represents their greatest achievement. They point to their modern farms and machinery, their commercialized and increasing production as well as the modernizing effect they have had on native agriculture. On the other hand the native population considers it to be the greatest iniquity perpetrated by the conquerors and alleges that a great mass of formerly independent landholders is now living in misery and forced to plough the stony mountainsides or to work as labourers on what was once their own property.

Before any opinion may be formed about the merits of rural colonization by Europeans, it is necessary to examine the various factors involved in the process and to survey the history of its growth. Algeria must occupy the forefront again in this account as it was here that colonization first began immediately after the conquest in 1830 and passed through its more stormy phases. Algeria is also the most Europeanized of the three territories and almost two thirds of all colonised lands lie within its confines.
FACTORS INVOLVED

Algeria as a country for European rural colonization and the French as settlers possessed certain attributes which were peculiar to them during an age of rapid territorial expansion and overseas emigration. On one hand, unlike the new world or Australia, Algeria had a large compact population estimated at between 2 and 3 millions, with a well-defined culture and regime of landed property. Most of the cultivable land was occupied even though indifferently, over large areas. On the other hand France did not have a high birthrate and its population was attached to the soil. Indeed as G. Froment-Guieyesse has summed up after comparing France with Britain and Italy, "economic, social and political causes favourable for continuous emigration did not exist in France." (i)

The proximity of Algeria to France and the similarity of climatic and other conditions over large tracts are factors that have been favourable to emigration. Only some 450 miles across the Mediterranean, emigrants never felt really isolated from the mother country. The vine-growers of the Midi found the littoral plains like home while the peasants of High Languedoc found the high plains of Setif and Sidi bel Abbes quite to their liking. In spite of these advantages, the colonization of Algeria was carried out only through great effort and expense on the part of the government. A consistent

(i) E.C.M. "Algérie", p.228.
thread of anti-colonialism that ran through French politics rendered the job still more difficult. That so many people did settle in Algeria was consequent upon the liberal terms offered to colonists who, during most early stages of colonization, had only to volunteer to immigrate into the country to receive free of cost, land, a house all ready, cattle, implements and liberal credits and could after a minimum term of residence either become absentee landowners or sell their land at great profit. It is now proposed to examine the development of colonization in its various stages and to comment on its salient features.

**History of Land Settlement in Algeria**

From the beginning, the French policy of land-settlement was dominated by three conceptions, "a belief in grants as opposed to sale, official villages as opposed to desultory individual action and small settlement as against capitalistic effort". (1) There were several phases of the process during which many different modes were tried and it was not till 1878 that a consistent policy emerged. The present colonization policy was finally shaped by the laws of 1904 and 1926.

**1830-1841:** The period immediately after the conquest was one of hesitation. The new country was ineffectively subdued, only some coastal tracts being under actual control; there was uncertainty as to its future occupation and the local property regime presented great difficulties. The first settlers

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to arrive were not Frenchmen but 400 German and Swiss emigrants destined for America who were persuaded to come to Algeria. (i) A few villages were established around Algiers but the most enterprising step of this period was the foundation of Bufarik in 1836 in a marshy and unhealthy tract. The village was planned officially, sites being allotted for 562 houses and 173 rural grants were made. With a year 110 hectares had been brought under cultivation. Most of this came to nought when the war against Abdul Kader started in 1839.

**Marshal Bugeaud, 1841-1848:** More important than hostilities within Algeria was the hostility of public opinion in France because, among other things, of the high mortality among colonists. Duvivier, himself an architect of the French conquest, wrote in 1841 "the plains, whether that of Bone, or of Mitija and many others are homes of disease and death. Improve them? No one shall ever succeed in that" (ii) Non-expansionists popularised the phrase that "Algeria is a rock without water, a place where only air is found and even that is bad"(iii) In this state of opposition in France and difficulties within, Bugeaud assumed charge in 1841 as the governor-general. From the start he declared his intention of doing something "enduringly useful" for France. He wanted

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to populate the land with soldier-colonists who would have on
one hand the discipline of soldiers to ward off the incursions
of the local population and on the other hand have the
initiative of private settlers. The government "acquired"
the lands more by force than by negotiation, the army cleared
them and helped in the construction of villages and roads and
when all was ready, families would be settled each with an
allotment 4-12 hectares. By 1847, 61 such villages had been
founded.\(^{(i)}\) While the government provided a free passage to
Algeria and free land and houses, the colonists were required
to bring the land under cultivation within a certain period
before being given the final title. By 1848, out of 150,000
hectares conceded, only 23,000 were owned under a final title
and many colonists had returned to France.\(^{(ii)}\)

Despite his policy of military colonization, Bugeaud
did not favour the current idea of the "refoulement" (driving
back) of the native population and believed that the colonization
of uncultivated land could be carried on side by side by both
Europeans and Algerians. He gave a real start to rural
settlements by Europeans and by the time of his departure in
1848, the number of colonists had gone up from 1500 to 15,000.

1848-1860: In 1848, there was an industrial crisis
in Paris following the closing of the national workshops.
It was decided to allot lands in Algeria to a large number of
the unemployed workers and by 1849, 13,500 of them had arrived.

\(^{(ii)}\) Piquet, Op. Cit. 149.
They were settled in 42 new officially created centres. The immigrants were complete strangers to agriculture and it is no wonder that large numbers of them sold their lands and went to the towns. Epidemics of cholera in 1849 also took their toll and precipitated a movement away from the centres of colonization. The opportunities of easier life in administration or commerce have always had the effect of attracting the town-loving settlers away from the countryside and despite all the assistance and encouragement given by the government, large numbers of the colonists settled at great expense have always migrated to the larger urban centres.

In 1851, the practice of making free grants was discontinued and as free sales of land in British colonies had given excellent results it was decided to give them a trial and sales of official allotments at token prices were instituted along with which complete possession was conceded. The aim of this step was two-fold. Firstly it was designed to remove the discouraging factor of free grants being conditional. Secondly it was expected to attract capitalists who could invest money in the land. While the practice of establishing planned villages of colonization was continued and 85 villages were thus established from 1851 to 1861 involving an allotment of 250,000 hectares to 11,000 grantees, "grande colonisation" or the exploitation of land by companies was also encouraged and in 1853, the "Compagnie genevoise" was granted 20,000 hectares.

(1) Ibid p.154
It had been stipulated that 10 villages of colonists were to be established but after 5 years, only 500 people had been installed. (I) The period from 1851 onwards increased the attraction for agricultural settlement as a law in that year removed restrictions on the export of Algerian produce to France. But the results of State organised settlement continued to be meagre.

1860-1870: Realising that several policies tried till then by the government had failed in spite of the provision of financial and other aid, Napolean III decided in 1860 that this part of the State's activities was economically absurd. Open sales were therefore introduced in that year and three years later the Emperor wrote that official colonization had failed beyond the possibility of doubt (ii). Henceforth, he held, small settlement by Europeans should cease and they should confine their role to that of being "seigneurs" (landed aristocracy) investing only their money into the land. A decree of 1864 absolutely forbade free grants. In other words all further extension of rural colonization was to be achieved by private enterprise. This period saw a decrease in the agricultural population of 1% and not a single new village was created from 1864 to 1870. (iii) The colonists in Algeria alleged "scandalous desertion" on the part of the mother country but

(I) Ibid p.156.
they had to wait for the Third Republic to restore the complete backing of the state without which the settlement of Europeans could not succeed. This period was, however, marked by several large grants and in 1865 24,000 hectares were granted to Société de la Macta et de la Habra and 100,000 to Société Générale.  

The Third Republic: 1871-1878: When the Third Republic was proclaimed in France in 1870, official colonization again sprang to popular favour. Even so the uneasiness caused by Napoleon's policy and by the series of famines and diseases after 1866 continued to make its influence felt for a decade.

The defeat of France in 1870 and the German annexation of Alsace-Lorraine posed the problem of settling thousands of loyal Alsations. It was therefore decided to allot "100,000 hectares of the best state-held lands in Algeria" to those who would emigrate. The state-held lands at this date could not have satisfied this demand had the Kabylie revolt of 1871 not yielded a large reserve in the shape of an expropriated area of 450,000 hectares of land and a large sum of money realised as indemnity. The Alsation settlers however proved no better than the worker-immigrants of 1848, being, like them, new to agriculture. According to an enquiry made in 1899, out of 1188 families settled originally, only 387 retained their concessions while most of the rest drifted to the cities.

(i) Piquet p.179.
The regime of 1878: The decree of 1878 regulated settlement for the next twenty-six years and for the first time gave a definite shape to the official colonization policy. Under this decree land could be obtained free on condition that the grantee resided on the land for three years and improved it to the extent of 100 francs per hectare. The grantee could leave after one year provided he installed another French family in his place. The area of individual lots was increased to 20-50 Ha. for Settlers in a village and 50-100 for isolated farms.

This was a period when all factors favourable to colonization appeared to combine. Large areas confiscated from the rebels were lying unutilized. A hardy and reliable class of settlers was at hand due to the depredations of the phylloxera in the Midi. The administration's policy was favourable for land-settlement and the development of railways was opening up the country-side. Thus it was that the period from 1870 to 1878 saw a great increase in the total area colonised (see graph). When the lands acquired from rebels had been exhausted, expropriation was resorted to although the French government refused a loan of 50 million francs to carry this measure out on a large scale. This was also the period when the infamous land regime of 1873 was in operation by which any one tribesman could get the tribal lands split up into individual lots. The combination of expropriation and forced sales had consequences altogether tragic for the native.

Graph showing the area colonised by Europeans in Algeria.
population who lost two-fifths of their lands between 1873 and 1889. (i) This period marked the extension of colonization beyond the Tell Zone into the interior. In all 643,456 hectares were settled by Europeans from 1871-1895. Of the original grantees numbering 13,301 only 5,184 remained on the land. The other 8,117 did not all leave Algeria but sold their lands to other colonists and gravitated to the cities. Ultimately the gainers were Algerian Frenchmen. This led to the criticism that official colonization was designed to transfer lands from the native population without adding considerably to the European rural population.

The results of official colonization during this period have been disputed. In a celebrated enquiry, de Peyerimhoff (iii) defended the high cost of this policy and the waste of effort involved by pointing to the increase of French population and the successful installation of hundreds of centres of colonization to act as nuclei for the spread of French influence. The economic development of the country had thus been precipitated and the conquest of the country rendered definite and lasting.

Roberts has pointed out the weaknesses of some of these arguments; de Peyerimhoff, in attributing all economic progress in this period to official colonization, neglects the

(iii) Enquête sur les résultats de la colonisation officielle de 1871 a 1895. Abstracted by Roberts, Piquet, Bernard etc.
"spontaneous or natural development as may have been going on at the same time and independently of the official policy".

The Burdeau Report of 1892 criticised the system of free grants and advocated free sales on the model of the system of 1860. This had already commenced in 1884 on a limited scale but following the growing criticism of the policy of official colonization, the principle was finally adopted in 1904.

The Law of 1904: The decree passed in 1904 changed the whole character of Algerian land-settlement. Sales became the rule but residence was encouraged by giving rebates to those settlers who personally lived on the land. To prevent the previous monopolization by Algerian residents, two-thirds of all land was reserved for immigrants. Sale of land to the native population was forbidden. Free grants could still be made under special circumstances and the maximum size of allotments was increased from 40 to 200 Hectares.

In theory, the new policy was designed to replace artificial colonization by spontaneous settlement. In practice, however, the Algerian Government continued to establish official villages even in lands acquired by free sale. Free grants also continued to be made in large numbers and according to Piquet, 2820 grants were made between 1901 and 1910 while only 431 lots of land were sold openly between 1900 and 1907.

(i) Dehio, p.227-228.
AGRICULTURAL COLONIZATION
IN TUNISIA.

(Source Geographical Handbook, N.R.D.)
The total amount of land acquired by Europeans between 1900 and 1920 was about 200,000 hectares. The latter part of this period saw colonization reduced and according to A. Bernard, "during the War and up to 1920, the natives had repurchased from the Europeans more land than they had sold them" (i)

Since then, large areas have been added to the domains of European colonization. The law of 1924 forbade all free grants except to French immigrants. (ii)

Recently, the government has again taken the initiative in an attempt to acquire more lands for colonization from the native population. The Martin Law in Algeria, passed in 1942, requires that in all areas already benefiting from the government's irrigation schemes, proprietors must cede 15% of their lands to the state without compensation. For regions about to be irrigated, the percentage is to be raised to 30 while it shall be 50 for all future projects. (iii)

Agricultural Colonization in Tunisia and Morocco

Land-settlements by Europeans in these countries have largely been achieved by private enterprise. Tunisia came under French suzerainty in 1882 and at first the government was reluctant to launch any official scheme of settlement. Vast domains were however bought by enterprising persons and

"out of the 1,094,700 acres owned by French persons in 1892, 1,027,900 belong to sixteen individuals"(i) Among the earlier domains to be established was the Enfida Domain of 96,000 hectares, the largest in all Africa, and official colonization did not start till 1901 and then only to counter the increasing Italian population by attracting Frenchmen to the land. Between 1900 and 1914, the government granted 125,000 hectares in lots of 100 hectares or more. Following the war there was a period of recession from the French point of view for over 80,000 hectares of land passed to Italians and the native population. In fact, French settlement in Tunisia has been very slow and until the Second World War, the numerous Italian and Maltese landowners were the leading political headache of the government.(ii)

A notable feature of land-settlement in Tunisia has been the settlement of the native population in the centre and south which has been largely responsible for the extension of olives. By 1912, 6,000 natives had been settled in the Sahel region and occupied along with 150 Europeans an area of 144,000 hectares. Most of the land in the Sahel was obtained by the expropriation of the extensive Siala domain(iii) (shown as Sialine lands on the map of Agricultural colonization in Tunisia).

(ii) Roberts (Op.Cit.) gives the total number of French landholders in 1928 as 1708 as against 1565 Italian and 102 Maltese, p.274.
(iii) Ibid, 276.
Rural colonization by Europeans in Morocco has been along the same lines as in Tunisia with private enterprise playing a leading role. Official colonization was carried out extensively only between 1924 and 1928 when large scale expropriations took place. The changed political temper made its influence felt recently. When an attempt was made to colonise the Beni Amir plain before 1939, public opinion and the revolt of the tribe had the effect of defeating it.

On the whole, the settlement of Europeans has not caused the same upheavals in Tunisia and Morocco as in Algeria largely because the colonization policy was not aggressive or aimed at establishing a considerable European population. The alienation of land was simplified by the system of Registration of Property. The changed manner of land-settlement in these countries is reflected in the larger size of average holdings.

**Present distribution of colonised land:**

The total area owned by Europeans in Barbary is given below along with the number of holders: (1)

<table>
<thead>
<tr>
<th></th>
<th>Area in hectares</th>
<th>Number of holders</th>
<th>Average holding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>2,700,000</td>
<td>26,000</td>
<td>103</td>
</tr>
<tr>
<td>Tunisia</td>
<td>770,500</td>
<td>6,000</td>
<td>128</td>
</tr>
<tr>
<td>Morocco</td>
<td>850,000</td>
<td>4,000</td>
<td>212</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>4,320,500</strong></td>
<td><strong>36,000</strong></td>
<td><strong>120</strong></td>
</tr>
</tbody>
</table>

Despois has divided these holdings into three principal categories:

(i) Those in cereal-growing regions, mostly non-irrigating, averaging 100 to 400 hectares and more. The larger ones are found in drier tracts where half the area is left fallow every year under dry-farming, e.g. the plateau of Sersou. Lately citrus plantations have been expanding in the irrigated parts at the expense of cereals.

(ii) Those that are devoted to vines are in general smaller affairs, 60-70% of these being below 10, and forming parts of larger estates, 17-25% have an area of 10 to 50 hectares while a number of very large vine-growing estates exist principally in the plains of Mitija and Bone.

(iii) Holdings under early vegetables, requiring intensive cultivation and yielding a high income from small areas support a high density of population so that holdings of as little as 4 hectares are not uncommon.

THE EFFECTS OF EUROPEAN COLONIZATION ON THE NATIVE AGRICULTURAL POPULATION:

The motives behind European colonization have become clear from the account of its development as also from the history of French land policy outlined earlier. One was to ensure the permanent occupation of the conquered lands by settling French cultivators in the belief that the "soil belongs to those who cultivate it". Later on when large numbers of immigrants from the overpopulated lands of Spain,
Italy and Malta threatened to outnumber the French colonists, official colonization was intensified to maintain French superiority in numbers. These motives, however honourable and glorious in their time cannot obscure the fact that the settlement of Europeans was achieved at the cost of "refoulement" (driving back) of the native population. The colonization policy which in the earlier stages had been tempered with humanity ended up in depriving the Arabo-Berber population of its best agricultural lands in Algeria and to a lesser extent in Tunisia and Morocco. The maps of colonised lands in Algeria and Tunisia show the location of these lands and when taken in relation to the physical background, there can be no doubt that these tracts are agriculturally among the richest in these countries.

One might be asked that granting the dispossion of the native population achieved through official colonization in Algeria, how is the forcible expulsion of the local cultivators to be proved in Tunisia and Morocco where lands were acquired mostly through direct purchases by capitalists. The answer, though it cannot be documented adequately on the basis of existing literature, may be given along the following lines. Firstly, a large proportion of the lands even in these territories was firstly acquired by the government through a system of "cantonnement" such as the description of a Moroccan tribe will later illustrate. Thus the government

(1) A. Bernard, Afrique Septemtrionale et Occidentale, p.113.
took a proportion of their land from each tribe and sold it to the colonists instead of giving it away. In this sense official colonization continued to replace the local population with settlers. Furthermore, the effect of the influx of capital on a land subject to the extremely variable climatic regime needs to be studied. In years of drought when the small-holders find themselves hard-pressed, it is not unnatural that they should sell their land-capital to those who offer them the hope of subsistence by buying up their lands. The most obvious and willing purchasers of their lands have been the European settlers although some native landlords have also been accumulating lands in this manner. This exploitation of calamity in an age of growing humanitarianism is a blot on the record of the administration which fails to provide adequate relief and has, therefore, been accused locally of deliberately countenancing the expansion of the settlers' domains in this manner.

Even in 1912 Piquet had reflected on the misery of the rapidly increasing native population "detached from the soil, forcibly impoverished and powerless to transform itself overnight into a working population" and had wondered if "French colonization had not perhaps been a little precipitate" (ii) He had made these remarks in the belief that "the land has been occupied by the colonists everywhere it has been possible" and drew his conclusions about what he

(i) J. Nouvel "La crise agricole de 1945-46 au Maroc et ses consequences economiques et sociales, La Revue de Geographie Humaine et d'Ethnologie" Vol. 1, 1948
had considered to be "an accomplished task". Yet the process of uprooting the native population has continued and the curve of the area acquired by colonists has mounted after Piquet's times as the graph illustrating the progress of colonization in Algeria shows. The graph, however, does not go beyond 1934. A comparison of the proportion of land held by Europeans in 1930 and 1946 will show the development of colonization in recent years:

**PROPORTION OF EUROPEAN LANDS IN ALGERIA 1930 and 1946**

<table>
<thead>
<tr>
<th>Year</th>
<th>European lands (in 1000 hectares)</th>
<th>Total agricultural lands</th>
<th>European percentage of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1930</td>
<td>2,340</td>
<td>9,716</td>
<td>24</td>
</tr>
<tr>
<td>1946</td>
<td>3,079</td>
<td>11,390</td>
<td>27</td>
</tr>
</tbody>
</table>

The actual increase in the area owned by Europeans during this period has been over 31%. The total cultivated area also increased during this period but this expansion was achieved mainly on the poor marginal lands. In the opinion of this writer the colonization of Barbary in general and of Algeria in particular has been achieved at the cost of the impoverishment and even destitution of the local population. In 1946, an official estimate put the number of agricultural families with insufficient or no land in Algeria at 600,000 or 60% of the total.

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(i) Ibid., p.206.
(iii) From Renseignement Statistiques et Agricoles, 1946
(iv) Documents Algeriens, "Paysanat Musulman", 1st June 1946.
Thus whatever the achievements of the colonists in the realm of the modernization of agriculture, this development cannot be divorced from the human context of misery and poverty it has created and the enduring hostility it has generated against progress as brought by the European civilization.

EUROPEAN COLONIZATION AND THE AGRICULTURE OF BARBARY

Whatever views may be held as to the debit side of colonization it has also got a credit side to it. The higher agricultural standards established by the colonists and their considerable influence in improving varieties and production cannot be doubted. A comparison of the new and traditional methods will be made in later chapters and their yields contrasted. The colonists have also been instrumental in bringing extensive areas, formerly ineffectively exploited, under intensive cultivation. They have also cleared marshy tracts of which the Mitija plain stands out. In doing all this, it should be recalled, they received every assistance from the government. Furthermore it is also true that in most cases all that the colonists have invested in the land has been their supervision for most of the farm-work has always been done by cheap native labour.

With the passage of years, some distinct tendencies have emerged. The fact that despite the prodigious efforts by the government over a century to populate the countryside with Europeans the number of landholders has come down in Algeria to
26,000 illustrates one of them. This is the concentration of land in the hands of a few and the creation of "what amounts to actual latifundia". Another trend has been towards the mechanization of agriculture. While it shall be discussed further in a later chapter, it has emphasised the problem of the landless natives by reducing the number of workers required on the land. It has also been largely responsible for the first trend by facilitating the cultivation of large farms and even conferring advantages on it. Lastly, the cultivation of commercial crops is becoming intensified and there has been a marked extension of citrus and fruit orchards, early vegetables, flax, sun-flower etc. In this respect the colonists are giving a lead to the rest of the cultivators in the diversification of agricultural production.

The Influence of Colonization on the Regime of Landed Property among a Moroccan Tribe (ii)

The change in the regime of landed property among the Sherarda is being described in detail because it represents in miniature many of those far-reaching developments in the man-land relationship that have been taking place all over Barbary. The study also illustrates how the system of landownership and tenancy is an economic and social expression of the interaction between a human group and the environment and undergoes a change when this environment is modified.

(i) A.Bernard, Pioneer Settlement, p.231.
(ii) Based on Jean Celerier, Op.Cit.
The Natural Setting of the Sherarda:

The tribe formerly occupied the eastern extremity of the Gharb plain along with the bordering hills. Their territory lay to the south of the Sebu from its confluence with Wadi Mikkes up to that of the Wargha. The geographic limits on the other sides are not so well-defined but could be placed approximately at Wadi Segotta on the east, Wadi Krumane on the south and Wadi El Hamma on the west. In 1912 (before the Protectorate) the total area occupied by their lands was over 154,000 acres and consisted of two natural regions.

1. The Low Plains are parts of the alluvial plain of the Sebu and its tributaries. They lie below 300 feet and are divided into two parts by an antclinal fold. The western part is drained by the Sebu, Rdom, Tihili, Hamma and Beht while the smaller eastern plain of which only one section belonged to the Sherarda is drained by the smaller wadis of Mikkes, Segotta and Mellah.

2. The ravined uplands consisting of two anticlinal folds with a synclinal depression between them. They reach a maximum height of 2,680 feet. The western ridge has been cut through by the Rdom in a gorge (see photo opposite). The crests of the folds are bare and rocky but between them lie several smaller valleys.
Climatically, the region is well-watered, the rainfall varying from 16" to 20" in the plains and exceeding 24" in the folded zone. Except for the crests, the soils are fertile and deep and the region is well-drained. The predominance of impermeable strata does not favour the development of subterranean reserves of water so that the area is subject to the vagaries of the rains for its harvest.

Summing up the natural conditions, the territory that formerly belonged to the Sherarda is one of the best agricultural regions of Morocco. It yielded good crops of cereals and leguminous crops. The abundance of watering points made it especially suitable for rearing cattle and sheep. That the area has greater potentialities was proved by the extension of citrus plantations after colonization.

The Sherarda and their Established Regime of Land

The Sherarda are descended from the Maqil tribe which immigrated into Barbary from Arabia during the 11th century. They are a warlike people who played a significant role in the rise and fall of dynasties in Morocco. Originally settled in the Sous region, they migrated to the Marrakesh plain where they continued their turbulent career. After an unsuccessful revolt in 1830, they were deported by the existing Sultan to their present habitat in the Sebu Basip. They consist of four tribal groups whose respective strength at the time of the 1936 Census

(i) Ibid, p.11
Shebanat 6,624  Zirara 8,399
Tekna 2,977  Ouled Delim 10,808

They were collectively allotted the area they occupied on the condition of providing military service to the Sultan. Thus the tribal assembly or Jemaa allotted a uniform parcel of land each year to every male member of the tribe capable of carrying arms. This consisted of about 20 acres and was called mokhzani - "held in the service of the administration". These warlike people, finding themselves settled in a fertile region soon became attached to the land although their land laws continued to be a simple unwritten state, administered by the Jemaa on the basis of orf (custom). They must have made poor soldiers because if the Sultan engaged in a prolonged campaign and the harvest drew near, the Sherardi braves would quit their swords for the scythe and desert in large numbers. Theoretically, the mokhzani were allotted every year before sowing time but in practice they became more or less permanent as tens of thousands of acres remained as collective property from which further allotments could be made to the younger generation.

Colonization

In pursuance of their policy of settling Europeans on the land, the French authorities made three successive requisitions of land as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>1919</td>
<td>17,400</td>
</tr>
<tr>
<td>1925</td>
<td>1,285</td>
</tr>
<tr>
<td>1929</td>
<td>8,715</td>
</tr>
<tr>
<td>TOTAL</td>
<td>27,400</td>
</tr>
</tbody>
</table>
This took away more than a sixth of their territory but what is more, the Sherarda lost all the western plain, the best and the most easily cultivated lands they possessed.

Results of Colonisation

(1) The Disruption of the Existing Regime

The different tribal groups were effected by this expropriation of land to different degrees. The Shebanat and Zirara who had their lands in the plains lost heavily whereas Ouled Delim were less affected, their lands being of a mediocre quality. The latter now occupied half of the remaining tribal lands and the dispossessed elements from the other groups found themselves in a sore plight. One of the first measures by the government to re-establish a balance was the allotment of 8,900 acres belonging to the Ouled Delim to the Zirara.

The great land-hunger produced by the loss of so much fertile land led to dissatisfaction and quarrels within the tribes and was accompanied by the growth of dishonest practices. The area of mokhzani allotments had been reduced to 17½ acres but even so the increasing numbers in the tribe made demands very heavy. Formerly the title to an allotment became established with marriage which was recognised as marking the attainment of adulthood. But whereas the impoverished tribal members could not afford to marry and thus claim a share, the well-to-do landowners would marry their numerous male progeny even before puberty and thus acquire several mokhzani allotments. Local civic
dignitaries - qaids, khalifas and sheikhs made use of their powers to accumulate large estates. Privileged persons like religious leaders and those holding special titles from the Sultan exploited the opportunity to their own advantage.

Certain established practices further complicated matters. Bernisha is an age-old institution based on a fact of soil chemistry. As leguminous crops grown in the spring enrich the soil for the following winter cereals, the occupier of the land can extend his leave on the ground that he is entitled to benefit from the soil he enriched during the previous year. This led to allotments and tenures becoming perpetual.

(2) Reduction in the number of Cattle came as an inevitable consequence to the reduction of collective lands on which they used to graze. The large collective enclosures containing the tents of a dwarf and the land reserved for the movement of animals (known as masha) became progressively reduced and privileged persons like local chiefs extended their cultivated land on to them. This made movement and accommodation of cattle and sheep a serious problem. The following figures show the extent of the reduction in numbers:

<table>
<thead>
<tr>
<th></th>
<th>Cattle (grown up)</th>
<th>Sheep and goats</th>
</tr>
</thead>
<tbody>
<tr>
<td>1925</td>
<td>12,684</td>
<td>66,447</td>
</tr>
<tr>
<td>1934</td>
<td>8,524</td>
<td>39,115</td>
</tr>
</tbody>
</table>

With their old-established regime in a chaotic state, the strong exploiting the weak, the cattle and sheep decimated, the
Sherarda made a plea for the intervention of the government to regulate the property laws and the system of allotments.

Re-organisation of the System

The task of reforming the regime in the light of the changed condition was accomplished smoothly with the co-operation of several departments of the governments as well as the Jemaa and the Caids. The unit of distribution was retained at the reduced area of 17½ acres. Actual distribution presented a problem as the lands left in the hands of the tribe after colonisation were of mostly of an indifferent quality and everyone was keen to have the limited valley and plain tracts. The duration of the mokhzani was prolonged to the lifetime of a holder and the age at which a male adult became eligible was fixed. These latter modifications of the old regime represented an advance towards private ownership though property could not be inherited.

That the new allotments were well-defined and of long duration was certainly an advantage but the loss suffered by the tribe through the colonisation of its best lands could not be remedied. Of the 5,644 people who were allotted mokhzani in 1935, only half found it possible to subsist on the land, the rest leased their shares on nominal rents and migrated to the cities, seeking work on buildings, roads or worked as labourers in the fields. The area of communal lands was down to 1,100 acres after the reorganisation, and the plight of the cattle and sheep was a great factor in the reduction in their numbers.
The standards of the cultivation among the tribe were never high. Now on reduced holdings and poorer lands, even subsistence was a problem.

Here we have an example of the influence of colonisation on the life and lands of a tribe, resulting in general impoverishment and migration. Célèrier piously hopes in his study of the tribe that the intensification of agriculture will solve the difficulties of making a living and of providing a livelihood to the increasing population. That, if achieved at all, shall certainly take a long time because modernisation is the more difficult among impoverished peasants. In the meanwhile, large estates have been created in the rich plains for European colonists who practise mechanised agriculture and have established extensive citrus fruit orchards on their large holdings (the average in Morocco, to remind ourselves, is 520 acres). They are practising efficient modern methods and obtaining high yields but can their material prosperity be divorced from the poverty of the large native population they have uprooted?
In Barbary both geographical and historical factors have combined to produce a great variety of modes of life. These range from the nomadism of the Saharan tribes involving extensive seasonal migrations to the sedentary orchard cultivation of the elevated Massifs with an adequate rainfall. Between these two extremes lie a series of transitions which can be distinguished by a study of the type of habitations, the materials used in their construction and the size and nature of their groupings. West Punjab also had a wide range of modes of life before the great irrigation schemes fixed the semi-nomadic population of the drier tracts to the soil, thus creating a fair degree of uniformity. Even so, the present day differences in the size and plan of villages are reminders of the former diversity and at the same time portray the existing variations in land use. Historical and social factors also figure prominently in determining the variations in agricultural settlements. On the whole, however, the interest of West Punjab from this point of view is less than that of Barbary so that a brief account of its agricultural settlements will suffice.

Travelling over Barbary, one is struck by the frequent and sudden changes in the types of habitation. Within the same physical regions there are contrasts between poorly built huts and large modern houses or between isolated tents and large aggregations of rural habitations. The very location of
villages and hamlets shows remarkable variations for in one area settlements may hug the river banks while in another they avoid valleys and lie perched above precipitous escarpments in defensible positions. The progression from north to south has a definite zonal character i.e. from houses and huts associated with sedentary cultivation near the coast to the tents of the Saharan nomads. But such is the diversity in the types and grouping of habitations within these zones that no generalisations in terms of physical factors alone can suffice. The role of historical and cultural factors as well as the present day economic position of different groups is equally important in determining the nature of the rural cultural landscape.

**Agricultural Significance:**

The modes of life and settlement interact significantly with the type and intensity of land use. The type of agriculture practised by the semi-nomad who is able to visit his cultivated lands only twice each season - once at sowing time and once for the harvest differs greatly from the constant care given to the land by the cultivator living close to his field all the year round.
The settlements mirror the social organisation, i.e. the degree of tribal cohesion which is directly related to the regime of landed property. Wherever the tribal organisation is still strong and mutual social and economic ties unaffected to any considerable extent by individualistic tendencies generated by modern developments, the collective regime of property prevails. This is mainly in the domain of nomadic pastoralism and semi-nomadic cultivation combined with large-scale stock-rearing. In zones of old established cultivation or wherever the impact of European culture has disturbed tribal collectivism, the individual or "melk" property regime is dominant.

The following account treats mostly of the Muslim rural population of Barbary because as a result of prolonged residence in the region, its social organisation, methods of land use and the modes of settlement are adapted to the environment and show greater differentiation. European rural settlements are, comparatively speaking, insignificant in their number. Even if their considerable economic and social importance is realised, they are all creations of recent times and do not vary to any considerable extent in their design and layout. The indigenous tent, hut, or house, differs little from the landscape by its height or colour whereas the modern European farm stands out as a sight at once foreign and unusual with its orderly stables and barns, the houses with red-tiled roofs and the geometrical shapes of the field and farm alike.
Even though the survey of European farms and villages is not by itself as important as that of indigenous rural settlements, the impact of their installation as well as the technical developments associated with western rule have disturbed the age-old adaptations to the environment. Everywhere the entire social and economic structure of the native rural population is undergoing change. In the previous chapter, the influence of European colonisation was considered in many of its aspects. Other developments such as the establishment of political stability and individual security, the development of modern transport and communications, the introduction of a monetary economy and the growth of foreign commerce have all widened the local horizons, undermined collective social and economic organisation and indeed modified completely the relationship of man with the soil and with other men. As stated in the chapter on the Agricultural Heritage, the main currents of civilization have hardly been disturbed. But the aspect of the rural landscape is changing as irrigation developments bring former pastures under the plough. The installation of a strong administration has reduced the power, influence, as well as the movements of the great nomadic tribes who often had the sedentary population of the valleys and plains at their mercy.

Such a study is not only of intrinsic interest as a compelling human development but has great practical utility. The population of Barbary is predominantly rural and is rooted in the soil. Any planning envisaging their social and economic
advancement must establish the characteristics of different groups in relation to the environment and the cultural factors, past and present. Neither paper plans based exclusively on the theories of economists, which often treat the peasant as an abstraction nor well-meaning administrators can achieve concrete and lasting results unless the peasant is placed in his natural setting and seen in the cultural perspective, bearing the weight of tradition on his shoulders. The geographer is perhaps the best equipped of all scientific investigators to work out an analysis of the system of forces that mould the peasant's way of life, his manner of cultivation and the nature of his settlement.

Factors Determining Modes of Life and Settlement in Barbary

PHYSICAL FACTORS: Although relief, climate, hydrography, soil and vegetation all influence the life and settlements of the population of Barbary, climate dominates the other natural elements not only by dint of its intrinsic importance but also because relief, running water, soil and natural vegetation are greatly influenced by climate. If man finds it impossible to maintain himself permanently at high altitudes it is more the occurrence of snow and the exceptionally low temperatures in winter rather than the actual elevation which force seasonal movements. The presence of water-supplies for domestic use and for irrigation is also as much a function of the climate as of the nature of geological strata although beyond certain limits, i.e. in arid regions, the rare downpours cease to be a
modifying influence in the life of the people and permanent settlements cluster round springs and artesian wells, as in the Sahara. In the domain of the semi-nomadic and the nomadic communities seasonal movements are directly related to the seasonal changes in temperatures and rainfall. Within climatic, and specially rainfall, zones, however, the finer aspects of distribution of settlements are governed by topographical features and the distribution of soil types as well as the nature of water supply.

This dominant role of climate is a feature of semi-arid regions as distinct from those temperate and tropical regions wherein the climatic conditions are generally favourable and the role of soil types and relief is more important. Furthermore whereas the soil can be improved by manuring or the use of fertilizer, and the steeper slopes can be terraced, there is no means of improving the climate by human effort. One can only remedy the deficiency of water by irrigation within the limits of available water supply. Beyond that the dominion of climate over modes of life is much more complete and lasting than that of the other natural elements.

The role of relief in the distribution of settlements is best summed up in the importance of plains and valleys by reason of their being better suited for cultivation, the ease of transport and exchange and the usually abundant supplies of water. Mountains and plateaux have difficult communications, cultivable land is rarer and the soils thinner. Water supply also presents problems so that even in mountains, it is the
valleys of streams that form the nuclei of settlements. Within plains, settlements lie above the periodically inundated flood-plains on terraces or other elevated features. Gentle slopes are best, for while the disadvantages of steep slopes are obvious, no slope at all leads to bad drainage and marshy conditions. This general description of the role of relief is elementary but has been given here because in Barbary it does not always hold and the reverse is often true, i.e. high Massifs with steep slopes have long been inhabited by dense sedentary populations whereas the low-lying valleys and plains have been the domain of the semi-nomad. For this climate and history are about equally responsible. Mention was made in summing up the chapters on the physical background how favourable relief features in Barbary and West Punjab/not always combine with favourable climatic conditions. The relation of this fact to the modes of life and settlements will now be examined.

Except in the north of Barbary, where rainfall is sufficient, the low plains and valleys have their well-known advantages for rural settlement discounted by prevailing semi-aridity. On the other hand precipitation increases with altitude. Beyond a height of 3300 feet, however, temperature conditions become unfavourable.\(^{(1)}\) The zone of high plains and lower mountains thus combines the advantages of suitable temperatures and adequate precipitation. Thus it is that the

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\(^{(1)}\) J. Celerier "Le Paysage Rural au Maroc" Hesperis 1943,
lower northern slopes of the Atlas ranges in Morocco, the Massifs of Kabylé, the dir (foothill) zone of the Moroccan Atlas ranges and the lower Pre-Rif and Rif mountains have been the zones of rich orchard cultivation with large fixed settlements. Higher up, weather conditions in winter become rigorous but even so cultivation of barley, the plantation of walnuts and along with them the settled hamlets exist up to heights of over 7,500 feet in the High Atlas of Morocco. Here, however, seasonal migration has to be practised as will be described later on in the chapter.

Reference may be made here to the map of settlements and cultural zones in the Tunisian Sahel adapted from Despois (No. 26) where settlements are seen to be concentrated north of the 12" isohyet. The concentration of a population deriving its livelihood mostly from olive orchards became impracticable further south as distance between individual trees would increase as would the distance between individual holdings. As isolated habitations could not withstand the periodic incursions of the Saharan nomads, and large agglomerations capable of doing so were out of the question as the orchards would stretch too far away from them, the olive plantations did not extend greatly west of Sfax till the establishment of a strong government under the French eliminated the fear of nomadic raids. Prior to that the 12" isohyet virtually formed the limit of sedentary villages.
The influence of water supplies is paramount in the actual location of settlements and the periodic resting places of nomads centre around watering-points. Some of the best-defined zones of settlement in Barbary are located along spring-lines at the foot of mountain-ranges i.e. at the foot the High Atlas in Morocco. The role of this factor will be pointed out later on when each zone or community is described in detail. Water-logged regions on the other hand are avoided. Before the French conquest, the marshy plains of Gharb, Mitija and Bone had few permanent habitations.

The role of soils in the distribution of cultivated land as well as of settlements is an important one. Certain heavy soils (such as the "tirs" of Morocco) have a high moisture-retaining capacity and ensure cultivation in years of drought. Coastal sandy soils (remel) in Morocco are also well-appreciated by the peasants and yield good crops under the prevailing conditions of high humidity. Such zones have long been inhabited by fairly dense sedentary rural communities. Regions of waterlogged or saline soils on the other hand have resisted human settlement. The problems of these areas and their possible solutions will be discussed in a later chapter.

The role of vegetation is evident in the modes of life and settlement in two ways. Firstly, for the pastoral population, the type and abundance of the pasture is of paramount importance. The Land Classification Map of Barbary indicates very generally the capacity of different vegetation
types. Thus, the dwarf palm - temperate grass zone which covers a large part of the lowlands and high plains is shown to be a region of medium carrying capacity - about the best in Barbary from this point of view. These as the subsequent account will show have indeed been prominent in the pastoral economy of the region. The second function of vegetation is its role in providing the raw materials for the construction of houses and huts of various types. The variation in the construction and shape of huts is related to the vegetation from which their building material is derived.

CULTURAL AND HISTORICAL FACTORS

The rural landscape is essentially a handiwork of man for which the natural environment is only a setting. He moulds it or shapes his adaptation to it according to his needs, his knowledge and his power. The nature of man's activity with relation to the soil is determined not by the individual but rather the collective group whether it is tribal or racial. The activity of the human group is not changed suddenly with a change of environment and may go on according to its ingrained habits after a change of habitat. Celerier sums up this influence as follows "A human group when it is installed or goes on to instal itself in a region, carries with it, by reason of its being a collective organisation, a system of psychological values, an internal dynamic spirit which is the most constant basis of its activity"(I). This influence is

(I) Op.Cit. P.143
reflected in striking anomalies in the types of settlements in a region due to the existence of a tribal group which migrated not long ago from another habitat. Many of the great transhuming tribes in Morocco are of Saharan origin and their use of the tent must be traced to Saharan precedents. The Ait Ayyash, who came from the south, established a large tent colony in the region of Fez, and a single walled oasis type village (ksar) in the Middle Atlas. The Iguerrwan found inhabiting tents around Meknes still have their distant cousins in the southern valleys of the High Atlas.

The group spirit and its attitude towards the land is not absolutely rigid and always reacts to a new environment by new adaptations and inventions, yet older traits tend to persist. Thus the second wave of the Arab invasion in the shape of the nomadic Hilalian and Beni Solaym tribes has left a lasting imprint and although many of these groups settled down, large groups today which trace descent from them practise transhumance at the Saharan Fringe.

The internal history of Barbary was largely shaped by the movements of the southern nomadic tribes towards the fertile plains of the north. One tribal group would conquer a kingdom by reason of its greater mobility, its hardiness, spurred on perhaps by drought. It would settle down in the plains and lose those qualities it had acquired in an unfavourable environment only to be over-run by a new nomadic invasion. Ibn Khaldun (1332-1406), the greatest Muslim scholar and historian Barbary

(1) E. Lacoste "L'habitation chez les transhumants du Maroc central" Hesperis 1934, p.193
has produced put the life of empires at three generations. "The first generation", he observes "maintains its nomadic character, its rude and savage ways of life; inured to hardships, brave, fierce, and sharing renown with each other, the tribesmen preserve their solidarity in full vigour; their swords are kept sharp, their attack is feared and their neighbours vanquished. With the second generation comes a change. Possessing dominion and affluence, they turn from nomadic to settled life and from hardship to ease and plenty. The authority instead of being shared by all is appropriated by one while the rest, too spiritless to make an effort to regain it, abandon the glory of ambition to the shape of subjection.... They retain however much of what they have known and witnessed in the former generation - the feelings of fierceness and pride, the desire for honour and the resolution to defend themselves and repulse their foes.... In the third generation the wandering life and rough manners of the desert are forgotten, as though they had never been .... they (the men of the ruling tribe) require protection like women and young boys" (1)

Role of Insecurity: This continuous rise and fall of kingdoms and the repeated incursions of the Saharan nomads into the plains and valleys of the north gave rise to the greatest single factor determining the type and location of settlements - insecurity. As periods of strong centralised administration were limited, sedentary cultivators in the plains always lay exposed to attack and pillage. This more even than climatic

(1) From a selection from his Prolegomena by R.A. Nicholson "Eastern Poetry and Prose" Cambridge 1922, p. 184-185
Aridity was responsible for the absence of sedentary settlements in most of the plains of Barbary. Only around large towns or in areas effectively governed for considerable periods such as the Atlantic coastal plains in Morocco protected by the Makhzen (administration) and the region of Tunis can permanent rural settlements trace a long history.

The prevalence of huts of various types (gourbis, nwalas etc.) made of straw and branches of trees can also be attributed to insecurity. If the population of a region found itself suddenly compelled to abandon the area there would be little loss in leaving behind such habitations which could be speedily reconstructed in another region. This enforced mobility of the population was also responsible for the premium placed on cattle and sheep as this was the wealth that could be easily transported during an invasion. The other reason for the importance of herds and flocks in the rural economy has been the uncertainty of harvests even in well-watered areas due to extreme variability of rainfall. Almost everywhere agriculture is associated with cattle or sheep rearing which occupy the peasants' families, particularly the younger members who get their initial training in husbandry by tending cattle.

Yet another consequence of insecurity is the concentration of sedentary population in the elevated Massifs. In the southern Massifs and mountains, i.e. Aures and the High Atlas, as not only many of the men, but the whole community sometimes follow the flocks and herds in their transhumance, fortified communal granaries (guelaa, agadir etc) were
constructed. These will be described in some detail later on in this account.

The influence of religion may be noted especially. Since the early Arab invasions, almost the entire population has been Islamised. The cult of Marabouts (i.e. belief in the holiness of certain persons and in their spiritual power has resulted in many places being venerated as sacred either because of the tomb of a marabout or the residence of a living one and usually both together as the descendants of the original saint continue to be revered. Such places are inviolate and a nomadic tribe even if it be starving from want would not raid them. Hence these have been the nuclei of large settlements in almost all regions of Barbary. They are usually marked by the absence of fortifications and the location of the domed tomb of the saint in a prominent position. Most places whose name commence with Sidi (meaning My Master) or Mowlay ("My Lord") - and they are fairly numerous - are of such origin.

The rôle of the Tribe: The influence of tribal migrations in transplanting types of habitations different from those locally in vogue was described briefly in an earlier paragraph. As tribal organisation exercises an important influence over the distribution of various types of settlements, some of its outstanding features may be described here. The behaviour of human groups over most of Barbary has been determined more

(i) A marabout is a descendant of the prophet Mohammed.
by their tribal loyalties than by their attachment to any particular region. This was more true of the former times of insecurity when in a habitat poor in natural resources, the struggle for the possession of oases, better lands and pastures led to the functioning of the tribal unit as the basic human group. This loyalty to the tribe ("biological patriotism" as Gautier put it) rather than to the land was a natural outcome of conditions in which limited stretches of territory could not support large communities who roamed over the countryside looking for pastures, a countryside belonging in effect to no one group. Where land was fertile and climate favourable, i.e. in the lowlands of the Tell and the coastal zone, invasion and conquest by other tribes made lasting attachment to the soil impossible. This tribal spirit has persisted even where sedentary cultivation and private ownership of land have removed the raison d'être of the tribal organisation. Settlements usually consist of members of the same tribal faction or clan and many of the customs and methods that go back to the period of residence in another habitat are still followed.

Tribal involves obedience to the chief of the family. The patriarchal family is the basic social unit. A group of families form a sub-unit called karouba in Kabylie, ikhs (or ighs) in Morocco. These units usually inhabit a hamlet or a section of a larger village. The next higher unit is the village (taddert in Kabylie, Arrem or dshour in Morocco and Ksar in the south)
The tribe consists of a number of villages and is an assembly of clans whose representatives from the jemaa or the central council which settles disputes and supervises various forms of pastoral and agricultural activity. The tribe need not always be a homogeneous group related by blood and may often be a combination of several groups brought together by common interest.

The extension of sedentary cultivation, the growth of communications and the establishment of peace and order during the period of French domination has weakened the tribal organisation. Large-scale movement of rural families to the towns has tended to mix the different groups. As was pointed out in the case of the Sherarda, colonisation has given an impetus to this exodus to towns which is by itself a normal development. Tribal loyalties die hard, however, and groups from a tribe tend to congregate even away from their home. The group consciousness of tribesmen can survive the tribal organisation by many years. This is proved by the experience in West Punjab where the colonisation of newly-irrigated colonies succeeded only when the government adopted the practice of settling members from the same tribes and social groups in the old settled districts (i) although the original tribal character of these people had disappeared generations earlier.

In the study of the human geography of lands where the tribal grouping has been a potent force till recent times the factor

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(i) Deva Singh "Colonisation of the Rechna Doab" Lahore 1929, p.18
of tribal loyalty needs always to be kept in mind.

**ECONOMIC FACTORS:** If a community can satisfy its requirements from the resources of its environs, migrations on a large or small scale are not necessary. The influence of the climate in enforcing seasonal movements translates itself into an economic factor, i.e. frozen lands at higher altitudes not providing subsistence for men and cattle in winter. In this respect the Land Classification Map of Barbary should be compared with the map showing the distribution of modes of life. The Land Classification Map is based on vegetation as an index of the climatic and other natural factors and on soil and it does not take into account the role of human endeavour to improve productivity. Thus large sections of the Middle Tensift and Um-er-Rbia valleys have been cultivated in the Tadla and Haouz regions under irrigation and these are areas which on account of their aridity are shown to be "unsuitable for cultivation". The map does, however, provide a useful basis for seeing how far the modes of life accord with the potential productivity of different regions. It will be noticed that the zone of "highly productive agricultural land" does in fact constitute the domain of sedentary fruit-growers in the humid elevated Massifs and of cereal-growing cultivators in the remaining lands except for forested areas. Most of the regions which appear as being unsuitable for agriculture but
are "grazing land of low carrying capacity" are inhabited by pastoral semi-nomadic communities. The zone of medium agricultural productivity is mostly under cereal cultivation by sedentary farmers. Thus, broadly speaking, the modes of life do correspond to the natural productivity of the different zones in Barbary.

Apart from this basic economic consideration, the types of habitations built by the rural population of a region reflect not only climatic or cultural influences but also the comparative prosperity of the peasants. The tent is made either of woven wool or of skins of animals, hence to erect it requires some wealth in the shape of camels, cattle or sheep. The prosperous sedentary cultivator lives in a mud or stone house whose size, height and materials vary with his wealth. The hut (gourbi or nwala) is on the other hand the habitation of the poor be they impoverished pastoralists or cultivators. The large modern farms with separate buildings for agricultural machinery and farm animals are always associated with the large landowners whether European colonists or Muslim notables. Herein the role of the size of holdings is paramount and if nwalas and gourbis dominate in Barbary, this is essentially because about two thirds of the peasants own holdings of a size that support them only according to the poorest standards of life and leave no surplus to enable the use of building materials necessary for houses.
PRINCIPAL TYPES OF HABITATIONS AND SETTLEMENT

In the course of the discussion of the main factors determining the modes of life and settlement, several types of habitations were referred to. Before their regional distribution and differentiation can be undertaken, their general features might be described here.

The Tent: (khaima) Tents are used over the larger part of Barbary, mainly in the semi-arid and arid parts by the pastoral population. Bernard has observed in the case of Algeria that tents do not occur where rainfall is more than 500 m.m. (about 20")\(^1\) This may be accepted as applicable to the whole of Barbary. Mountains are another limiting factor as tents are not suitable for high altitudes. The tent was introduced into the region by the Arabs and consists of flīj or strips of material of varying width made from woven wool, fibre of dwarf palm and often of skins of camels, goats sown together. The strips are stretched over a framework of poles which varies in design over different parts of Barbary. The width of a flīj is usually 16-28" and length several yards. They are sown together according to the size of the tent which vary in width from 12 to 22 feet in the case of smaller tents to 40-50 feet in the case of larger ones. Each tent is divided by means of a woollen curtain into two parts, one for the men and the other for women and children.

Whereas it is true that all the nomads live under tents, all those who live in tents are not necessarily nomads. In the plains of Western Morocco, the tents form the roofs above thatched or mud walls and are used as permanent habitations by the sedentary population. The tent is also used during seasonal migrations by tribes living in houses, i.e. the Shawia of Aures.

In recent years, the tent has retreated with the extension of cultivation. According to the map drawn by A. Bernard and E. Doutte in 1917, tents extended to the coast of Oran. Observations by the present writer as well as by other authors writing after that show that the gourbi has replaced the tent as cultivation has advanced at the expense of grazing.

Tents are usually arranged in dwars. A dwar is a circle of tents in which the central space (msaha) is reserved for the animals. The location of dwars is so planned that they are not easily observed, i.e. behind some natural obstacles off the main routes. Thus it can happen that the traveller may traverse a densely populated area without being aware of it. Lately with the establishment of law and order, dwars have tended to diminish in size and even isolated tents are a common sight.

Huts: (gourbis, nwalas) Numerically, huts are probably the most numerous type of habitation in Barbary. They

(1) Bernard, A, L'Afrique Septentrionale et Occidentale P. 89
A tent in the plain of Beni Amir in Morocco. It consists of several lengths ("flij") of woven wool joined together covering a wooden framework.

This photograph illustrates the structure of a hut (gourbi). The walls are made of tufts of diss grass (Ampelodesma Mauritanica) tied to stakes dug in the ground. The framework of round stakes to be covered with a grassy thatch for a roof is also seen. On completion, the gourbi will resemble the one seen partly to the right.
A dwarf of nwalas in the plain of Beni Amir. Notice its circular arrangement with an enclosure in the middle to shelter the flocks of sheep at night. One such flock with its young shepherd is seen in the foreground. Unstacked hay visible near the nwalas nearest to the camera.

Modern European-styled farm-buildings under construction. These are being erected for skilled labour (mechanics and tractor-drivers) on a large citrus growing farm belonging to a Muslim landlord in the Gharb plain. Behind the building under construction, the corrugated iron roof of the large granary on this farm can be seen.
characterise the average cereal-growing cultivator although they are often associated with the semi-nomad in which case they are intermediate between the tent and the house i.e. in the middle Um-er-Rbia valley (plain of Beni Amir)

There are many types of huts of which the materials vary according to the vegetation. Straw, reeds or branches of various trees and bushes are used on a wooden framework. The two main types are gourbi which is rectangular with a double slanting roof (Photograph No. 2) and the nwala, a conical hut like that found in Sudan which is typical of Morocco. The zeriba of southern Tunisia and Algeria is constructed with trunks of date palms. Gourbis and Nwalas are both grouped as dwars with a central open space for animals. Photograph shows a dwarf outside the irrigated sector of Beni Amir(1) consisting of several nwallas.

The hut, the permanent habitation of the poor peasant, is not only expressive of his poverty but also of the fact that in the past cereal cultivation did not fix a semi-pastoral people to the soil. A hut provided shelter in the prevailing conditions of penury, insecurity and a mode of life in which grazing animals were usually at least as important as cultivation. The gourbi or nwala occurs at greater heights than the tent, covering most of the Tell in Algeria and Tunisia with the exception of the Kabylie Massif. At the same time it is associated with a higher density of population than the tent.

(1) Described later in the chapter on Irrigation.
Intermediate between the hut and the house is the meshta in Morocco, of which the walls of mud or sun-dried brick bear a low thatched roof and it is used by sedentary cultivators in the lowlands of Western Morocco. The word meshta means a winter residence and is applied in other parts of Barbary, notably in the mountains to the winter-house which is the chief home of tribes transhuming in summer. This brings us to a confusion of nomenclature about which care needs to be taken by the field worker. Thus the word khaima meaning tent is often applied to any habitation and especially to huts in the Gharb plain and its borders. This probably originated in those groups, who having originally been tent-dwellers continued to call new types of habitation by the same name.

The House: (dar) The house is in principle the typical habitation of the fruit cultivator and characterises the population fixed to the soil over most of Barbary. It consists of stone or mud walls with a flat roof. Only the Kabylie region and some of the neighbouring Massifs have gabled roofs, tiled with slate apparently because the Kabylie region is among the wettest in Barbary, there is usually snow in the winter for which a flat roof would be unsuited.

The typical house or dar consists of one room without any windows but with some holes in the wall at the top. The fireplace is always in the centre of the room and consists of three stones put together. Very often the single large

(1) J. Celerin, "Le Maroc" P. 49
room is divided by means of a wall into two parts, one reserved for the cattle and the other for the family. Above the stable is usually a garret reserved for women and children.

Houses generally occur in closely packed villages with narrow lanes, and unless gabled, they present a flat-topped surface on the plain and a step-like appearance on a slope as the rows rise one above the other in hill country. The village is almost always located in a defensible position above steep slopes or precipices. Sometimes, a village may consist of hamlets inhabited by families and clans, each lying near its own lands and yet close enough to the other quarters of the village to group together against an intruder. This is true especially of northern Morocco.

Scattered houses characterise only those regions wherein the rural population has enjoyed a reasonable amount of security. The Cap Bon region of Tunisia has its garden-cultivators living close to their lands.

Houses of European-type using modern building materials such as steel girders, cement etc. have been adopted by the well-to-do Muslim farmers in regions where colonisation has been intense. These houses are most marked around agglomerations of European population in Algeria, i.e. Oran, Sidi bel Abbes, Mascara, Algiers (see map of types of habitations) In the department of Oran modern villages were planned in some cases for native peasants displaced by colonisation. (1)

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(1) A.Bernard & E.Doutte - Op.Cit. P.227
Fortified Store-Houses are found in sedentary villages in the elevated parts of Southern Barbary where limited seasonal transhumance is practised. The villagers store their grain and other valuables in these storehouses which occupy the safest positions in the village or the neighbourhood and there are separate cells or rooms for each householder. In the Aures Massif these buildings are several storeys high. They are called guelaa and are often located in such formidable positions that no guardians are considered necessary. (1)

In southern Tunisia where they are known as ghorfas they consist of round roofed cells in rows, often several storeys high. In Morocco they resemble the guelaa of Aures in certain parts i.e. the Anti Atlas and are called agadir or assume the appearance of four towered Mghremt (see photo 26) which also house families sometimes.

Fortified Rural Centres: While most old-established sedentary villages in Barbary are placed for defence against attack, true fortress-settlements have developed in certain zones. Above the foot-hill zones of the Atlas ranges in Morocco, large fortified strongholds were built in the valleys. Locally known as kasbahs these once housed turbulent feudal chieftains whose importance was recognised by

(1) G.H.T. Kimble "The Berbers of Eastern Algeria" C.J.1941 P.342
the Sultan. Among these are Warzazat and Kasbah Tadla. The chiefs have lost much of their political influence by the establishment of French suzerainty but their settlements have usually become regional administrative centres.

**Absence of Market Towns:** On account of ever present insecurity and the absence of a large surplus among tribes with predominantly subsistence economy, no rural market towns arose. Instead, the function of exchange was taken over by weekly open markets or fairs (suqs). Some market centres have developed since the French conquest awakened the region to the requirements of world trade and commerce and introduced modern transport.

**The Urban Settlements and their Role:** The cities that grew up during the Arab epoch were mostly new centres created at the behest of a reigning monarch. The older cities decayed. Among these new cities those in Morocco deserve particular attention because many of them served at one time or the other as royal capitals and exerted a considerable influence on the countryside by settling large numbers of people whose needs led to the destructions of forests and the extension of cultivation. Fez, Meknes, Marrakesh and Rabat have all been capitals of Morocco. They are said to owe their origin and growth to the fancy of the kings of the time. Fez was founded in 808 A.D. by Idris II, Marrakesh in 1062 by Yusuf ben Tafshin, the founder of the Almoravid dynasty. The shifting of capitals was not entirely due to whims of fastidious monarchs but followed the policy of the kings in accordance with the well-known
A village in the irrigated section of the Beni Amir Plain. Nwalas without courtyards mix with houses with courtyards to indicate not only the relative prosperity of different peasants but also their recent change from a largely pastoral way of life. There are no planned streets but the houses are jumbled together in an incoherent mass.

Village of Amizmiz at the foot of the High Atlas. This is a large settlement built on a dissected fan of a large perennial stream and consists of two-thousand houses. View taken across the wadi shows terraced olive groves in the foreground, the village rising in tiers on the slope opposite as well as the lower gentler slopes that are partially terraced for unirrigated cultivation.
26 Tighremt (fortified grain-store) south of Marrakesh. Some of these towered structures are also used as communal residences. In the foreground land is barren for the lack of irrigation.

27 European village of Enfidaville in Central Tunisia midway between Tunis and Sousse. It lies at the centre of the large estate of Sidi Tabet covering 247,000 acres. It houses the European managing staff and is a regional administrative centre. Building to the right is a mosque for Muslim workers. Field of barley in the foreground across a small stream.
geographic principle laid down by Vaughan Cornish. Each of
the capitals has been located in a productive region ("Storehouse")
such as the Haouz plain around Marrakesh or the Fez-Meknes
region. Marrakesh lay on the vital route to the south from
which its founder originated, Fez and Meknes both lie on the
important route along the Taza Gap to Algeria. Rabat, the
present capital, was chosen with the Moroccan Sultans
concentrating their attention on European coastal invaders.

The cities have been a world removed from the rural
settlements and their old established inhabitants have always
considered themselves to be the real gentleman, hadria, distinct
from the peasant settlers of towns, the berrani. Only four
cities in Barbary are known as hadria, Fez, Rabat, Tlemcen and
Tunis. (ii)

The older cities of Barbary consist of three parts,
the citadel or kasba, the residence of the ruler or governor
and his advisers and servants, the ghetto or mellah, the quarter
reserved for Jews and the main body of the town, the medina
with its numerous suqs (bazaars) and markets. These towns have
always been centres of administration, culture, trade and
handicrafts. Their agricultural influence has not extended
beyond their immediate environs. Some of the larger absentee
landlords live there. Usually the inhabitants of the outskirts
are cultivators of vegetables and fruits. But on the whole

(i) "Great Capitals" London 1922, p vii to ix
(ii) A. Bernard Afrique Septentlonale et Occidentale P.87
The town of Mateur in northern Tunisia lying in the centre of the Mateur plain with the undulating Beja region in the distance. Notice the mixture of flat-roofed old type houses in the distance and the tiled and gabled roofs of modern houses in the foreground. Mateur is one of the few old towns that might be called a rural marketing centre.

Town suq (market) at Mateur devoted to the sale of cattle. This one is held weekly on Monday in this large courtyard around the domed tomb of a marabout (saint). Modern buildings around are banks.
the urban settlement in Barbary has always been out of harmony with the countryside by its appearance, activity and spirit.

The Open Market or Suq: As stated, there was a marked absence of market towns over the region before the advent of the French. The number of sedentary settlements was small over large areas and even these did not have any considerable commercial activity. Under conditions of a semi-nomadic life, difficult communications and insecurity, there came into being the institution of the weekly market at which the members of neighbouring tribes could exchange their surplus produce for other necessities. The suq has long since become established as a feature characteristic of the rural economy of Barbary and plays such a significant part in the social, economic and political life of the rural population that it continues to thrive despite the growth of numerous trading centres all over the region in recent years.

The suq is held once a week in an area which may be occupied by one tribe or a subdivision of a tribe and is named after the day of the week on which it is held (i.e. Suq el-Arba, the Wednesday market, Suq el-Khemis, the Thursday market etc.) Larger tribes may have one on every day of the week in their different sections. The suq is never held on the same site on two successive days but may sometimes take place near the same site on two different days if there is sufficient demand for its functioning in that neighbourhood.
The arrangement and activity of a large suq in Morocco may now be described. The reason for this choice is twofold. Firstly the suq is found in its most characteristic form in Morocco where French rule came latest and consequently the new rural centres have not changed the aspect of the suq. Secondly the suq reaches its greatest development where exchanges take place between products of contrasted economies i.e. between the products of the mountain-dwelling pastoralists or arboriculturists and the produce of the cultivators and artisans of the plains and valleys. These contrasts are most developed in Morocco.

The map showing the distribution of suqs in Morocco shows some distinct alignments corresponding to the zones of contact between tribes having different resources and modes of life. The N.E. to S.W. trend north and north-east of Marrakeh and the east-west arrangement of suqs to its south mark the contact between plains with sedentary cultivation and mountainous zones within which pastoralism is dominant. East of Fez there is a similar east-west arrangement of suqs at the foot of the Middle Atlas where exchanges take place between pastoralists and grain-cultivators. Between Meknes and Port Lyauty a curved line of suqs occurs where the Mamora forest with its wood-gatherers and pastoralists comes into contact with the cultivated plain. East of the Atlantic plains between Rabat and Safi, a noticeable alignment is N.NE to S.S.W. at the edge of the central Massifs which are largely semi-nomadic. A concentration of suqs also marks the lines of contact between the
Distribution of Sugs in Morocco

(from 1897, i.e., 1897, Geographic 1902)
Plan of a large rural house (Dar) in Morocco.

[After Pons, R.G. Morocco, 1939]
Sous plain and the bordering ranges.

This emphasis on Morocco should not mean that the suq is disappearing in Algeria and Tunisia and is being displaced to any large extent by the new towns. The main currents of native life go on side by side with the development of internal and external commerce and though the wares sold at a suq may change from native woven cloth to machine-made textiles, the suq itself continues to function as a medium of exchange and as a social factor of great influence.

A large Moroccan suq as will be described now represents most of the features common to most suqs in other parts of Barbary. It has an important political function as this is where the tribe congregates and justice can therefore be conveniently administered. Hence the centre of the larger suq is usually occupied by a group of tents housing the tribal and government officials. They collect dues and taxes, administer justice, and while some are maintaining peace and order others known as adoul (lawyers and solicitors) give legal sanction to the larger transactions such as the selling and purchase of animals. (1)

Around the administrative nucleus stretch the tents of traders selling comparatively valuable goods. They are grouped into three main sectors which are regularly arranged in the same

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(1) The account of the Moroccan suq is based largely on W. Fogg "The Suq": A Study in the Human Geography of Morocco" "Geography" 1932, 257-267. The writer however did visit a number of suqs in different parts of Barbary - see photographs.
Diagrammatic Plan of a Suq
(after Fogg, Geography, 1882)
positions so that clients do not experience difficulty in locating them. The Kaisarya quarter contains foreign manufactured cotton and silk cloth, embroidery and fancy goods. "Suq-el-Haik" houses sellers of woollen fabrics and native outer garments. Lastly the "Suq-el-Altarin" or general grocery quarter sells sugar, tea, candles and other grocery wares.

In the outer circle swarm the miscellaneous traders, usually grouped in a fashion resembling that in towns. The usual positions are indicated on the accompanying diagram reproduced from Fogg. The livestock section forms a very important part of every suq and considerable numbers of sheep and goats as well as cattle, camels and horses change hands. Near the slaughtering section, a group of traders roast pieces of meat on portable braziers providing the poorer tribesmen with their weekly treat of meat.

Indispensable for any suq are the entertainers - acrobats, snake-charmers and story tellers who provide amusement to the tribesmen.

The suq usually commences early in the morning and reaches the peak of its activity in the forenoon. By the afternoon only the people of the neighbouring dwarfs remain and before the sun sets, the place is so completely deserted that the stranger will find it hard to imagine the morning's activity. During the few hours of its weekly existence, the suq is "like a vigorously pulsating heart; the heart of the tribe"(1)

(1) Ibid p.260
It is not only the centre where all the larger commercial transactions and the weeks shopping for the households is carried out, it is also an occasion for meeting other members of the tribe coming from miles away. Gossip, rumours and news are exchanged and this is the only occasion when the tribe comes into contact with some representatives of the world beyond its limited confines.

The social significance of the suq is further enhanced by its usual association with a marabout. Many of the tribesmen though without any business to transact, turn up to partake of the baraka (blessing) of a living saint. In the past days of insecurity and tribal rivalries, the marabouts made the suqs possible by their great religious influence. To the peasant or tribesman inhabiting the wide open spaces of the countryside of Barbary, the day of the suq is a real holiday, the only event which diversifies his monotonous life. Here is business to be done, home needs to satisfy, amusements, justice and last but not least, the blessings of a revered person. The French government has realised the importance of these weekly markets and exercises considerable control and supervision over them. They are also used for giving publicity to government laws, schemes and campaigns.

The location of a suq is determined by custom and the general convenience of access. There are certain essential requirements for a site which have to be satisfied. First and most important of all, water-supply must be adequate for the
supply of thousands of men and animals. Hence suqs are always near excellent wells, springs or a river. Secondly, the ground conditions should be such that under the feet of such large numbers of animals and men, the ground does not become muddy in winter or dusty in summer. Hence stony sites are preferred on flat lands. A hill summit or a slope is chosen where convenient. Sometimes if ideal conditions are not available, the site may be shifted slightly from season to season.

Suqs vary in size according to the resources of the area, and the density of population on the one hand and the strength of appeal of the tomb or the marabout near the suq on the other. Many suqs are of purely local importance and attract only small numbers. Such are the suqs in the higher parts of mountains i.e. the High Atlas. (1) The larger suqs are regional in character and attract thousands of people from a large radius. Some of these have grown into large settlements in recent years e.g. Suq-el-Arba and Suq-el-Khamis, the two centres of the Mejerda valley in Tunisia and the Suq-el-Arba du Gharb in the Gharb plain of Morocco. The geographical advantages of their positions may be noted. Suq-el-Arba du Gharb lies where the main route from Tangier meets the one from Rabat and Kenitra on the one hand the Fez-Meknes on the other. It is also at the zone of junction between the Gharb plain and the Rif Mountains. The two Suqs of the Mejerda valley lie at the centre of the broader part of the plain between the High

(1) W. Fogg "Villages and Suqs in the High Atlas" S.G.M. 1935, 147
Tell to the south and the fertile Beja region to the north.

Suqs are also held in some of the older towns, i.e. in Mateur in Tunisia, two weekly suqs are held, one reserved specially for sale of animals and the other for general purposes. Very often such specialised functions distinguish the several weekly suqs within the territory of a tribe.

Because of its root in local diversity and the corresponding economic and social conditions the suq is bound to continue as a significant and picturesque feature of the rural landscape in Barbary. In a larger way annual fairs of a religious nature (moussems) are also important media of trade and social contact. They take place at the tombs of the more important saints. One of the largest in Barbary is the one that takes place in the Gharb plain at Moulay bu Selham.

**MODES OF LIFE AND SETTLEMENT IN THEIR REGIONAL ASPECT**

The prevalent modes of life in different parts of Barbary will now be described mainly in relation to agricultural land use and settlement. At the very outset in may be stated that agriculture figures in a greater or lesser degree among all the communities of Barbary and the distinction between nomads, semi-nomads and sedentary groups is based on the relative importance of cultivation and grazing. As Despois has observed "There is no region in Barbary which is purely pastoral"(1) Even the full nomads, i.e. those who have no fixed habitation and move about constantly have some small

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garden-plots or a few date palms in some oasis, managed by the oasis dwellers (ksourians) in the capacity of share-tenants (khammes).

Similarly within a tribe some family groups are more sedentary and own cultivated land while others practise seasonal migrations with their animals, the main source of their livelihood.

This diversity of the mode of life within the same tribe is reflected in the types of habitations. A map of the types of habitations in Barbary has been drawn here from a variety of sources\(^{(1)}\) including field observations. Its study illustrates this mixture of agricultural and pastoral activity for over considerable areas tents are used along with houses or with gourbis, or with both. The comparison of this map with the map showing modes of life also brings out the intimate relationship between the type of habitation and the mode of life. Permanent houses are associated with sedentary fruit farmers, huts of various types with cereal growers while the tent figures in different areas according to the importance of pastoral activity and the magnitude of seasonal movements, becoming the dominant type of habitation in the steppes and among the Saharan nomads.

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\(^{(1)}\) Among these are a map of types of habitations in Tunisia in E.C.M. "Tunisie", page 99, an old map in A.Bernard and E.Doutée, Op.Cit; in addition statistics of the types of houses in Morocco in Annuaire Statistique du Maroc 1945-46 have been used along with a map of the modes of life in E.C.M. "Maroc".
Regional Types: The following account of the modes of life and settlement in the regional aspect has been grouped under the three main types - nomadic, semi-nomadic and sedentary. These types broadly conform to the physical conditions, particularly to rainfall as was established earlier by comparing them with the Land Classification Map. The fully nomadic communities inhabit the arid part of Barbary and many of them spend only a part of the year outside the Sahara. Hence only a brief description of their movements in relation to the factors described earlier has been considered adequate for this study. The semi-nomadic population combines a greater amount of agricultural activity with grazing and inhabits most of the regions that are of special interest to this study, notably on the fringe of areas of sedentary cultivation where agriculture has been extending in recent years under irrigation (Shelif Valley, plain of Beni Amir in Morocco) or under dry farming (plateau of Sersou) This has been accompanied by changes in the mode of settlement. As the ultimate aim of this chapter is to provide a background for the study of settlements as well as agricultural land use, these areas have been dealt with in comparatively greater detail. The importance of sedentary agricultural communities is obvious but the detailed regional account of their settlements will be given in the chapters on Agricultural Regions. Agricultural land use in relation to crop-production will also be treated in a subsequent chapter.
THE NOMADS: In the arid Saharan fringe of Barbary the movement of tribes between the Sahara on one hand and the Saharan and the Tell Atlas on the other has not only been by their pastoral requirements but also encouraged by their commercial activity. These regions are the **bled Seguia** (areas of irrigated cultivation) of Moroccan parlance in which cultivation is possible only at water-points - wells, springs or rivers. The oases grow mainly dates and do not produce enough cereals to satisfy the local requirements. The nomadic tribes have long been the only link between the inhabitants of the oases and the cereal-growing lands further to the north. They transport the dates, carpets, etc. produced in the oases to the Tell zone in the north and bring back cereals and other products in return. Their commercial activity has declined considerably as roads and railways have linked up the important oases with the north. As the meagre natural vegetation of this zone practically dies out during the long summer drought, the pastoral movement to the north is a feature which is bound to continue as long as the desert communities depend mostly on grazing for their livelihood.

Two Saharan tribes inhabiting the regions around the oases of Laghwat and Wragla - the Arbaa and Said Arba have been accustomed to moving from their winter encampment in the Sahara to the Tell in the spring and summer, spending these months in the plateau of Sersou and the High Plains of Constantine. Formerly they used to move in large picturesque
caravans in May, carrying their tents and merchandise on the
camels. They would graze their flocks and sell the produce
of the Saharan oases, mainly dates, in the local markets. In
October they would begin the long trek back to collect the
date harvest. In the past few decades, the development of
European colonisation in their summer pastures as well as the
general extension of cultivation due to the increase of local
population has restricted the areas available to them. Their
movements are now regulated by the French administration and
they migrate in small groups of 10-15 families accompanied
by their animals.

Movements of smaller magnitude take place among
the tribes inhabiting the eastern High Atlas, the Saharan Atlas
and the Saharan fringe at their foot. In autumn there is a
movement from the snowy mountains in which grazing is impossible
to the warmer valleys below. In summer, other groups move to
the fertile pastures higher above. Cultivation is carried on
along principal streams and around springs. Here is found
the sedentary settlement typical of oases and the more
favoured valleys, the ksar. Families live in houses made of
puddled clay and sun-dried bricks with flat roofs. These are
closely packed with narrow lanes in between them and unless
an agglomeration is protected by the venerated tomb of a
marabout, it has high ramparts all round. The ksourians are
usually tributary to a nomadic tribe and cultivate very
small plots of land or an orchard containing a few date-palms.
They also tend date-palms or fields for the nomadic tribes. Apart from dates, the main produce, small quantities of other fruits such as pomegranates, apricots etc. as well as cereals and vegetables are also grown. Land is owned individually but the necessities of common defence and protection in the past have imposed a large amount of communal co-operation. Water from the rivers or springs is shared according to strict customs and unwritten laws. In Morocco, such ksour occur principally along the main streams of the southern High Atlas - Guir, Ziz and Dades as indicated on the map of types of habitations. Underground water channels or foggaras irrigate the oases in some parts of southern Algeria and Morocco.

The migratory tribes live in tents made from a mixture of wool and camels' hair. The Beni Guil of eastern Morocco carry the domain of the pastoral nomad to the coastal chain in an area where there is a large break in the southern chains of the Atlas.

**THE SEMI-NOMADS:** The semi-nomads may be defined as those who have a fixed habitat which they occupy for a part of the year but which they abandon for some time to search for pastures. The zone permanently occupied is the one where cultivation is carried on but as agriculture alone cannot support them, the requirements of their flocks necessitate seasonal movements. The range of gradations in the importance of agriculture, in the season and nature of their transhumance is
very great under the complex combination of factors discussed earlier. We can simplify their description by taking them in several categories and elaborating on significant divergences from region to region within these. The present writer has adopted three such categories as shown on the map of Modes of Life.

1. The Semi-Nomads of the Steppes - inhabit the arid and semi-arid areas bordering the domain of nomadic communities. They are mostly semi-nomadic in the transitional sense i.e. they were formerly nomads but are beginning to settle down as cultivation is extended on account of the limitation of pastures and the increase of population. Permanent settlement on the land is not possible without irrigation.

2. The Semi-Nomads of the Mountains - who practise pastoral transhumance because the agricultural resources of the mountains are inadequate to support them and large numbers of tribal communities must follow the flocks and herds to the different seasonal pastures. Herein the communities are part-sedentary and part-nomadic.

3. The Semi-Nomads of the Moroccan Meseta who are intermediate between the above two. They have been pastoralists largely because of the semi-arid climate in which cultivation does not always give good harvests. They come closest to the cereal farmers of the lowlands as their habitat is essentially
fixed and their movements very limited (see diagram showing seasonal movement in the plain of Beni Amir). Despois (ii)
following Celerier has included this region in the zone of semi-nomads and sedentary cultivators lying between the coast and the Middle Atlas. Although sedentary villages are common enough on the banks of perennial streams or near springs in the zone separated by the present-writer, pastoralism accompanied by limited movements is much more important than in the Atlantic plains and the number of tents used very much greater. The relatively greater dependence on pastoral pursuits away from the coast is a natural consequence of the decrease of rainfall, the thinner and often stony soils and the more rugged topography.

Semi-Nomads of the Steppes

Eastern Morocco, Algeria and Tunisia have a zone of elevated high plains and plateaux in which natural conditions show a fair degree of uniformity. The zone is not continuous because of the interpolation of the Beni Guil in eastern Morocco, but it is everywhere characterised by a low rainfall, a steppe-like vegetation and an absence of large and perennial irrigation supplies. There are slight differences between different groups according to their history and degree of evolution as well as local variations in the conditions of natural environment.

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(i) The differentiation of the third category can probably be extended to other parts of Barbary, particularly to some of the lowland steppes of Tunisia. The writer's observations in that region were so limited, however, that they cannot be the basis of any departure from the general scheme of their present classification.


(iii) Op.Cit. p.45
The Semi-Nomads of Eastern Morocco:

(i) Celerier has calculated the population of Eastern Morocco as consisting of about 100,000 sedentary inhabitants and 76,000 nomads, yet three quarters of the area forms the domain of tent-dwelling nomads, the sedentary population being concentrated in the few places where water-supply is abundant, i.e. some areas along the Muluya and its tributaries. They are inhabited by house-dwelling cultivators living in large agglomerations similar to the Saharan ksour. In these a wide variety of fruit trees are grown, notably in the neighbourhood of the settlements, while further away extend fields of cereals. Apart from these "islands" of sedentary agriculture, life resembles that of the Saharan nomads except for the fact that large areas are annually sown with cereals, especially barley and may yield a good harvest once in several years. The various tribes also own parcels of fertile land and small orchards in the areas favourable for cultivation so that they are in some small measure fixed. The evolution towards sedentary cultivation has been rapid in certain areas on account of colonisation and increase of population. The plain of Angad south of Oujda is indicated in the Map showing Modes of Life as the zone of sedentary cereal and fruit cultivation. This was until recently the domain of semi-nomadic pastoralism. Between Oujda and Taza several tribes practise seasonal migration, leaving the region for the high plains in the south in February, returning in May to harvest their crops. They dwell mostly in tents.

(i) Celerier Op.Cit p.87 He includes in this zone the entire area described in the chapter on STRUCTURE AND RELIEF as Eastern Morocco.
The Semi-Nomads of the Algerian Steppes:

Parts of the Saharan Atlas, notably the Mountains of Ksour are inhabited by tribes owning extensive pastures so that large scale migration is unnecessary. Their seasonal movement consists of a descent to the southern depressions in winter and a summer movement to the sides of the mountains. The habitations of these tribes are chiefly gourbis made of stone and crude sun-dried bricks with thatched roofs. Houses have increased with the extension of cultivation recent years and the animals of many tribes now move accompanied only by the shepherds and graziers. As the population has increased with security, the seasonal migrations towards the north in search of work have increased. Certain tribes such as the Oulad Nail and Oulad Amergo as far north as the plateau of Sersou. (i)

The Tribes of the High Plateaux have had their former commercial activity between the cases to the south and the centres of the Tell region greatly reduced as a consequence of the development of communications, particularly the railway to Colomb-Bechar. The Hamian were a prosperous tribe, renowned for its cavaliers and traders. They lost heavily in their resistance to the French advance in 1900 (ii) and took to the tending of sheep and cattle with the indemnity they received for their severe losses. Some of them still journey as far north as Saida either to do some trade or work for the harvest. The collection of alfa grass in the steppes is yet another source of income.

(i) Despois, Op.Cit. p.236
(ii) Ibid p.238
Their animals, however, do not move with them to any considerable extent. They have remained tent dwellers for the most part.

Among the tribes living south of the Massif of Warsenis, gourbis and houses have increased at the expense of tents as the colonisation of the Sersou region has restricted their pastures and made cultivation necessary. The rearing of camels and horses, formerly their main activity has been everywhere in decline.

The tribes of the Hodna depression consist of a mixture of sedentary and nomadic groups. Several communities still travel in caravans to the north as far as Kabylie, selling salt from the Sebkha and dates from the southern oases. Most of the tribes are really semi-nomads who cultivate the alluvial soils bordering the Shott by means of irrigation from rustic dams. They live for half the year in houses, gourbis. They leave in small dispersed groups in April and May for the High Plains of Constantine and tend their own cattle as well as those of the inhabitants of these areas. Their tents are found in dwars all over the region between Souk Ahras and the plain of Mejerna. As the result of the extension of cultivation, the number of their animals has gone down to as low as two or three per family. As a result, "pastoral nomadism is diminishing but the nomadism of labourers is maintained or even increases."(1)

The Semi-Nomads of Tunisia:

In the high steppes, the large Hammama tribe may be chosen as a community typical of the region. They cultivate

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(1) Ibid p.241
the fertile alluvial soils where the wadis emerge from their upper courses, and the larger sedentary settlements are located at the convergence of wadis. At the same time the area of these rich tracts is so limited that large groups tend sheep, goats and even a few cattle. Their tents are scattered in the pastures for the greater part of the year but are found concentrated in the cultivated areas at harvest-time. The sedentary groups have their gourbis and houses agglomerated close to their fruit and olive orchards. The poorest among the tribe move continuously with their tents looking for work. On the whole, however, the Hammama, like many tribes of the high steppes do not practise extensive movements.

The tribes inhabiting the Tunisian Dorsal come down to the neighbouring plains each winter. In recent years as large parts of the plains have come under cultivation, these movements have become restricted and only shepherds and graziers descend with their animals.

The low steppes of Tunisia present some special types of nomadism. In a habitat where growing of cereals presents the same risks and advantages as in similar semi-arid parts of Barbary, the constantly high humidity enables the extension of olivets. While a semi-nomadic life is quite compatible with the growing of cereals, olive orchards require constant attention and so an increasing number of the population has become fixed. Most families retain their mobility, however, and even if they
have houses near the orchards, they set out in spring with tents to other regions to graze their flocks. With greater distance from the coast the usual features of semi-nomadic life in the steppes become apparent, the tribes living by pastoral pursuits but also cultivating cereals in some favourable spots - depressions, valleys etc. Cereals have been extending in recent years with the increase of population. Large numbers migrate seasonally to the Sahel for the olive harvest.

Recent Changes in types of Habitations

Although the principal changes in the economy of nomadic life have been described, namely the diminution of pastures and hence of flocks, the extension of cultivation following colonisation and increase of population, the accompanying changes in habitations call for comment.

As everywhere, modes of life are in evolution and the habitation has ceased to be an exact index of activity. Only among the nomads does the tent convey an idea of dependence upon grazing with the few sedentary communities living in ksour that differ so radically from the dwar of tents. The most notable change in the habitation of the nomadic communities has been a reduction in the size of dwarfs owing to greater security.

Among semi-nomadic groups, tents, gourbis and houses are all used. Many a tent-dwelling community has continued to live in the old fashion even after taking to settled cultivation. Gourbis and houses have multiplied in the neighbourhood of cultivated areas but their dwellers use tents for several months

(i) Ibid P.243
when they accompany their still numerous flocks. The gourbi as was described earlier is not always intermediate between the tent and the house for the change from pastoralism to agriculture in a prosperous community means a direct change to the house. (i) The gourbi is essentially the habitation of the poor.

**Semi-Nomads of Mountainous Regions**

In the Middle Atlas, eastern High Atlas and the Aures Massif as well as a part of the Rif range, pastoral life is always accompanied by partial dependence upon sedentary agriculture. The seasonal movements take the shape of a winter transhumance to the plains and a summer transhumance of the Alpine type to the higher slopes. Agriculture is not of the shifting type as in many parts of the steppes but consists of the intensive irrigated cultivation of terraced hill-sides with fruit cultivation playing an important part. The house has long been the normal habitation, tents being used only seasonally by those sections of the tribe (consisting of groups of families) that move up and down with the animals. We may now undertake a brief description of the two main regions having this mode of life - the mountains of Central Morocco and the Aures Massif.

**The Semi-Nomads of Central Morocco**

Apart from their advantages of greater precipitation for cultivation which is restricted by relief, soils and water supply to the gentler valley slopes, these areas have great reserves of pastures under conditions favouring quick vegetation growth.

(i) Ibid p.254
In this respect the plateau-like heights of the Middle Atlas have an advantage over the much dissected High Atlas and Rif ranges. Consequently pastoralism has always been more important here\(^{(1)}\) than in its neighbouring mountains. Natural vegetation is preserved here to a greater extent than in most other mountains in Barbary. That is why one of the larger tribes of the Middle Atlas, the Beni Mguild, have found it possible to subsist almost entirely by pastoral pursuits and have remained tent-dwellers. Their winter pastures in the Sebu basin having been closed to them for several years when they resisted the extension of French sovereignty during the 1920's, their once numerous flocks dwindled in numbers and they were forced to cultivate here and there. Among other tribes of the Middle Atlas, the larger section of whom formerly used to depend upon grazing, there has been a great extension of cultivation since French blockade during their resistance closed the routes to the plains where they could exchange animal products for cereals. Following the establishment of French sovereignty, although the obstacle to trade was removed, the growth of agriculture persisted. Cultivation is restricted, however, to the valleys and the lower fringes where vegetables, olives, figs and almonds are grown under irrigation while wheat and barley flourish without it. The economy of the region has undergone a far-reaching change with the development of modern road transport and large numbers of tribesmen work in the farms in the plains or enlist in the army. The house has become the dominant habitation in all seasons.

\(^{(1)}\) Celerier "Le Maroc" p.70
tents being used only by shepherds and graziers. The eastern and southern slopes of the Middle Atlas have settlements resembling the Saharan ksour.

The Shawia of Aures

Among the Shawia, who are of predominantly Berber stock, agriculture plays a leading part and grazing is secondary as a basis of livelihood. The emphasis varies from the Tellian conditions of the northern heights, where forests of oaks and conifers occur, to the southern valleys penetrated by desert conditions. In the north, with the help of irrigation from the main streams, cereals, beans, figs, apricots, pomegranates, tomatoes, nuts and dates are grown. Unirrigated cultivation of cereals is also carried on but is a gamble on the capricious rainfall. The two seasonal movements are northwards in summer to the richer and higher pastures and southwards in autumn to harvest dates in the oases around Biskra.

The Shawia are village dwellers and use two types of settlements. The meshta is a collection of houses or tents grouped over the cultivated lands of the valley or wherever the Shawia possess agricultural land. The deshra on the other hand is usually perched on heights overlooking the valleys, the houses rising tiers one above the other. The latter is protected as much by difficulty of approach as by invisibility. Towards the south, the two types combine. During the period when the tribe is away in tents in the northern pastures, grain

and valuables are protected in fortified store-houses called guelaa which are even more difficult of access than the village.

**The Semi-Nomads of Forested Mountains**

The mode of life of the inhabitants of forested mountains differs somewhat from that of the Middle Atlas or Aures. They depended in the past mostly on grazing in the forests for their livelihood but the effective state management of forests under the French administration has limited their rights to use them, excluding entirely the entry of goats and camels as they are so destructive of vegetation. Because of the consequent diminution of pastoral activity, there has been an increasing reliance on agriculture while collection of wood and work in the forests supports considerable numbers. The habitations range from tents to gourbis and houses, the last making their appearance only in sedentary settlements in the larger clearings.

Beginning from the west, the Zaer-Zayan Massif is inhabited by tent-dwelling semi-nomads grazing cattle in the still abundant forests. They also cultivate some land on the fringes of the plateau or in the valleys.

In western Algeria, the inhabitants of the southern most Tell range have become almost completely fixed over the last fifty years or so, following the colonisation of their winter pastures in the Tell plains and they have begun to cultivate their lands. Although many have changed from tents to gourbis and houses arranged in small hamlets, the tent
is still used widely and even those groups who now live in fixed habitations have kept their tents to use when following their cattle in spring. Tribal cohesion has disappeared to a large extent. A similar mode of life subsists in the Massif of Wadennis though the region is much poorer.

The forested mountains south and east of the Kabylie Massif have a population that is fixed, lives in gourbis or houses agglomerated in hamlets located around springs or in clearings. It depends mostly on cereal-cultivation which, at the high altitudes suffer from winter frost and snow. Fruit cultivation is neglected but growing of tobacco is a speciality. Seasonal emigration in search of work in the neighbouring plains and valleys occurs on a large scale. Cattle and sheep are also kept, though in restricted numbers.

The Semi-Nomads of the Moroccan Meseta will be described in relation to their agricultural activity in the chapters on Agricultural Regions under "The Central Massifs" of which they occupy the part south of the Zaer-Zayan plateau. As distinguished from other semi-nomadic groups they also extend to the unirrigated parts of the Tadla plain.

The Sedentary Cultivators

The major part of the rural population of Barbary comes under this heading. It is their activity and their problems which constitute the subject of this thesis and come in for detailed and systematic treatment in subsequent chapters.

(i) Despois Op.Cit. p.276
A composite village (Beni Bahdel) above and just downstream from the dam of same name. It lies on the southern slope of the Mountains of Tlemcen and is typical of elevated fruit growing regions. The steep slopes with crags are fault-scarps while the valley of the Tafna river at the foot of the picture is a gorge. The village comprises three "quarters" or hamlets inhabited by different sections of the Beni Bahdel tribe. Two of these are seen in the photograph, one on the upper ledge near the top and one in the middle above the terraced fields. Trees are olives which constitute the cash crop. Cereals are cultivated on the terraces.
Farm settlement typical of intensively colonised region. It lies on the crest of a gentle undulation in the Baja region of Tunisia. The situation of the houses on top is due to its thin infertile soil. Large modern European farm with fabled roof and aeromotor to the right with huts of the workers lying in rows to the left. In the immediate foreground, the fertile lower slope is fallow ploughed. Just beyond, the farm building has a small garden attached to it marked by cypress trees (This aspect is fairly typical of colonists farms in Barbary)
Here it is proposed to outline only the essentials of their mode of life and lay down certain principles that determine the types of habitations used as well as the nature of agglomerations. A detailed account of their settlements will be given under the various agricultural regions.

Over most of the low-lying plains and valleys, sedentary cultivation has extended in recent years following the establishment of security. The traditional centres of sedentary cultivators have been the elevated and well-watered Massifs of the High Atlas, Rif and Kabylisa for reasons that were discussed in the first part of this chapter. Although animals are kept, they form only a secondary source of livelihood. Along with these Massifs, other notable zones of sedentary village-dwellers have been the Cap Bon and Sahel regions of Tunisia. It is to be remarked that these as well as the elevated regions are devoted essentially to the cultivation of fruit trees. This preference for arboriculture is directly related to the climatic regime. Fruit trees that are adapted to the Mediterranean climate find water at greater depths than other crops and are thus not adversely affected by the variability of rainfall. Another reason for their dominance in the over-populated Massifs is that they support a higher density of population. But while they offer these advantages for a dense settled population, they also require constant care and attention which is possible only under conditions of security and peace. The olive has often been referred to as the tree of peace, but other fruit
cultivation requires security. In this respect again, the above-mentioned regions presented manifest advantages, the Massifs because of their natural difficulty of access and the northern Tunisian lowlands because of the settlement of the Moors from Spain.

Some of the groups inhabiting the regions that will not be treated at length later on may be described briefly here.

The Shleuh inhabit the southernmost chains of the Atlas system (the High Atlas and the Anti-Atlas) and the Sous plain between them. They depend mainly on the cultivation of fruit - almonds, figs, olives and apricots - while some cereals and vegetables are grown wherever possible. Rainfall being higher in the High Atlas, irrigated cultivation extends to heights of 6,600 feet and walnuts figure increasingly at high altitudes. Life is centred in large villages most of which are dominated by large collective granaries (agadir or igherm). These villages centre around springs or permanent streams. They usually consist of several hamlets each inhabited by an ikhs (kin group brotherhood). Grazing is carried on as a secondary source of livelihood and small numbers of shepherds and graziers move to the higher pastures (known as tichka in the High Atlas) in summer. They use special summer houses of stone or thatch and the use of the tent is limited. Fortified granaries are less important in the High Atlas.

The Jebala and the Rifans who inhabit the Rif mountains also depend upon fruit cultivation. They live in houses of
a type peculiar to the region being constructed of mud walls in two stories, the upper storey with a thatched roof serving as a grain store. This is reached by means of a ladder. These houses are locally known as nwalas and should not be confused with the nwalas of the lowlands. The population is concentrated in large agglomerated villages.

The Kabylie Massif in Algeria and especially the Kabylie of Jurjura is inhabited by village-dwelling arboriculturists. The olive is the principal source of food and wealth though other Mediterranean fruits are also grown. Trees benefit from manures and from irrigation. There is little land to spare for pastures and relatively few animals are grazed. Bullocks used for ploughing land are often jointly owned by several peasants, such is the scarcity of draught animals. Cereals (especially barley) are grown on terraces.

A special house-type is associated with the Kabylie Massifs consisting of a single storied house with gabled roofs. Although the popular conception of the picturesque Kabylie village perched on a crest is not wrong, such villages are not as common as they are supposed to be. More common are the villages scattered in several small quarters (kharouba) which together form the village (taddart)

Most of these Massifs are greatly over-populated. Despite the rare ingenuity and care shown by the vigorous and active populations to extract the maximum from a poor and stony
soil, large numbers have to migrate to the plains in search of work. The Kabyles in particular work in large numbers on European farms in Algeria, or live in towns doing trade and commerce. Since the First World War they have emigrated in large numbers to work in factories in France.

The Sedentary Population of the Plains and low Hills

For reasons of insecurity and lack of irrigation, the low-lying valleys and plains were not inhabited by sedentary cultivators on a large scale and grazing of cattle formed an important source of livelihood. Tents and huts arranged in dwars were the dominant type of settlement, sedentary villages clustering around the sacred tombs of marabouts. By establishing peace and security the French administration removed the fear of rival tribes or nomadic intruders. But this factor by itself would not have sufficed to fix the population who would have followed the traditional mode of existence by geographical inertia. It was the acquisition of large areas by European settlers which limited the pastures and rendered cultivation necessary. The example of the colonists and the increase of population were other factors which stimulated this development.

The evolution from semi-nomadism to sedentary life is by no means rapid because traditional ways die hard among a people attached to their way of life. J. Despois\(^1\) has summarised

\(1\) Ibid p.305-307
the process of growth towards sedentary life among a tribe of the High Plains of Eastern Algeria. Before 1830 the tribes Oulad Abd-en-Noor and Eulma lived in tents and moved regularly between the Srawat, fertile and well-watered hills in the north and the Sebakh, vast alluvial depressions with the marshy sebkhas in their centre in the south. After sowing the Srawat area with wheat and barley, they would migrate with their cattle and sheep to the Sebakh, going as far south as the Hodna depression in severe winters. They would return in spring to harvest the crops and grazed the animals on the stubble. By 1864, first signs of fixation began to appear when meshtas (winter huts) were constructed and grouped in hamlets in the Srawat region. Most families still retained their tents but only a part of the tribe migrated southwards. As colonisation acquired more lands more and more hamlets sprang up, the number of tents decreased and fewer people migrated with the reduced flocks. Slowly as population increased even the lands in the Sebakh area were ploughed up and collective properties were divided. By now the fixation of the tribes is complete and they inhabit gourbis made of sun-dried bricks with thatched roofs.

The nature of settlements in all the cultivated lowlands and plains need not be described here in detail. A distinction may however be made between the areas of intensive colonization where European type houses and settlements are
numerous. The two main effects of colonisation have been on one hand to stimulate those of the native cultivators with sufficient lands to adopt their type of cultivation, i.e. in the Mostaganem region 8000 fellahs cultivate 32,000 acres of vines. The other result of colonisation has been the creation of a large landless proletariat which produces a glut of labour. There is a continuous movement of labour from region to region so that the labourers do not construct permanent houses but live in gourbis.

In areas of less intensive colonisation, fixation of the rural population to the land has taken place mainly through the increase of population. Fields have come to have definite boundaries as the sense of private ownership has replaced periodic redistribution within tribes. Gourbis and houses have multiplied at the expense of tents.

As stated earlier, the detailed description of settlements in the cultivated plains will be given in the chapters on Agricultural Regions.

**MODES OF LIFE AND SETTLEMENT IN WEST PUNJAB**

Unlike Barbary, almost all the rural population in West Punjab is devoted to sedentary cultivation or related pursuits. Consequently no differentiation is modes of life is called for. It may be recalled, however, that in the not very distant past, extensive areas in the Bar uplands now comprising
the Canal Colonies were barren prairies in which a nomadic population grazed its cattle. Life was insecure and the sedentary villages were confined to the neighbourhood of rivers. Even these had to pay protection money to the raiding nomads. As the country became gradually settled following the establishment of an effective administration under the British, the cattle-lifting nomads had to make a living out of more honest pursuits and quasi-permanent settlements called "rahnas" were established. (i) The various groups, however, still depended largely on cattle and moved around looking for pastures and violence or thieving still persisted. It was only after the great canals were opened and these semi-nomads settled in villages that this mode of life disappeared. (ii) In other parts of the province traces of the ancient dependence on pastoral pursuits are found in the great value put on cattle wealth.

Attention may now be concentrated on the various factors that determine the nature of rural settlement. The basic unit of the rural landscape is the village. As in Barbary, the village is usually inhabited by a tribal or family group, the tribes, which are numerous, tracing their descent from various invaders of the country in the past or from some illustrious or legendary history figure within the country. Whatever their origin, they have a marked sense of unity and possess a patriarchal organisation. Certain leading families exercise

(ii) For dates of the opening up of different canals, see Chapter on Irrigation where an account of the colonization of irrigated lands is also given.
great influence and possess vast agricultural domains so that they have a far-reaching influence on the pattern of settlements as the following account will show.

A repetition of the various factors involved in agricultural settlement would be unnecessary. Those factors that apply specially to West Punjab or any other features peculiar in themselves may however be briefly indicated.

**Physical Factors:** As in Barbary, a combination of favourable climatic conditions and fertile land has taken place only in restricted regions which have long since been densely populated by a sedentary population. These are the sub-montane districts and the northern part of the Potwar Plateau. The fertile alluvial plains receiving less than 15" of rainfall were settled densely only on the basis of irrigation.

The rivers of West Punjab have figured prominently in determining the nature of the habitations and of settlement. Their liability to annual flooding made villages seek higher ground. At the same time as the lands moistened and enriched by floods are among the most fertile, temporary houses or huts have often been constructed in these tracts. Thus in the Mianwali District, huts predominate in the riverain lands on either side of the Indus. (1)

The influence of vegetation (or rather the lack of it) is discernible in the use of mud even in temporary structures because vegetation in the semi-arid plains has never been over-abundant since the Bar regions were brought under cultivation.

(1) Punjab District Gazetters, "Mianwali", 1915, p.44
Cultural Factors:

Mention has been made above of the role of tribal loyalties in agricultural settlements. This is a powerful factor indeed because the colonization of the newly irrigated areas did not succeed till the system of sending village and clan groups was established. In a population of small-holders, co-operation between the cultivators is necessary in the execution of various agricultural operations, the loan of implements or of cattle and the provision of help against difficulties. In this family ties play a leading role.

The influence of religion was most marked in the foundation of villages when several religious communities - Muslims, Hindus and Sikhs - lived side by side. Thus each community would tend to live in villages of its own or within larger villages, in quarters special to its members. Within communities, smaller religious groups of various orders and classes had the same tendency and among Hindus, the caste system used to play an important role. With the substitution of this multi-religious society by an almost purely Muslim population this factor is bound to recede into the background.

Security is again a factor that has operated powerfully in the past, resulting in the foundation of large, compact and fortified settlements but has today been replaced by the opposite tendency - that of dispersion under peaceful conditions. Many of the older villages in the Salt Range and the Totwar Plateau stand out as having been founded as strongholds.
Economic factors especially the relative prosperity of villagers play an important role in determining the size and structure of the habitations. In most villages, the larger landowners live in double-storied brick houses while the smaller owners and the tenants inhabit the typical Punjabi rural house—mud walls enclosing a courtyard with one or two rooms at a side and an open veranda in the medium sized houses. It is customary to keep the cattle in the courtyard. The roof is always flat and built of wooden rafters covered with reeds over which mud is then spread thickly.

The Influence of Irrigation: In those parts of the province where agriculture is largely dependent upon irrigation rural settlements have been influenced greatly by the sources of irrigation water. While it is possible to have compact villages under canal irrigation, well-irrigation encourages and even necessitates dispersion particularly if wells are located at considerable distances apart. Residence near the well offers obvious advantages of closer supervision of cultivation and irrigation and saves all the time or energy wasted in journeys to and from fields.

Towns: in West Punjab have largely developed as regional markets for agricultural produce or as administrative centres. There are some ancient cities like Lahore, Multan and Sialkot whose influence on the surrounding countryside is comparable to the older capitals of Barbary. New towns have also grown up and progressed in the Canal Colonies and
Lyallpur which was an insignificant village before 1890 had a population of 70,000 according to the 1941 census. Unlike Barbary permanent marketing centres have always existed in West Punjab.

**Regional Types of Villages:**

The influence of various physical, cultural and economic factors is reflected in a variety of village types found in the province. These can be grouped as follows:

**The mountain villages of the Murree Hills:** In these steeply sloping hills, cultivable land is scattered in small parcels on gently sloping spurs or on narrow terraces on the mountain-side. Hence the dispersion of villages reaches some of its extreme forms as each family finds it advantageous to build its house, cattle-shed etc. close to its own lands. Villages therefore merge into one another and consists of widely scattered houses grouped either by tribal or family ties or merely for the convenience of revenue collectors. More compact settlements occur on larger spurs or on "galis" - places where parallel ridges are joined by a col.

**The Potwar Plateau and Salt Range** are characterised by villages divided into several sizeable hamlets with one large central abadi (group of houses). The reason for this dispersion is primarily the quality of the land. As much of the land is eroded by gullies and ravines and traversed by the wide pebbly beds of torrents, cultivable land is restricted to small areas where it needs careful embankment and manuring.
Hence the rural population scatters itself into "dhoks" or hamlets of varying size. The territory of individual villages may cover vast areas, 50 to 100 square miles being not rare for the larger ones and may include a large number of dhoks. The Jhelum District Gazetteer gives another reason for the occurrence of scattered hamlets, this being that the warlike ruling tribes scattered their tenants close to the land to exploit them better and afforded them protection from their strongholds. Some old villages in the Salt Range are located on high ridges and bear out the function of insecurity. In the more fertile areas of the Potwar Plateau the Chachh tract of Attock, large compact villages are the rule.

(3) The Old Settled Districts: These include the sub-montane tract and the central Punjab districts of Gujranwala, Sheikhupura and Lahore. Rainfall in these districts can support unirrigated crops though somewhat precariously in the last two districts where irrigation has long been developed. Cultivable lands are compact and have been densely settled since ancient times. With these districts is associated the typical Punjab village - an agglomeration of mud houses with narrow crooked lanes, the larger houses (occasionally brick ones) being in the centre while the poorer and smaller houses of tenants and menials stretch on the outskirts. A mosque or a temple usually lies in a prominent position. Most villages have a pond of stagnant water created by the removal of earth for building houses. This is used for watering the cattle.

Occasionally a few scattered houses may occur near wells but the type settlement is a compact one within which the community is a well-knit entity.

(4) The Canal Colonies: The old established villages in these tracts consisted of numerous small hamlets scattered around wells although with greater dependence on canal irrigation, larger and concentrated settlements were also encountered. Settlements established since the commencement of perennial irrigation have been planned by the state and while the houses are still constructed from mud, they are roomier, are aligned along regular streets and there is also provision for a central open space in these villages.

(5) The Western Districts: Here, cultivation still depends upon a precarious inundation canal irrigation with wells providing the only secure source of water-supply. Hence there is a dispersion of villages into small groups of dwellings around the wells. In the western part of the Shahpur District at the foot of the Salt Range, villages occur in dhoks with the central dhok at the edge of the plain while smaller groups of habitations lie on the hill slopes or out in the plain.

Settlements in the Thal desert consists of large, sedentary villages even though the people are still largely pastoral and wander over considerable distances. Wherever wells are used for irrigation, however, a centrifugal tendency sets in.

(i) Punjab District Gazetteers: Shahpur, 1917, p.51
In Mianwali district, villages consisting of scattered houses, are found in the mountainous tract. These resemble those in the Murree Hills. Along the Indus, settlements tend to cluster on higher banks due to the danger of floods.

Some individual examples of villages will be provided under Agricultural Regions.
Chapter 11

IRRIGATION

The practice of irrigation is a fact of human geography subject to the control not only of natural environment but also of men. Just as natural vegetation represents the sum and total of environment, the systematic application of water to land to grow crops is an integration of both the physical and human conditions.

In semi-arid areas such as the major parts of the regions under review, irrigation is the cardinal factor in agriculture and in the rural landscape. The contrast between unirrigated and irrigated areas is striking and is reflected in the life of the people and their standard of living. The unirrigated tracts are usually barren wastes with a sparse vegetation on which subsist the animals of a semi-nomadic population that knows no comforts, little security and lives close to starvation. If the rains come in time and in some quantity, the few fields sown carelessly yield a harvest that maintains the wandering group for some time. If the season is one of drought as it is more often than not, famine and misery are the result. Such was and is the state of human life in those of the semi-arid parts of Barbary and West Punjab that depend upon the rains. Irrigation completely changes the aspect to one of smiling fields, well-planned villages and flourishing sedentary communities of prosperous peasants who produce more than their need and obtain all the amenities
of life. In many an unproductive waste, the transformation has taken place recently through the construction of modern irrigation works, i.e. the Lower Chenab Colony in West Punjab or the Plain of Beni Amir in Morocco. The statistics of their evolution will be given later but it is obvious that irrigation provides the one answer to all the problems, economic and social that arise out of that crowning disability of environment - scarcity of water to grow crops.

Factors in the Development of Irrigation

Basically the formula for the development of irrigation is a simple one. The need for irrigation should be present, facilities for it should exist and there should be sufficient human ingenuity and social organisation to utilise the water-resources.

All these factors vary at different times and places. The need for irrigation may not be felt even in a semi-arid region if there is only a sparse population that can make its living comfortably out of pastoral pursuits. The facilities for irrigation may be perfectly or imperfectly known according to the stage of culture of the inhabitants. Finally the intelligence of the population may not rise above the obstacles to the utilisation of water resources, and technical ability or social cohesion or both may be lacking rendering large-scale irrigation impossible.

Taking up the two regions under consideration, we
may now establish the bases for the development of irrigation. The limit of unirrigated cultivation of staple crops, i.e. cereals, is 16" (i) in Barbary and 20" in West Punjab. (ii) Except for a limited northern fringe, the major part of both the regions is thus in a zone where agriculture becomes precarious without irrigation. Even in the humid sections, the seasonal distribution of rainfall reduces the agricultural utility of seemingly high amounts of precipitation and it has always been found useful to irrigate crops in order to ensure high yields. The variability of rainfall is yet another hazard which endangers the livelihood of the peasant even in the most favourable parts. Finally the increasing commercialisation of agriculture has introduced crops like citrus fruits in both the regions, cotton in West Punjab and some parts of Morocco, and many others which cannot flourish without irrigation. From the climatological viewpoint, then, irrigation is a necessity almost everywhere in these regions.

The social and economic need for irrigation has been increasingly felt as the population has continued to grow at a very high rate indeed. The population of West Punjab grows about the fastest in the Indian sub-continent which itself is a region of phenomenal increase. From 1901 to 1941,

(i) This figure was quoted to the writer by almost all the farmers and agricultural officers he met. Also mentioned by several authorities on the region, notably Despois Op.Cit P.99-101; Bernard, Afrique Septentrionale et Occidentale, P.47
(ii) The amount of rainfall necessary for unirrigated cultivation is higher in West Punjab because rainfall occurs mostly in summer - the season of high evaporation
the overall increase in numbers amounted to 7 million.
Barbary too is a region of great population growth and Algeria
for which alone figures are available for a long enough period,
almost doubled its population in 50 years from 1886 to 1936
from 3,200,000 to over 6,000,000. As the area ultimately
suitable for cultivation is limited, the only means of supporting
this fast increasing population is by bringing more areas under
the plough and intensifying production in regions already
exploited. Irrigation alone can enable that to be achieved.
It can also help in raising the standards of living which are
pitifully low at present.

Coming now to the facilities for irrigation, West
Punjab is one of the most favoured regions in the world. The
alluvial soils of the plains are everywhere rich in most
elements of fertility. The alignment of the great rivers
which spread out over the entire plain in such a fashion as to
be able to water the dry wastes in between by gravity is by
itself an advantage of the premier importance. Their water
régime as set out in the chapter on hydrography is such that
the melting of snows brings down abundant supplies during the
most precarious part of the year - the hot and dry early summer.
The quantity of water available throughout the year has proved
to be sufficient for all needs. Barbary by reason of its
smaller rivers with an unfavourable regime of water supply has
facilities for irrigation that can hardly compare with West
Punjab. There is a superabundance of water during a season

(1) Georges Froment-Guieysse "Histoire de la Colonisation et
Elements de Demographie" I.C.M. "Algerie et Sahara" P.238
when rainfall is sufficient and irrigation is unnecessary. In the absence of extensive snow-cover, the rivers run dry and tend almost to disappear during the summer when water is most needed. Large-scale harnessing of such streams have proved to be much more costly and difficult. As regards underground supplies they are again present almost everywhere in West Punjab at low depths (see map) whereas their occurrence in Barbary is limited to comparatively small areas.

The factor of human ingenuity and of co-operative or state-organised enterprise has varied in history as we noted in a previous chapter. Many of the methods still practised in both our regions have come down through the ages without being greatly modified. The greatest development of irrigation works has, however, taken place during the past hundred years or so when modern scientific technique and a marked degree of political stability enabled the ruling western powers to put into operation irrigation works on a scale hitherto unknown in these regions.

Today the old and the new systems exist side by side and shall be considered separately in order to bring out their characteristics and the way they are adapted to the natural and social environment. After treating the growth, the merits and the future of these systems, their influence on agriculture shall be discussed, followed by an account of rural settlement in irrigated colonies and its effect upon the semi-nomadic
peoples of these areas. The benefits of irrigation having been fully appreciated, its problems will then be taken up in this and the subsequent chapter.

BARBARY

Before the French conquest of Barbary, several modes of irrigation were in existence dating back mainly to the early Islamic times. These were admirably adapted to the environment and to the needs of a simple society that knew not of capital or of state-enterprise. They were governed by complicated customary laws of water rights. Since the advent of the French however, large modern irrigation works have been constructed primarily for benefit of European settlers. The older systems have persisted among the communities that have used them since long but the French administration has modified their management to some extent in order to make them conform to the irrigation policy of the State as well as to increase their efficiency. They are also being modernised. We may now study the traditional and modern systems separately.

The Traditional Systems:

These consist of various types of wells, earthen barrages and stone dams that impound water during one season and khettaras or underground channels connected by wells which

(1) The writer is not aware of any study of these laws which would doubtless be of interest. Most French authors remark on their intricacy and pass on to other things.
Well in the Kairwan region of Tunisia. A mule pulls a leather bucket up by means of the pulley seen on the well. Peasants mud house in the background. The land is flat and covered with natural grassy growth immediately around the well which is of modern design, i.e. stone bricks have been set by means of cement.

A well with a "dalou" in the Cap Bon region of Tunisia. This ingenious water-lifting device consists of two bullocks who walk down an inclined surface thus pulling two leather baskets which empty themselves automatically into the water-channel. Cactus on either side; a ploughed field and fruit trees in the background. This device is of ancient design as rough and crooked branches have been used against stone masonry in the well described above.
Wadi Fodda Dam. Note its different structure from the Ghrib dam - a concrete wall instead of a massive pile of stones and masonry. Built across a stony gorge. Its catchment area has been planted with trees to prevent silting up. Notice the heights of the Warsenis seen faintly. The dam has been irrigating the Orleansville plain since 1937.

The large reservoir at Laâjerda which is going to further regulate supplies from the Ghrib Dam. Notice cultivated land in the background with gentle hills on the left. White patches are ripened barley. Trees seen are fruit trees on the left but a canopy of natural growth on the right.
are designed to bring sub-soil water over distances with a minimum of evaporation. The last-named system is limited, apart from the Sahara, to the Haouz or Marrakesh plain in Morocco. There are also the springs which are utilised through canals or "seguias".

The account of these systems must remain very general as statistics are not available of their total number and the areas they irrigate. The one exception is the khettaras on which a paper was recently read by M. Petit, Agricultural Engineer of the Division of Marrakesh. This is fortunate as this is one of the most interesting systems of irrigation to be found anywhere.

Taking up well-irrigation first, the exact delimitation of the area where it is practised is difficult. In most alluvial plains where sub-soil water is not too deep, it may be used to a lesser or greater extent. There are also artesian supplies most prominent in southern and central Tunisia. The writer noticed well-irrigation on a really large scale in two regions, both in Tunisia - the Hammamet-Nabeul region of Cap Bon and near Kairwan. Only these will be described in some detail.

Wells are, in many ways, the ideal means of irrigation. As each proprietor owns his well, he can obtain water whenever he likes and in whatever quantities desired according to the

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(i) L'Irrigation par Rhettaras de la Palmeraie de Marrakech" 1949 Unpublished.
requirements of the crops. As water does not have to be carried over long distances, there are no great losses by percolation or evaporation. Finally not only are there no rents and duties to be paid but the system is also free from all official formalities that become the bane of the peasant's life in large-scale government schemes.

Irrigation by wells is practised almost to perfection in the Hammamet-Nabue1 region of Cap Bon whose inhabitants have "an innate sense of irrigation and of gardening"(i) The well laid-out fields, the correctly aligned water channels and the traditional clump of mulberry trees near the well to provide shade to animals and man bespeaks their inherited skill.

Demands on labour are heavy in the cultivation of fruit trees, principal citrus fruits, as well as vegetables and entire families participate, even the children assisting. Very high yields are obtained and it is not rare to see a family of 8 persons subsisting on a garden of 2½ acres. The multiplication of the number of wells has resulted in many wells beginning to dry up. This is a grave menace to the agriculture of a prosperous region. Official steps have been taken to conserve supplies by limiting the number of new wells and also to increase sub-soil reserves by building small dams in the zones of percolation. (ii)

(i) P. Penet "Les Irrigations" La Tunisie Agricole, Vol.31, 1931, P.52
(ii) "L'Hydraulique Agricole" E.C.M. "Tunisie" P.403
The area in which well-irrigation is practised near Kairwan is known as Al Awarab. The water is of an excellent quality and is used to irrigate olive trees as well as cereals covering 750 acres. Several modes of lifting water from the wells are used with the help of animals. Principal among these are "da'tou" or pairs of bullocks or mules pulling up a self-discharging leather bucket from the well by walking down an incline (see photo) and an ordinary pulley arrangement in which the pulling up of the water is done again by animals.

Rustic dams of mud and stone are constructed across most wadis to hold up the waters of floods and use them for irrigating the fields on both sides. This may more properly be referred to as inundation rather than irrigation as water often covers the fields in times of flood. This type of irrigation has several advantages under the existing conditions:

(a) It utilizes the waters of the average floods to advantage.

(b) Whenever a flood of unusual force occurs, the barrage gives way, thus saving the lands on either side from erosion or coarse deposits.

(c) A temporary dam of this type is very economical and is often constructed by communal effort without capital expenditure.

This mode of irrigation is used widely in Barbary, notably in Algeria and southern Tunisia where the writer
visited the site of several such dams in the region of Kairwan. Brunhes, commenting on the relative merits of the large barrage-reservoirs (which at that time were either being silted up or destroyed by violent floods) and of these temporary constructions, also remarked that the latter responded much better to the natural and economic conditions. \( \text{(i)} \) The only risk with these dams is that the rivers and wadis may change their courses so rapidly in the open plains that a region which once benefitted from them may become a barren waste. There are instances of this having occurred in the Kairwan region.

Irrigation from springs is practised pretty universally in Barbary wherever a sufficiently regular supply is available. The water is used effectively or otherwise according to the qualities and traditions of the users. P. Penet observed how in most of central Tunisia, the mountain nomads were practising irrigation from the abundant springs in an indifferent and wasteful manner, growing native fruits or cereals on fields that were not properly levelled and divided into beds. \( \text{(ii)} \) Recent administrative measures taken to group owners of water-rights into associations and to give them agricultural supervision has improved matters considerably. These measures shall be described later on but everywhere, the exploitation of these natural sources is being improved and modernised.

\( \text{(i)} \) Jean Brunhes "L'Irrigation dans la Peninsula Iberique et dans l'Afrique du Nord" Paris, 1902, P.182

\( \text{(ii)} \) Ibid, P.50
The khettaras of the Marrakech region in Morocco are a feature that never fails to impress the visitor. The countryside is dotted with rows of wells, some of them shallow, at the bottom of which water may be seen flowing through a channel, others so profound that the eye does not penetrate the sombre depths. These are underground channels which tap the sub-soil water abounding south of Marrakech and bring it by a slope more gradual than that of the surface to irrigate the lands around Marrakech. Tradition ascribes their construction to Youssef ben Tafshin who conquered the region in 1092 and wanted to remedy the scarcity of water. He also founded the date-palm plantation which today covers over 32,000 acres and is the only one of any size north of the Atlas.

The khettaras are apparently of Persian origin and are still in existence in Iran and Baluchistan where they are known as "Karez".

The streams which emerge from the High Atlas to the south of Marrakech lose most of their surface water by percolation through their porous deposits. In a region in which rainfall is less than 12", cultivation is impossible without irrigation. Water cannot be brought by surface canals as it occurs at considerable depth. Hence this ideal solution of the problem was arrived at in the use of khettaras and they have continued to flourish till our times. Today there are 600 khettaras in the Haouz plain. Their length varies

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(1) Most of this account is based on M. Petit's paper.
from 160 feet to over 4 miles and the depth of the wells from 8 feet to 200 feet according to the depth of sub-soil water. They lie mostly to the east of Marrakech and their direction follows the general slope from the High Atlas towards the Tensift.

The khettaras had great advantages as means of irrigation before the advent of pumping. They brought water over long distances to the fields without much loss by evaporation. Once constructed, apart from periodic clearing, no attention was required. No animals were needed to work them as with wells. There is no doubt that they have played a great role in converting the environs of Marrakech into a veritable garden, for apart from the date palm, cereals, vegetables and fruit trees are also irrigated. Their merits were recognised even by the French administration which constructed several large khettaras to supply water to European settlers and to supplement the supplies of old ones.

In recent years, however, it has increasingly been demonstrated that tube-wells not only possess the merits of the khettaras but have several additional ones. Khettaras were dug at a time when labour was extremely cheap and indeed to see the length and depth of some of these makes one wonder how much painstaking toil must have gone into them. Today labour costs have gone up so much that a khettara costs more than five times the cost of erecting a tube-well giving
the same quantity of water. Furthermore whereas khettaras could not but tap the sub-soil water superficially, a tube-well with modern boring apparatus can be dug to a depth where its supplies would be constant and secure and not be endangered by a lowering of the water-table. The khettara covers a large area with its wells outside the lands of the proprietor. Nowadays, with increasing population pressure on the land, it is not possible to appropriate such considerable tracts. The flow from the khettara being constant, the sub-soil reserve is being used up even when water is not actually needed. Also the water being exposed at so many wells, does not possess the same purity as water from a tube-well. All these considerations prove conclusively that the tube-well is superior in all respects to this age-old system.

Gradually, the khettaras are being replaced by tube-wells. Even during the last few years, the heavy cost of having the khettaras cleared after the damage caused by torrential rains has prevented many owners from having them cleaned. As many as a hundred khettaras have fallen into disuse. M. Petit is of the opinion that as time passes, this picturesque feature of the landscape will perhaps disappear completely and feels that the gain to the economy of the region through the more systematic and effective means of tube-wells will be incomparably greater. There are instances, however, of a few disused khettaras being revived, repaired with cement
and the writer saw one on which an electric pumping engine had been installed. It is possible that to save the high cost of annual repairs, more and more owners will have their khattaras thus "modernised" but to imagine that they will ever be completely abandoned is difficult as the local population is greatly attached to the system that has served them for centuries. Moreover complete abandonment would be a loss by itself as so many thousands of wells, now in use, will be pure waste. The writer is of the opinion that both khattaras and tube-wells can flourish in the Marrakech region side by side.

The Modern Systems

However ingenious and well-adapted they are to the environment, the traditional systems of irrigation have depended upon the unco-ordinated enterprise of individuals and groups with very elementary technical means. While their exploitation of underground water renders irrigation possible all the year round, their use of wadis and rivers does not attempt anything more ambitious than to inundate their lands during floods. With the advent of the French, the control of water-resources was assumed directly by the state which then attempted to store up the super-abundant supplies of one season for use during the period of drought through the construction of large dams. Although the conception is simple enough, Barbary presented very special problems to the engineer and the development of the great dams has been a notable feat in the
face of these difficulties, a feat rendered possible only through the advanced technical means at the disposal of the government. The chief problems in their construction are as follows:

(1) It is difficult to find suitable dam-sites in areas with resistant and impermeable rocks. This problem is particularly serious in Algeria where about the best terrain available consists of resistant limestones that are deeply fissured. Hence the difficulties in the way of giving the dams a solid foundation have been enormous.

(2) The water regime of the wadis and rivers is extremely irregular (for details was chapter on Hydrography) and has often spelt catastrophe for works previously executed. The extreme intensity of floods defies scientific calculation so that provision has to be made to withstand the impact of the type of flood that may occur once in a century. This lesson has been learnt at a great cost as the dam of Wadi Fergoug in the province of Oran was destroyed in 1927 by a flood of proportions that had not even appeared to be credible to either the engineers or the cultivators. Hitherto, over a period of sixty years, the highest flood-period flow had been 11,100 cusecs whereas the flood which wrought this havoc attained to 185,000 cusecs. (i)

Despite these difficulties and the enormous cost incurred to overcome them, the construction of large dams has been found the only really safe means of providing guaranteed

(i) Martin, M.R. "Les Grands Barrages et les Irrigations en Algerie", p.9
The Beni Bahdel Dam on the Taftana is a picturesque structure built in a faulted basin. Notice the scarped fault at the top of the picture and the white outcropping limestone strata. Picture shows the hydro-electric plant at the foot of the dam.

The Nfis Dam, in Morocco, lies at the foot of the High Atlas some of whose heights are visible over the top of the dam. To the extreme right a part of the hydro-electric power station is seen. On the right the slope has been terraced and engineers quarters constructed. At the bottom the road from the power station to the main Marrakesh-Amizmiz highway.
Drainage channel in the Affreville plain indicated in diagram. Vines on either side. The lower gentler and the higher steeper slopes of the Miliana Massif are noticed clearly. Some of the lower heights are wooded.

The main canal in the Beni Amir plain. The water is kept at a high level in the central section to maintain regulated supply to distributaries. On the right, flat surface of the plain can be seen with a nwala in the distance.
supplies of water. The seven older dams which existed in Algeria before the new scheme was adopted in 1920 have either been destroyed by floods (Fergoug), silted up (Meurad) or had to be modified and enlarged (Sig and Hamiz). This is because these dams were not only not capable of withstanding sudden floods but also their capacity was limited to storing up the supplies of one rainy season for use in the following summer. This introduced an element of uncertainty as rains failed frequently and the limited capacity of the reservoirs became reduced rapidly through silting up.

The existing system of reservoirs in Algeria and Morocco was planned in 1920 when the need for storing the water of several rainy seasons as well as of taking adequate precautions against floods was realised. Accordingly these irrigation works have been conceived on a large scale. The table below gives the facts and figures about the quantity of water stored, the areas that are being irrigated now as well as the ultimate total in prospect.

<table>
<thead>
<tr>
<th>Dam or Weir</th>
<th>River or Wadi</th>
<th>Capacity</th>
<th>Irrigable Area</th>
<th>Area Irrigated in 1947</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOROCCO</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>El Kansera</td>
<td>Beth</td>
<td>8,015</td>
<td>74,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Tadla</td>
<td>Umer Rbia</td>
<td>-</td>
<td>98,800</td>
<td>37,000</td>
</tr>
<tr>
<td>Nfis</td>
<td>Nfis</td>
<td>1,836</td>
<td>74,000</td>
<td>12,500</td>
</tr>
<tr>
<td>Wadi Melah</td>
<td>Melah</td>
<td>706</td>
<td>2,900</td>
<td>1,800</td>
</tr>
</tbody>
</table>

(1) Figures of actual irrigation in Morocco approximate.
Photograph shows the Ghrib dam, the artificial lake formed behind it and the hydro-electricity plant at its foot. The bare slope to the left has been terraced at its foot to prevent silting up of the bed. Cypress trees on both banks of the river for similar purpose. On the right above the dam is the small colony of engineers and workers. Photograph taken late in May on a day of passing clouds.
The Bathan Barrage on the Mejerda in Tunisia. Flow of water is controlled by means of iron gates operated by the levers seen in the photograph.
construction epitomizes all the natural problems that have to be overcome by the engineer. It is also the only dam constructed on the Shelif, perhaps the most capricious river in the country. Its site lies about 30 miles from Affreville in a region consisting of unconsolidated marls and friable sandstone. The construction of a rigid wall adopted earlier for Wadi Podda could not be envisaged hence an enormous embankment was created, over 245 feet in height and the side on which water was to be stored made impermeable with the ingenious use of alternating layers of coal-tar and cement. About 8,000 tons of cement and other chemical products were injected into the basin to fill up the fissures and thus minimise loss by infiltration. A very clever device has been used to evacuate waters of great floods without damaging the foundations of the barrage, the water falling into successive cement basins before flowing downstream. After running a hydro-electric power station at the foot of the dam the water flows downstream and is then again taken out by a pumping station at Lavigerie. A large artificial reservoir is being created here to act as an additional store. The dam is designed to irrigate the plain of Affreville.

The Wadi Podda Dam: This has been constructed on very secure geological foundations of hard limestones in a deep gorge and is 290 feet high. The bed-rock of the basin was extensively fissured but the injection of over 6,700 tons of cement and other chemical products has overcome this handicap. The dam rises almost vertically on the side away from
the artificial lake it has created while it slopes gradually on the water-side. This was the earliest important undertaking of the 1920 programme to be completed - in 1932. After running a power-station the water is controlled for irrigation by means of a small weir with adjustable iron gates to regulate the flow. The water from the dam of Wadi Fodda irrigates the plain of Orleansville.

**The Beni Bahdel Dam:** A very novel and elegant design has been used for this dam on the Tafna, completed only in 1948. The water is held back by multiple inclined arches constructed of reinforced concrete. Its height is 180 feet and the separate construction of these arches has enabled each of them to be given a secure foundation. The device used for evacuating floods is equally ingenious providing a large surface along which water may flow out once it exceeds the safety level by means of a series of projecting conduits at that level. The water released from the reservoir into the hydroelectric plant is canalised by means of a small weir several miles downstream. This dam will irrigate the plain of Marnia and also supply water to Oran.

Not all the dams in Barbary are designed to collect the water of several seasons in a large reservoir and then to release it for irrigation as required. Along streams which have a constant flow, it has been found possible to construct the less elaborate weirs which only raise the level of the water sufficiently high to be diverted into irrigation canals. The
principal work of this type is in Morocco below Kasba Tadla and irrigates the plain of Beni Amir. There are several small barrages of this type in Tunisia of which one on the Mejerda is shown in the photograph opposite.

Mention may also be made of the use of oil engine pumps on wells as well as of tube-wells. The former are used extensively in Tunisia while the use of tube-wells is becoming specially important in the Marrakech plain where 250 tube-wells have been dug up till now. Pumping water directly from the rivers is also resorted to particularly in the Gharb plain in Morocco.

**Design of Irrigation Channels:** Water being so precious, so rare and so expensively stored, all canals and distributaries are being built in cement. In the latest projects like those of Ghrib and Beni Bahdel, pre-fabricated concrete pipes have been employed. These, although costly, transport water over long distances without loss by evaporation and percolation.

**Prospects of Expansion:** The water-resources of Barbary have by no means been exhausted by the existing systems of irrigation and large projects are yet in hand. The Irrigation Map of Barbary shows the areas that are to be irrigated in the near future.

The greatest scope for expansion is undoubtedly in Morocco with its larger rivers and catchments. Basing his
calculations on the flow at present utilised and the ultimate total that could be used for irrigation, V. Bausil has calculated that the area irrigated in Morocco can be raised to well over 3 million acres. (i) The principal schemes planned are as follows:

(a) The irrigation of the plains of Abda and Doukkala by means of a weir on the Um-er-Rbia at Im Fout. Beginning with 125,000 acres, the irrigated area will ultimately be raised to 500,000 acres.

(b) The irrigation of the plain of Triffa (lower Muluya) by means of a weir on the river Muluya and the installation of a large number of tube-wells. The area irrigated will be 74,000 acres. (ii) Weirs are also being planned for the Sebu and its tributary the Wargha to bring the whole of the Gharb plain under irrigation.

In Algeria, a new programme of further irrigation works has been prepared in 1946 and it is planned to raise the area irrigated by modern works to 500,000 acres. A possibility of sensational magnitude was recently hinted at by M. Gautier, the chief of the geological department through utilising the underground water resources of Shott-es-Sharqui. This interior basin of about 16,000 square miles receives a rainfall of 12" and

(i) L’Hydraulique Agricole au Maroc, Rabat 1947
(ii) Dutard, J. "Contribution a l'étude de la mise en valeur des Triffa", Rabat 1949
allowing for the maximum possible losses by evaporation, it has been estimated that every year 21,000 million cubic feet of water percolates into the sub-soil. This keeps the Shott impregnated with water throughout the year, even after the prolonged summer drought. The plan for the utilisation of this vast store of precious water envisages its transportation by means of underground works (tunnels etc.) to the Tell basins that border the High Plateau. It is estimated that 500,000 acres could be irrigated from the supplies available. A research centre has been opened to investigate the possibility which may lead to similar utilisation from the sub-soil reserves of other closed basins. (1)

Apart from these large-scale projects, there is great scope for expansion in the development of small local sources of irrigation like wells, barrages etc. The organisation of the country into water-resource groups in Tunisia since 1933 is a very useful innovation. Each region with similar problems and with joint or related sources of water supply is administered collectively and communal irrigation works are undertaken. Individual proprietors are provided with boring apparatus or technical advice and loans and subventions are also provided. Hitherto administered primarily to the benefit of colonists, the system has also helped native cultivators. Large schemes like the development of the Kasserine region in southern

(i) G. Drouhin "L'Equipment Hydraulique de l'Algerie" T and E - No.2, 1948, P.16-18
Tunisia have also been undertaken under a plan for rural uplift (Plan d'Amenagement Rural). (i)

THE AGRICULTURAL DEVELOPMENT OF IRRIGATED AREA AND SOME OF THEIR PROBLEMS.

The coming of irrigation in a region certainly brings great advantages with it but also entails responsibility and co-operative effort as well as a rational utilisation of the water to the best advantage. Among the benefits of irrigation are security from the vagaries of the weather, higher and regular yields, better balanced food, greater employment of man-power and ultimately a higher standard of living. Commercial crops that cannot be grown without the security provided by irrigation are introduced and indeed in the case of Barbary, the great expansion in citrus plantations is the most important single agricultural development in recent years.

We shall now proceed to study the agricultural trends in the irrigated areas as seen through the production figures over several years. A number of areas that have benefitted from irrigation for a number of years have been chosen, named after the barrage that irrigates them and the acreage of various crops given in the following table:-(ii)

P.T.O.

(i) E.C.M. Tunisie, 396 - 412

(ii) Based on Service de la Colonisation et de l'Hydraulique Compt. Rendu 1947.
## Crops

<table>
<thead>
<tr>
<th>Crops</th>
<th>Wadi Fodda (Region of Orleansville)</th>
<th>Charon (Lower Shelif)</th>
<th>Bakhadda (Region of Relizane)</th>
<th>Percentage change total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1939 Acres</td>
<td>1947 Acres</td>
<td>1939 Acres</td>
<td>1947 Acres</td>
</tr>
<tr>
<td>Cereals and winter crops</td>
<td>5110</td>
<td>4875</td>
<td>9000</td>
<td>8445</td>
</tr>
<tr>
<td>Lucerne</td>
<td>1694</td>
<td>971</td>
<td>247</td>
<td>210</td>
</tr>
<tr>
<td>Maize</td>
<td>40</td>
<td>120</td>
<td>-</td>
<td>82</td>
</tr>
<tr>
<td>Olives</td>
<td>127</td>
<td>135</td>
<td>662</td>
<td>997</td>
</tr>
<tr>
<td>Vine</td>
<td>1180</td>
<td>724</td>
<td>600</td>
<td>37</td>
</tr>
<tr>
<td>Fruit trees</td>
<td>1447</td>
<td>3232</td>
<td>135</td>
<td>1225</td>
</tr>
<tr>
<td>Citrus</td>
<td>1508</td>
<td>3427</td>
<td>1062</td>
<td>3100</td>
</tr>
<tr>
<td>Truck crops</td>
<td>1072</td>
<td>2124</td>
<td>1320</td>
<td>5075</td>
</tr>
<tr>
<td>Number of users</td>
<td>462</td>
<td>369</td>
<td>167</td>
<td>633</td>
</tr>
</tbody>
</table>

The following generalisations may be made from these figures:

1. There has been a general recession in the area under cereals and other winter crops i.e. leguminous crops like peas, beans etc.

2. Lucerne has tended to diminish. This, from the point of view of crop-planning, is unfortunate. This tendency appears to signify the neglect of stock-rearing which can have a

(i) In 1939, the quantities of water available being limited, cereals were not irrigated but other crops were.

(ii) Other than citrus.
beneficial influence on the food balance and the supply of manure.

3. Vine has decreased in area. Since this is a commercial crop, and now other commercial crops such as citrus and other fruits, are available and provide better and more assured returns this appears to be natural.

4. The most noticeable single feature has been the great expansion in the acreage of fruit trees, olives and truck crops.

These developments will be pursued in greater detail in a later chapter. It may be added here that the acreage under cotton, now insignificant, increased noticeably during the war years 1941-1944.

The table below indicates percentages under different crops in several irrigated sectors. These are significant in themselves but it is not possible to judge as to what shall be the ultimate proportion of different crops in the long run because as Rebour has estimated the time taken to achieve the complete utilization of an irrigated area is 20 to 25 years. (1)

<table>
<thead>
<tr>
<th>Crops</th>
<th>Wadi Fodda</th>
<th>Lower Shelif</th>
<th>Bakhadda</th>
<th>Habra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fallow &amp; ploughed</td>
<td>46.76</td>
<td>9.81</td>
<td>15.1</td>
<td>10.37</td>
</tr>
<tr>
<td>Natural pastures</td>
<td>2.21</td>
<td>1.25</td>
<td>24</td>
<td>9.43</td>
</tr>
<tr>
<td>Cereals</td>
<td>20.32</td>
<td>33.70</td>
<td>23</td>
<td>18.86</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Crops</th>
<th>Wadi Fodda</th>
<th>Lower Shelif</th>
<th>Bakhadda</th>
<th>Habra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanent Forage crops</td>
<td>2.20</td>
<td>4.60</td>
<td>0.6</td>
<td>0.43</td>
</tr>
<tr>
<td>Olives</td>
<td>0.40</td>
<td>13.51</td>
<td>4.93</td>
<td>2.32</td>
</tr>
<tr>
<td>Vine</td>
<td>2.74</td>
<td>0.10</td>
<td>0.4</td>
<td>0.83</td>
</tr>
<tr>
<td>Citrus</td>
<td>7.43</td>
<td>2.35</td>
<td>10.3</td>
<td>27.45</td>
</tr>
<tr>
<td>Other fruit trees</td>
<td>4.76</td>
<td>1.10</td>
<td>3.9</td>
<td>2.55</td>
</tr>
<tr>
<td>Vegetable crops</td>
<td>10.31</td>
<td>19.46</td>
<td>16.3</td>
<td>23.15</td>
</tr>
</tbody>
</table>

It may be added that the percentage of crops in various irrigated sectors cannot be compared with each other as they are related to the natural conditions that prevail in them. These regional variations will be taken up in a subsequent chapter.

The development of newly irrigated areas has presented certain problems related mainly to the utilization of water, the crops grown and methods practised. The best use could not be made of irrigation water unless all the potentialities of a region had been explored previously through experiments and the nature of the soil determined. Once that had been accomplished, the choice of crops after water became available was comparatively easy. Rebour, however, points out the following lessons learnt from errors of cultivators using irrigation\(^1\) for the first time:

1. Unexperienced labour - The workers or tenants ploughing the land had to be trained in the practice of using irrigation.

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\(^{1}\) Ibid P. 70-80
2. Growing of commercial crops like citrus and other fruits at the initial stages of irrigation is a hazardous step. Less remunerative but more secure crops like cereals or forage crops are safer starting points.

3. Over-irrigation: There has been a tendency in areas irrigated for the first time to use too much water. The cultivators irrigating their fields from the Wadi Fodda Dam for the first time in 1940 used twice as much water as their counterparts in the region of Perregaux who had a long experience of irrigation. Five years later their consumption showed a noticeable fall. Excessive irrigation wastes fertilizers and tends to interrupt soil aeration.

4. The distribution of water from a dam has to be carried out among hundreds, even thousands of cultivators, hence a communal spirit of co-operation is necessary. The design of fields should facilitate quick distribution.

As the extent of irrigable areas was limited the Algerian Government has enforced the utilization of irrigation facilities under threat of expropriation. This step must be considered along with the Martin Law\(^1\) requiring voluntary handing over of a part of the holding benefiting from irrigation. Thus local proprietors unwilling to part with a portion of lands if irrigated stand to lose all of them. Both ways, the administration amasses further reserves of land for further European colonisation. Similar steps are proposed for Morocco.\(^\text{ii}\)

\(^{\text{i}}\) See Chapter on Land Tenures and Holdings
The practice of irrigation in Barbary has led to a great increase in prosperity and total production but is carried on under the shadow of the great reservoirs ceasing to function after some time. The period of usefulness of a dam has been estimated at 70-30 years. (1) The cause of this is the silting up of the reservoirs, the greatest single peril facing irrigation. The catchment area of the Wadi Fodda Dam is 25-30% wooded and yet it has been silting up at an increasing rate as the following figures will show.

Deposits from 1932 to 1937 21 million cubic feet per year

1937 1941 42
1941 1944 130

In other words, out of a total capacity of just over 7,900 million cubic feet, 312 million cubic feet have been silted up in 12 years'. The problem is of immense proportions and its solution will be discussed under Soil Erosion. Waterlogged lands and salinity of soil and water are other problems that are sometimes associated with irrigation in Barbary. We shall treat them in the following chapter.

The Transformation of the Plain of Beni Amir:

This is the only large irrigation project completed in Barbary which has benefited the local population almost exclusively and brought about a complete change in exploitation of the land. We shall study this experiment of introducing a semi-pastoral

IRRIGATION IN THE PLAIN OF BENI AMIR

Scale 1: 100,000

Irrigated Area
Projected Canals
Power Station
Roads

KARBA TRAD
BARRAGE
Beni M'dinar
Dム at Qum el-Wadane
people to modern methods under irrigation in detail.

The Plain of Beni Amir lies on the right bank of the Um-er-Rbia below Kasba Tadla in Morocco. It is a flat alluvial plain occupying a height of 12-1500' and slopes very gradually towards the river. The river, as we noticed under Hydrography, is the largest one in Barbary from the point of view of water-supply which never dries up even during the summer drought and can therefore be used for irrigation by the simple means of a weir. The annual rainfall of the plain does not exceed 10" and as is typical of Barbary, is extremely variable. On this plain lives the tribe of Beni Amir which before the coming of irrigation reared large numbers of goats and sheep on the meagre grassland vegetation and also planted the soil with barley which would yield a good crop only once in five years when the quantity and distribution of the rainfall proved to be favourable. Their habitations were mostly concentrated along the river and along with the tribe of Beni Moussa to the south, they practised a limited transhumance within the plain itself (See Sketch 30).

Before irrigation of the plain was undertaken, an experimental farm was created at Dar Oulad Zidouh to apply the slightly saline water of the Um-er-Rbia to various crops that could possibly be grown under irrigation. Regular trials were begun in 1931 (i) and the water was found generally suitable.

(i) E. Miege "La question des eaux salees au Maroc" R.C. Marocaine, 1931, p.230.
A weir was constructed across the river by the same year and a canal was completed taking water from this weir to the northern part of the plain so that irrigation could be affected by gravity.

The beginnings of irrigation in 1936 were followed by widespread unrest among the tribe which broke out into open revolt at one stage. This development has been variously explained. The official explanation attributes this to the fact that the Beni Amir were incited by the well-to-do of the neighbouring cities who used to acquire lands and make profits whenever crops failed; yet another explanation given is that the tribe hated to undertake the labours required by irrigation. The local intelligentsia give an explanation that is more plausible - that it was planned to install European colonists in the plain as had been done in other irrigated regions and the tribe rebelled. The situation became calm, however, when the intention of making this scheme into an experiment in improving the tribe's lands and cultivation methods was announced through the Sultan and a special office created in 1941 at Fqih-bin-Salah. This office has played a vital rôle in the development of irrigation because it co-ordinates the work of several independent departments such as those of Public Works, Agriculture, Rural Equipment etc.

Since 1941, the area under irrigation has steadily increased as more canals and distributaries are completed. In

(1) Tallec "L'évolution du milieu rural aux Beni Amir, Beni Moussa, Bulletin d'Information du Maroc, Special number, 1946. P.264-
1948-49, about 50,000 acres were irrigated. The ultimate objective is to have the following proportion between different types of crops:

- 50% of the area devoted to plantations of olives, fruit trees etc.
- 20% stock raising
- 15% commercial crops like cotton, sesame etc.
- 15% subsistence crops.

But during the initial stages, it is difficult to establish these percentages as the tribe is accustomed to growing barley and must be taught slowly. By 1948-49, 12,400 acres had been planted with fruit and other trees, olives taking pride of place (400,000 trees) following by apricots, figs, almonds (100,000 trees). Other crops grown and the areas covered by them were as follows:

- Barley 12,400 acres
- Wheat 5,000 acres
- Leguminous crops 5,000 acres
- Cotton 2,470 acres
- Lucerne 2,500 acres
- Vegetables 1,250 acres
- Some 13,000 acres were in fallow.

The object of the proportion of crops planned is to produce only enough food to satisfy the needs of the cultivators and at the same time to produce commercial crops of the type that bring in high returns, thus to raise the standard of living.
Diagrammatic sketch showing the seasonal movement of cattle in the Beni Moussa Basin.
Diagrammatic Sketch Showing the Present Arrangement of Irrigated Fields in the Beni Amir Plain.

Projected Arrangement of Irrigated Fields in the Beni Amir Plain.

- Cereals
- Tomatoes
- Boundary of fields
- Canal
- Pests
- Cotton
The irrigated area is divided into a number of sectors each with an area of 2,000 to 3,000 acres. Each sector is under the supervision of a European monitor who distributes improved seeds, fertilizer and supervises the crops.

**Holdings and Methods of Cultivation:**

Before this scheme was undertaken, most of the plain was held collectively by the tribe although there were areas held as melk. The office at Fqih bin Salah redistributed the land among the tribe before actual irrigation.

Although the size of holdings varies from $2\frac{1}{2}$ acres to over 600 acres, the average holding consists of $7\frac{1}{2}$ acres which is sown as follows:

- $2\frac{1}{2}$ acres - cereal (Barley or wheat)
- $2\frac{1}{2}$ acres - Leguminous crop (peas, beans) or cotton
- $2\frac{1}{2}$ acres - Fallow

Under irrigation and with the application of the super phosphate fertilizers provided by the Office, it is possible to obtain two harvests a year. These usually consist of a cereal and Sesame or a leguminous crop and cotton. The office maintains 50 tractors and 7 harvestor-combines which can be rented by the small peasants at fixed rates. Although these are being utilised increasingly, the primitive plough is still used by a large number of the peasants.

The Office cultivates about 5,000 acres directly while there are two European colonists one with 150 acres, the other with 1240 acres.
The irrigated area is divided into a number of sectors each with an area of 2,000 to 3,000 acres. Each sector is under the supervision of a European monitor who distributes improved seeds, fertilizer and supervises the crops.

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Although the size of holdings varies from 2½ acres to over 600 acres, the average holding consists of 7½ acres which is sown as follows:

- 2½ acres - cereal (Barley or wheat)
- 2½ acres - Leguminous crop (peas, beans) or cotton
- 2½ acres - Fallow

Under irrigation and with the application of the super phosphate fertilizers provided by the Office, it is possible to obtain two harvests a year. These usually consist of a cereal and Sesame or a leguminous crop and cotton. The office maintains 50 tractors and 7 harvester-combines which can be rented by the small peasants at fixed rates. Although these are being utilised increasingly, the primitive plough is still used by a large number of the peasants.

The Office cultivates about 5,000 acres directly while there are two European colonists one with 150 acres, the other with 1240 acres.
The rapidity with which the pastoralist tribesmen have acquired the modern methods of cultivation, crop rotations and all the care that goes with intensive cultivation has surprised the authorities. It had been planned to tutor the Beni Amir for a period of up to 12 years by having a large staff of European experts. These experts are all there, but the tribe has soon learnt how to take care of its new plantations and fields.

**The Results of Irrigation:**

The inevitable consequence of the introduction of intensive cultivation was a reduction in the number of animals that were formerly grazed on these praries. There were over 2000 horses before the scheme, now there are none. The diminution in the number of sheep has not been so great because a large part of the plain is still unirrigated and the flocks of the cultivators are looked after by their kinsmen further west under a sharing arrangement.

Very high yields have been obtained with the intensive methods used (see later chapter on crop-production) and the population has increased rapidly. The following figures of population change of the Beni Amir along with the changes during the same period among neighbouring tribes brings this out. (1)

<table>
<thead>
<tr>
<th>Tribe</th>
<th>1936</th>
<th>1947</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beni Amir</td>
<td>24,101</td>
<td>41,162</td>
<td>+ 70</td>
</tr>
<tr>
<td>Eastern Beni Amir</td>
<td>17,153</td>
<td>27,943</td>
<td>+ 62</td>
</tr>
<tr>
<td>Beni Moussa</td>
<td>12,131</td>
<td>9,766</td>
<td>- 19</td>
</tr>
<tr>
<td>Ouled Bon Moussa</td>
<td>22,296</td>
<td>17,727</td>
<td>- 20</td>
</tr>
<tr>
<td>Beni Wjgane</td>
<td>12,576</td>
<td>13,530</td>
<td>+ 47</td>
</tr>
<tr>
<td>Ouled Arif</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(1) Atlas Monographique des Beni Amir-Beni Moussa, 1947
The change taking place in the habitation of the Beni Amir is very interesting. The normal house-type among them was the nwala, a cone shaped hut, and mud houses were built only by the notables. As one goes from the areas newly irrigated, to those that were among the first to benefit, there is a progressive diminution in the number of nwalas while the cubic-shaped diyar tend to increase.

Cattle did not figure prominently in the pastoral economy of the pre-irrigation days. Now well-known Moroccan breeds are being introduced and reared on lucerne and berseem both of which have succeeded very well in this area.

**Some Criticisms:**

The use of tractors and fertilizers as well as of other technical facilities provided is sometimes officially enforced and the peasant presented with a bill at the end of the harvest. This has sometimes been known to exceed the total income of the smaller peasants who are thus obliged to borrow. This imposes a severe strain and cases have already been reported of a small holder selling his land to clear his debts. This overzealous propagation of mechanised cultivation and expensive appliances must be kept within limits otherwise misery will result instead of prosperity. The classic French practice of sending in a large official personnel is similarly a heavy drain and appears to justify local criticism that the object of the scheme is to give employment to Europeans rather than to improve the lot of the peasant.
Future Prospects:

It is proposed to increase the area irrigated to over 250,000 acres in the plain of Beni Amir and its southern counter-part, the plain of Beni Moussa. A dam is being constructed at Bin+el-Widane on the El Abid and its water will be transmitted to the plain through a tunnel. The irrigation and settlement of the areas to be irrigated in future is being improved and the lessons of the experience gained so far are to be employed.

Among the features of the new irrigated colonies will be model villages of 150 families and 2,000 acres. (1) One great inconvenience in the area irrigated at present is that the land is parcelled into small scattered plots on which ploughing and harvesting is difficult and the number of canal distributaries has to be excessive. In the new colonies, fields will be aligned in squares along canals and crops arranged in strips to facilitate mechanised ploughing (See sketch 3i).

Conclusions:

This is the first instance of the French administration undertaking to transform not only the land through irrigation but also its people. In an amazingly short period, the Beni Amir have begun to practise modern methods of intensive cultivation with an efficiency that would be hard to beat.

(1) This approximates fairly closely to the typical canal colony village in West Punjab.
Their transformation is a proof that if the state provides all the facilities and means of improvement, the indigenous population of Barbary can bridge the gap of centuries between their use of land and the modern scientific technique in a very short time. This experiment is an encouraging success and the practice could be extended into other tracts planned for irrigation so that there may be a lasting cultural benefit from the contact of the local population and the West.

WEST PUNJAB

It would be no exaggeration to say that few regions of same size and population in the world depend as much on irrigation as West Punjab. Of its total cultivated area of 18,474,237 acres, 12,511,450 acres or 68% (i) are irrigated. We have already studied, in brief, the factors that led to this development. Map shows the proportion of area irrigated by various means in the different districts. The districts getting less than 10" of rainfall are the most heavily dependent on irrigation. It will also be noticed that government canals occupy a dominating position among the irrigation systems of the province.

Irrigation in West Punjab dates back to times immemorial and many ancient ways of watering the lands have persisted as in Barbary. Like Barbary again, their role in the agriculture of the province is only of a minor importance as

(i) Figures from Season and Crops Report, 1945.
compared to the great modern canals. We shall, however, take
the traditional methods of irrigation first and study their
relation to the environment, physical and human. Happily,
statistics are more plentiful for West Punjab than in the case
of Barbary.

The Traditional Systems:-

In the case of West Punjab, they are chiefly wells
and inundation canals.

Wells:- Well-irrigation is probably the oldest means
of irrigation in the province and still occupies an important
position accounting for 13.3% of the total area irrigated.
There are 197,159 wells, 137,629 of them masonry and the rest non-
masonry. Their distribution by districts is shown on Map 77.
Their greatest concentration occurs in Sialkot and the three
south-western districts of Multan, Muzaffargarh and Dera Ghazi
Khan. They are mostly confined to the khadir areas where
water-level is high. In the Potwar region, they are almost
the only means of irrigation as the topography is unsuitable
for the development of canals.

Wells are the ideal means of irrigation in West Punjab
because of a number of factors. Among an independent-minded
people like those of West Punjab, they provide self-sufficient
source of water for which no co-operative effort is required.
They have also developed among a peasantry that is innocent of
all use of capital and lacked the skill to attempt more ambitious
projects. Finally during recent times, wells have proved to be admirably suited to the small and scattered holdings that continue to be the rule in the province.

As a rule well irrigation is not practised wherever the depth of the water is greater than 35 feet as beyond that depth the cost of lifting water is excessively high as compared to the value of crops grown. (i)

Several means of lifting the water from the wells are applied. Those used extensively are as follows:

(1) **Persian Wheel (Rahat)** is by far the most common device applied. It consists of a large drum over which passes an endless rope or iron ladder with buckets attached to it at uniform spacing. The lower part of this ladder reaches below the water surface. The drum revolves when a pair of bullocks give motion to a toothed disc (or **chakla**) which is linked with the drum by means of a cog-wheel. The water pours continuously into a water channel. The persian wheel is a flexible device in which the size of the buckets or of the rotating drum can be altered according to varying water depths. The older types are wooden but iron persian wheels are becoming popular as they have proved to be more efficient. In some cases only the buckets and iron ladder are introduced on to a wooden drum instead of the old-fashioned earthenware pitchers and ropes. Worked usually by draft animals, a few persian wheels here and there have been worked by oil engines or electricity.

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(2) Charas;—This method is not very common in West Punjab now having largely been replaced by the Persian wheel. It resembles the dalou of Barbary and is worked by a pair of oxen going down an incline.

(3) Dhenkli or counterpoise lift;—This is the poor man's device for lifting water from a well. It consists of a bucket made of leather or iron, suspended by a rope from the end of a pole which has a counterweight at the other end and is balanced, see-saw fashion, on a stout upright support. The lift is worked by manual labour and the counterpoise is of such a weight that no great exertion is required to depress the lift when empty or raise it when full. It is usually employed where the water in a well is not deeper than 6 feet or so.

(4) Jhatta or Swing basket;—This consists of a basket or a shovel-like scoop and is swung by two men, one standing on either side holding the ropes. It is suitable only for shallow water.

Wells have been modernised in numerous cases with the help of centrifugal pumps or electric motors which materially increase the amount of water available and also reduce the cost of lifting water.

It may be added in conclusion that wells allow of intensive cultivation much more than canals as water is available in required quantities whenever desired. Thus even in canal colonies, wells have been dug to supplement the irrigation from
canals that may or may not be available exactly when required.

**Inundation Canals**

These are among the oldest canals of the province, most of them having been in existence at the time of the British annexation in 1856. Many are as much as 200 years old. In some cases they were in a serviceable condition while in others they had been allowed to deteriorate into choked and useless channels. Most of them have been improved and extended during recent years.

These canals are taken off from the rivers without any dam or weir and flow with water only during the high water season, i.e. from the end of April to the middle of October. The depth of the water during inundation is usually 5 - 8 feet but may be as much as 10 or 12 feet. Waterings are irregular and infrequent. During the early period of supply, lift irrigation is practised but when water has risen sufficiently, summer (kharif) crops are irrigated by flow. Considerable areas are flooded with the double object of manuring the land by silt deposit and of saturating it with moisture for the following winter (Rabi) season. The following figures give the area of seasonal crops in acres for 1935-36.

<table>
<thead>
<tr>
<th>System of Canals</th>
<th>Kharif</th>
<th>Rabi</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indus Inundation Canals</td>
<td>134,934</td>
<td>109,232</td>
<td>244,216</td>
</tr>
<tr>
<td>Shahpur</td>
<td>47,531</td>
<td>23,909</td>
<td>71,440</td>
</tr>
<tr>
<td>Muzaffargarh</td>
<td>161,633</td>
<td>246,670</td>
<td>408,308</td>
</tr>
<tr>
<td>Chenab</td>
<td>113,515</td>
<td>80,533</td>
<td>194,048</td>
</tr>
</tbody>
</table>

Everywhere, the Kharif crop was more important except in the case of Muzaffargarh canals which were supplemented by numerous wells for the Rabi crop. Water from wells is provided for important crops like wheat and sugar-cane as supplies from canals are not enough. The early and late supplies of water from the canals are of great value as the early supplies determine the area of the sowings while the later supplies are valuable for maturing the crops and also determine Rabi sowings.

Inundation canals are used to irrigate lands on either side of the river and hence reach their greatest development where the rivers begin to converge near Penjnad and the Khadir widens out at the expense of the Bhangar.

Since the completion of the Haveli Project in 1839, some 550,000 acres formerly irrigated by inundation canals have been brought under perennial irrigation (i) so that the last two groups - the Muzaffargarh and Chenab Inundation Canals have largely been replaced. At present the two main areas irrigated by inundation are the khadir of the lower Indus and the riverain tract of the Jhelum below the Salt Range.

MODERN WORKS

These consist mainly of perennial canals deriving their water from rivers across which weirs are constructed to ensure a permanent and well-regulated supply. Some of the later systems such as the Sutlej Valley Canals provide only a seasonal supply according to the supplies available from the river.

(i) Sir Bernard Darley "The Development of Irrigation in India" Journal of the Royal Society of Arts, Vol.XC 1940-41, P.49
We may, at this stage, pursue the development of the modern canal systems in the light of the physical as well as the social and economic conditions of the province.

**Historical Survey:** The only perennial canal in existence before the advent of the British administration was the Hasli canal which brought water from the Ravi to Madhopur to the royal gardens near Lahore and also irrigated some cultivated land. It had been constructed by Ali Mardan Khan in 1633 during the rule of the Mughal Emperor Shah Jahan.

The British administrators noticed the irrigation possibilities of the province soon after its conquest and remarked on the existing irrigation works that were being utilised with marked harmony and co-operation. What led to the development of irrigation was, however, the recurrence of famines over a number of years. Erratic monsoons caused widespread distress in 1851-2, 1860, 1868-69 and 1877-78. The three main causes of the famines were:

1. Pressure of population on the land
2. Periodic failures of rainfall
3. Lack of transport facilities and means of communication

Famines thus tended to create a balance between population and food supply.

The government, by launching upon an extensive development of irrigation, endeavoured to remove this extreme...

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(i) P.W. Paustian "Canal Irrigation in the Punjab" New York 1930 P.25
Khanki Weir on the Chenab. This shows the sluices controlling flow to the Lower Chenab Canal seen to the left.

The Ferozepur Weir, one of the Sutlej Valley dams. Photograph shows the two canals that take off to the east and are now included in East Punjab. The weir also supplies water to the large Dipalpur Canal irrigating Montgomery District. Notice the wide expanse of the river below the weir.
Lining the bed of a canal of the Thal Project with bricks to prevent seepage which brings about a double loss - the loss of valuable irrigation water on one hand and of the surrounding lands through water-logging on the other.
Lining the bed of a canal of the Thal Project with bricks to prevent seepage which brings about a double loss - the loss of valuable irrigation water on one hand and of the surrounding lands through water-logging on the other.
reliance upon a capricious rainfall.

The first undertaking, commenced in 1850-51 sought to enlarge and extend the existing Hasli Canal so as to irrigate the Bari Doab up to Multan. Irrigation actually began in 1861 and the project proved to be a success. This has since come to be known as the Upper Bari Doab canal whose commanded area is now shared by territories belonging to Pakistan and India.

The severe famine of 1877-78 led to the Government planning new protective works and three projects were prepared, the Sidhnai canal, the Lower Sohag and the Para canals, both to irrigate the lower Bari Doab and the Rannagar Canal which developed subsequently into the Lower Chenab Canal. The Sidhnai was begun in 1882 and completed by 1886, its head being situated on the Ravi River above Multan. The Lower Chenab Canal was commenced in 1884 as a minor project on an inundation basis but got soon silted up so that a new project was undertaken in 1390 and completed in 1392. The colonisation of the Rechna Doab by this canal, one of the most extensive and successful irrigation systems anywhere, will be studied in detail along with the general survey of colonisation, as it epitomises most of the features of human and economic transformation following irrigation in the province.

The Lower Jhelum Canal was the next to be undertaken and although opened in 1901, was not completed till 1917 on account of disputes with owners of the private canals in the
area commanded. It takes off from the Jhelum at Rasul and irrigates the western portion of the Jech Doab.

The Triple Canal Project is one of the most ambitious and original irrigation schemes to be completed in the province. For a long time the bare tracts of the Montgomery and Multan districts had presented attractive possibilities for irrigation only if water was available. The Ravi hardly had enough water to feed the two canals already taken off it, the irrigable tracts were far from the Sutlej while the Chenab itself was being used pretty exhaustively by the Lower Chenab Canal. The Jhelum alone had vast surplus supplies. Three canals were planned (whence its name) by which the waters of the Jhelum, the Chenab and the Ravi were to be integrated. The Upper Jhelum Canal taking off at Mangla carries the waters of the Jhelum to the southwest, irrigating the land through which it passes and empties its unused supplies into the Chenab river at Khanki. This water is utilised by the Lower Chenab Canal taking off at the opposite bank so that the supplies of the Chenab are freed for other irrigation purposes. These are tapped at Merala where the Upper Chenab takes off and after similarly irrigating thirsty lands on both its sides, discharges its contents into the Ravi at Balloki where the Lower Bari Doab canal takes off to irrigate the problem area. The project has surpassed all expectations of its success by irrigating much more area than
planned. Commenced in 1905, the entire project was completed in 1913.

The Sutlej Valley Project was undertaken in 1922 and envisaged the utilisation of the seasonal supplies of the river by means of four weirs at Ferozepur, Salaimanké, Islam and Panjnad. It was completed in 1932 and is another of the systems that have been imperilled by Partition. It irrigates the southern parts of the districts of Montgomery and Multan.

The Haveli Project has been completed in 1939 and takes off water at the junction of the Chenab and Jhelum rivers to irrigate areas formerly commanded by inundation canals and also to supplement the supplies of the Sidhnai Canal.

The Thal Canal is the last irrigation project, held up by the second World War but now being completed. It takes off at Kalabagh where the Indus emerges from its upper course and is designed to irrigate the desert spaces of the Sind Sagar Doab.

The following tables give the details of areas commanded and irrigated by the systems whose development has been traced above:

\[\text{(1) Original area designed to be irrigated } 1,871,235 \text{ acres} \]
\[\text{Actual irrigation attained (1943-44) } 2,623,309 \text{ acres} \]

Table of Particulars about West Punjab Canals, 1935-36

<table>
<thead>
<tr>
<th>Name of Canal</th>
<th>Length of canals and distributaries (miles)</th>
<th>Area commanded (acres)</th>
<th>Area to be irrigated (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Bari Doab</td>
<td>1835</td>
<td>1,563,046</td>
<td>1,083,750</td>
</tr>
<tr>
<td>Lower Bari Doab</td>
<td>1467</td>
<td>1,801,107</td>
<td>877,908</td>
</tr>
<tr>
<td>Upper Chenab</td>
<td>1421</td>
<td>1,535,077</td>
<td>567,048</td>
</tr>
<tr>
<td>Lower Chenab</td>
<td>2890</td>
<td>3,611,819</td>
<td>1,884,989</td>
</tr>
<tr>
<td>Upper Jhelum</td>
<td>711</td>
<td>558,624</td>
<td>302,037</td>
</tr>
<tr>
<td>Lower Jhelum</td>
<td>1191</td>
<td>1,340,645</td>
<td>756,390</td>
</tr>
<tr>
<td>Sidhnai</td>
<td>313</td>
<td>418,444</td>
<td>243,623</td>
</tr>
<tr>
<td>Haveli Project</td>
<td>-</td>
<td>1,161,164</td>
<td>714,256</td>
</tr>
<tr>
<td>Sutlej Valley Project:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pakpattau</td>
<td>-</td>
<td>1,367,817</td>
<td>745,835</td>
</tr>
<tr>
<td>Dipalpur</td>
<td>-</td>
<td>1,082,570</td>
<td>584,280</td>
</tr>
<tr>
<td>Mailsi</td>
<td>-</td>
<td>733,374</td>
<td>393,373</td>
</tr>
<tr>
<td>Thal Canal</td>
<td>-</td>
<td>4,599,739</td>
<td>2,170,000</td>
</tr>
</tbody>
</table>

(Source K.S.Ahmad, Op.Cit. Punjab Irrigation Reports)

The Effects of Irrigation:—

In West Punjab it would be true to say that the desert has bloomed in the canal colonies and the precious water constitutes the very life-blood of the rural population which has been attracted to those lands from congested districts.

The settlement of a well-knit and hard-working peasantry in well-planned villages was achieved by a colonization
process which will be considered later. Two developments that lend themselves to quantitative analysis may be considered:

(1) **The growth of population:** The increase of the total population of West Punjab from 1901 to 1941 was 82%. But the rate of increase varied from district to district as Map shows. The highest increase was recorded in the canal colony districts of Lyallpur, Shahpur, Montgomery and Multan where it was over 100% and exceeded 200% for Montgomery. The increase in unirrigated districts, i.e. Jhelum, Rawalpindi and Attock was less than 50% as indeed it was in the south-western districts getting non-perennial irrigation. The growth of population in the irrigated areas was not all due to natural increase, for a large proportion of it resulted from immigration from the congested districts.

(2) **Increase in Cultivated Area and Unit Yields:** Census estimates give the increase in cultivated area for the province as it was before Partition and it is not possible to make district-wise calculations over long periods because district boundaries were changed on a number of occasions. The provincial figures do give a general idea of the growth of cultivated area. When it is realised that most of the increases took place in the districts now comprising West Punjab, the real extent of expansion for this section can be recognised. In 1868, per capita cultivated area amounted to 1.25 acres of which only .06 was irrigated by canals. By 1881, for a population increase of 6.3% over that of 1868, the cultivated area increased by 16% so that the cultivated area per head of population

(i) Calculations made from Census of India, 1941, Vol.VI, Punjab.

(ii) These figures are abstracted from *P.W.Paustian, Op.Cit.* Chapter V.
increased. The Census Reports of 1891, 1901 and 1911 indicate a higher rate of increase of cultivated area than the increase of population so that the cultivated area had risen to 1.41 acres per capita by 1921. As against only 6.3% of it that was irrigated in 1868, 36% of it was irrigated in 1921. Most of the increase in cultivated area took place in West Punjab districts. The total increase in cultivated area in the undivided province from 1868 to 1921 amounted to 8,828,000 acres while the total increase in canal-irrigated area was about 9,901,000 acres which clearly shows that canal irrigation played the dominant part in the increase of cultivated area. This trend has continued and by 1944-45 cultivated area had increased by 4 million over the 1921 figure to over 33 million acres while canal-irrigated area had also shown an increase of 2,210,000 acres again showing the contribution of large-scale irrigation to the increase in cultivated area. By 1941, however, the increase in the population had so far outstripped the increase in cultivated area that cultivated area per capita was down to just over 1.1 acre as compared to 1.41 in 1921.

Unit yields from irrigated land are everywhere considerably higher than those obtained without irrigation. This fact has been demonstrated by a comparison of the yields of several crops from the two types of land in a later chapter.

The Colonization Process with special reference to the Lower Chenab Colony

The success of irrigation projects in West Punjab has depended largely upon the organisation of the settlement of immigrating cultivators. Although the British government kept political

(i) Calculated from Season and Crop Reports, 1941-42, 1944-45 and the Census of India Report 1941, Vol.VI.
considerations in view and "yeomen" and service grants to loyal persons were made and although military requirements of animals for the cavalry and transport also played their part, the main object of establishing canal colonies in West Punjab was to relieve the pressure of population upon the land in those districts that were congested. The scheme took great ingenuity, patience and perseverance in its execution. "The disposal of the colony land, its survey and its assessment, the settlement of the immigrants, the planning of villages, markets and towns, the provision of the means of communications"(i) all called for the utmost care on the part of the government.

The plan that was developed in the colonization of the Rechna Doab has remained the prototype for later enterprises. To recognize the share of the native inhabitants in the settlement of new land, to call only agricultural classes of men to settle and to choose immigrants of good character, to arrange that so far as possible a colony village should be composed of one body of men headed by their leader, to foster the growth of tidy villages - all these have remained the chief principles of colonization and were developed in the Lower Chenab Colony.

The Settlement of the Colony The lower tract between the Chenab and the Ravi rivers was formerly known as Sandal Bar and constituted a barren steppe in which semi-nomadic tribes of a criminal character grazed their cattle and sheep. Some of the pre-irrigation changes in their mode of life were described earlier.

When the colonization of the area started in 1890, the nomadic population tried all in their power to make things difficult for the

(i) Deva Singh, Op.Cit. page 3
settlers. Difficulties of obtaining labour and of transport made life still harder. Steady progress was made however and by 1895, over 428,000 acres had been allotted. The soil proved its fertility and as the news spread, colonists eager to settle in the area began to pour in from all parts of the province. By 1909, when allotments were almost complete, 1,341,938 acres had been settled.

The Selection of Colonists Because of the excess of applicants over the number required, the government was able to exercise choice. Agriculturists with a good background and character were selected from the congested districts - mostly in Eastern Punjab. In the distribution of settlers, the government took care to avoid possibilities of incessant communal conflict. Generally speaking, the peasant grantees (abadkars) in each village belonged to the same tribe, professed the same religion and originated from the same home district. Exceptions to this rule were often the source of trouble. Military pensioners were settled, according to (1) regiments as well as tribal affiliations. Among the tribes or classes of cultivators selected, those with a reputation for hard work on the land were given preference e.g. Jats, Arains and Rajputs.

The rights of the indigenous groups were not ignored. After a period of repression due to their hostility to the settlers, they were given generous grants of land and have since settled down to a peaceful agricultural life. Thus in 1903 the area held by them covered 253,752 acres. The tribes known as Hitharis which already practised sedentary cultivation in the riverain tracts were recognised in their proprietary rights and owned 135,578 acres in 1903. The former nomads have proved to be adaptable and have become

(1) Ibid p.19.
good cultivators.

**Disposal of Colony Lands**  The several considerations that determined the colonization policy were outlined at the beginning of this section. One factor which was not mentioned was the desire of the government to obtain returns for its huge capital outlay on the project which amounted to 25.2 million rupees by 1900. This coupled with the desire to settle a better class of loyal cultivators who could invest money into the land resulted in grants being made to yeomen, capitalists and auction-purchasers. Thus it is that small peasants, yeomen, capitalists and horse-and mule-breeders were the principal grantees of land.

It was decided to make rights in the land inalienable along with the policy of settling resident cultivators. The bulk of the land was granted to peasant settlers to preserve the tradition of the province as a country of the small peasant. Proprietary rights were conceded after a period of probation during which they were required to pay only limited dues. Conditions of clearing the land, breaking it into fields and doing all the necessary work to bring it under cultivation were enforced. The area of a peasant grant was fixed from 14 to 83 acres (half a square to three squares).

Yeomen grantees came from families of large proprietors in other districts and also included a considerable number of pensioned Army officers chosen by their commanding officers. They were not expected to cultivate the land directly nor was their residence on it enforced. Allotments were considerably larger to this class of cultivators. They were charged a **nazrana** (money
upon entry) which was really a token price because the real object of these grants was to settle a class of influential landlords loyal to the government.

**Capitalists** differed little from yeomen and had to be men with resources, influence and a record of meritorious service to the British government. Army officials were also eligible. The area of allotments varied from 6 to 20 squares or 156 to 566 acres.

**Auction-purchasers** were those buyers who wanted to invest money without residing on the land or supervising its cultivation through tenants. They paid the full price of land as bid in an open auction.

Among **Service Grants** to cater to the needs of the Army were camel grants made to Bilocches to rear camels for army transport which did not work—and mule-breeding grants which were a conspicuous success.

As most of the natural vegetation was cleared, a fuel famine threatened the settlers. The government therefore enforced tree planting conditions on one hand and also gave small parcels of land to each village to maintain tree nurseries. The consequence was that the Chenab Canal Colony is one of the best wooded parts of the plains of the Punjab.

**Planned villages** It was the object of the government to create villages of a type "superior in comforts and civilization to anything which had previously existed in the Punjab". At first they contented themselves with allotting a village site of liberal
dimensions but when unsightly and unhygienic villages began to develop, the need for a standard plan was realized. Several types of villages were planned for different parts of the colony with provision of an open square in the middle of the village, wide straight lanes and houses of specified dimensions.

The Colonization Process in other canal colonies

The system which finally emerged from the Chenab Colony experience has become more or less standardized. Before the canals were dug, the tract to be irrigated was divided into large squares or rectangles for purposes of determining the approximate position of the main line and branches in relation to potential colonies of settlers. Each of these divisions was a multiple of the smaller rectangle or square into which the land would later be divided for purposes of allotment. The smaller divisions varied in area from 22.5 acres as in the Sidhnai Colony to 27.3 acres in the Lower Jhelum and Lower Chenab colonies. In the Triple Canal Colonies, the rectangles were 25 acres each. In the selection of colonists the same considerations that were described earlier were always kept in view. The preservation of the community or tribal spirit was given special attention. Land was then granted in these units and of 22.5 to 27.5 acres to small peasants and to the various other classes of settlers described under the Lower Chenab Colony. In the Triple Canal Project for example the Government announced the following plan of distribution:

1. For peasant colonists of older irrigated areas, 680,000 acres (of this 175,000 acres for service conditions)
2. To relieve congestion in other areas - 80,000 acres
3. To be sold at auction - 125,000 acres

(i) Faustian, Op.Cit. 62-63
4. Reserved for agricultural and regimental farms - 100,000 acres
5. 75,000 acres for landed gentry.
6. 40,000 acres for irrigated forests and fuel reserves
7. For the semi-nomadic tribes that formerly lived in those areas - 40,000 acres
8. For ameliorating the condition of depressed classes - 40,000 acres
9. For Service in First World War - 22,000 acres

Comments

This system of settlement in irrigated colonies has worked very well. The improved appearance of the landscape, the preservation of the traditional spirit along with the introduction of improved crops and methods is a great tribute to its merits. It is of interest to note that after the distribution of land, the government did not enforce any startling changes in the mode of cultivation such as the compulsory use of fertilizer or machinery as in Beni Amir. By demonstration and propaganda, however, better varieties of wheat, American cotton and lately citrus fruits have been introduced. The larger landlords have given the lead in the introduction of improved techniques.

Chapter 12

THE PROBLEMS OF WATERLOGGED AND SALINE LANDS

In the agricultural landscape of Barbary and West Punjab, one comes across low-lying plains ideally suited for cultivation by their situation, climate and soil conditions lying barren and unutilized. These are the waterlogged lands which exist naturally in the former but have developed in the latter through irrigation. While large tracts become uncultivable through a surfeit of water, extensive areas in the semi-arid parts of both our regions suffer from an excess of salts in the soil which renders them sterile and unproductive. In this case again the salt exists naturally in Barbary while the natural salinity of the West Punjab soils has become greatly accentuated through the extension of irrigation. Both these types of land present major agricultural problems and offer great possibilities for reclamation through technical and agricultural devices.

We shall now study these two problems one after the other in relation to the regions under survey.

WATERLOGGED LANDS

Some of the largest low-lying plains of Barbary are or have been swampy due to the lack of natural drainage. The plains of Bone, Mitija and Oran in Algeria and the lower Gharb plain in Morocco are cases in point. These regions were hardly utilized fully before the advent of the French and were partly used for grazing because of their excellent pastures. Although dismayed at first by their unhealthy character, the
French administrators applied themselves to the task of reclaiming these potentially rich lands by means of drainage channels. They cleared the Mitija plain of its marshes during the very first decades of colonisation and the rich agricultural centre of Boufarik stands in the centre of what were formerly malarial swamps. It is now kept healthy and protective by a network of drains.

The existence of these extensive water-logged areas is due mainly to the causes that have been cited under hydrography to have led to the formation of the merjas, i.e. impermeability of the clayey deposits, the inability of the intermittent streams to maintain a constant base level and finally natural obstacles in the shape of coastal dunes and uplands.

**THE PROBLEM OF THE HABRA PLAIN**

The water-logged lands in the well-watered regions of Bone and Gharb lie in the comparatively humid parts of Barbary receiving 20"-50" of rainfall. The lower plain of the Habra in Western Algeria receives less than 15" of rainfall and owes its water-logged state as much to imperfect drainage on account of lack of adequate slope as to over-irrigation. This offers a close parallel to West Punjab. Its reclamation, however, has presented great obstacles. The river empties itself into the Macta marshes that are separated from the sea by sand hills built through marine deposition. It has been found impossible to create an opening towards the sea as coastal currents tend to maintain deposition. It is proposed to erect tube-wells
in circles and pump out the water from the sub-soil. If official experiments succeed, the colonists who own most of the plain are expected to follow suit. A bore-hole 130-160 feet deep is being planned to study the nature and permeability of strata. Waterlogging in the Habra plain has been accompanied by the upwelling of salts in large quantities. That is a question for the second part of this chapter.

The reclamation of the several marshy tracts around Bone has recently been undertaken. The eastern part of the plain covers an area of 50,000 acres of which it is expected to bring 40,000 under cultivation. The three systems of drains now being dug by means of mechanical excavators will discharge their contents respectively into Wadis Bu-Tamira, Bu-Allalah and Besbes. Several aqueducts and siphons will have to be constructed to make drains cross natural channels and flood-control measures taken.\(^1\) The draining of the western Bone plain which has an area of 24,700 acres was also commenced in 1948. Similar reclamation enterprises are in progress in the regions of Lakes Petzara and Tonga to the west of Bone.

The merjas in the Gharb plain cover 220,000 acres and that they can be fully reclaimed for agriculture was proved by the draining of a merja of 30,000 acres by a large company some years ago.

\textbf{WEST PUNJAB}

Water-logging through natural causes has existed in the West Punjab and the Shakargash tehsil in the north-east

\(^1\) Service de la Colonisation et de le Hydraulique, Compte Rendu 1947, P.11-15
has long suffered from it through the accumulation of flood water from hill torrents in Jammu State into Khadir depressions. *(i)* This is, however, a comparatively humid tract in the foothills. The recent extension of water-logging in the irrigated canal colonies was one of the consequences of irrigation. With the channels flowing several feet above the level of the surrounding plain, hydro-static pressure was exerted by water seeping through the permeable channels into the sub-soil. Continuous additions to the underground reserves finally raised the water table so near the surface that cultivation became impossible over large areas. As distress spread to more and more villages especially in the Rechna Doab, remedial measures were suggested and sporadic efforts made to apply them. It was only after the abnormal rains of 1925 when large areas became waterlogged that the seriousness of the problem was realised and a Waterlogging Enquiry Committee formed to investigate the extent of damage and explore various remedies. In his report, Mr. Lindley, one of the members, reported the area already damaged in West Punjab tracts to amount to 146,200 acres, 128,000 of these being along the two Chenab canals. *(ii)* It is interesting to note that damage was very slight in the lower part of the plains and the Lower Bari Doab Colony was hardly affected. He estimated the areas threatened by 1937 to be at over 3,300,000 acres. Actually the area waterlogged by that year was considerably smaller.

*(i)* E.S. Lindley "An Estimate of the areas affected by and threatened with water-logging with their past history etc" Punjab, Irrigation Branch Paper No. 31, 1923, P. 11
*(ii)* Ibid, P. 18
Since then extensive experiments have been conducted to find out the exact causes of waterlogging and try out various remedies. The results of these are summarised in the following account.

A geodetic survey by Messrs. Wilsdon and Bose(1) showed the existence of an underground water ridge running across the plains at right angles to the direction of the flow of the rivers. This ridge divides the province into two parts; upstream of it the water-table has approached the surface over extensive tracts, while downstream the extent of water-logging is limited.

A systematic survey of the Rechna and Chaj Doabs upstream of the rock ridge was made through recordings of water-level in wells and rain-gauge stations. The conclusion drawn was that both rainfall and irrigation contribute to the rise of the water-table but that the major cause of the rise was monsoon rainfall. Subsequent observations have confirmed this and Diagram shows the relation between the rise of water-table and the monsoon rainfall in the Upper Chenab area. As a result of this study, it was suggested that a drainage system should be constructed in this area to deal with the storm water of the monsoon period. Work has been in progress since 1936 and it seems probable that the water table in this area may be stabilized.(ii)

Irrigation affects the water-table in two ways. A certain amount of water is lost by seepage directly from the

(1) Wilsdon, B.H. & Bose, N.K., Punjab Irrigation Research Institute, Research Publications Vol.6, No.1 1934
Monsoon Rainfall and the Rise of the Water-table: Upper Chenab Canal Area

From: Taylor and Mehra "Soil Degradation Problems in the Rangal"
canals. Of the water used for irrigating crops, a certain amount also passes to the sub-soil. Since seepage and irrigation are almost constant from year to year, it is impossible to analyse their effects by statistical methods. (i) Recent surveys in the Rechna doab showed that although seepage was the main cause of water-logging it could not be guaranteed that the lining of canals would be an effective remedy. Experiments with the effects of irrigating crops of rice and cotton have shown that 11.3% of the total water used for rice and 3.5% of the water used for cotton are added to the water-table. This proves irrigation water to be an important factor in water-logging. (ii)

Lindley's forecast of large-scale deterioration has happily proved to be wrong on account of a feature of West Punjab soils. The impermeable soil crust has been found to be 10 feet or more in thickness and the water-table does not rise above the crust. On the basis of this it may be said that areas in which the soil crust is at least 10 feet thick are in no danger of water-logging.

Since Wilsdon and Bose's geodetic discovery, it has been found that water-logging has been spreading even downstreams of the ridge. A suggestion has been made that the underground ridge may have caused the heading up of the sub-soil stream and that the rise of the water-table downstream has been taking place due to sub-soil water flowing over the crest. (iii)

(i) Ibid
The various remedies for water-logging that have been suggested since the earliest enquiries are as follows:\footnote{Montagu - Op.Cit.}

1. Restriction of irrigation supplies.
2. Excavation of drains.
3. Lining of canals.
4. Pumping from the sub-soil.

Of these the first has been found to be impracticable as it limits agricultural production. Drainage has until recently been the only effective means of checking waterlogging. A large network now exists in the areas affected. Experiments are still in progress with various lining materials. The new canals constructed since the problem of waterlogging became serious have been lined with bricks to restrict seepage losses. Most notable among these are the Haveli canals. Finally tube wells offer an attractive possibility and several experiments in pumping the deep water back into the canals have on one hand lowered the water table and also increased irrigation supplies. The Rasul Hydel Project envisages the utilisation of a large part of its electric output in tube-wells in the water-logged areas of the Rechma and Shaj Doabs. The water-logged area has been diminishing steadily in recent years as a result of the success of reclamation measures.

SALINE AND ALKALINE LANDS

Such lands are widespread in the world in low-lying semi-arid regions and the problems of their reclamation have recently been studied by the Food and Agriculture Organisation of the United Nations.\footnote{H. Greene - "Using Salty Land", Washington, 1948}
It is significant to note that tracts included in West Punjab have been quoted especially in this work as problem areas wherein notable advances in reclamation have been made. We shall apply some of the principles developed in this work in the course of the following region-wise analysis.

**BARBARY**

Saline lands occur extensively in Barbary and even where the lands themselves are not impregnated with salt, saline water in the steams presents problems in its utilisation. The existence of innumerable such wadis in Barbary was pointed out earlier under Hydrography. The problem, apart from the closed basins of the interior, is most serious in lowlands near the coast, particularly in western Algeria. Here extensive tracts are impregnated with salt on account of the lack of drainage in the depressed basin.

A study made some years ago for Morocco treats the problems of Barbary as a whole and, in fact, derives most of its factual basis from Western Algeria. It ascribes the occurrence of saline lands to two factors:

1. Geological - The outcrop of triassic strata is everywhere marked by salinity as these rocks are rich in salt and gypsum, having been formed during a period of intensive evaporation from closed basins. Primary rocks exposed in Morocco are also saline.

2. Climatic - The climatic regime of Barbary is marked

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Influence of Salinity on the Limits of Irrigated Land.

Scale approx. 1: 200,000
by an excess of evaporation over percolation. This has resulted in a concentration of salts near the surface particularly in the great inland closed basins. Low-lying lands tend to have a high salt content if drainage is not adequate.

The most common salt found in Barbary is sodium chloride which is highly soluble in water. It usually forms a hard impermeable crust at or near the surface. Sodium carbonate is rare in Barbary.

The saline lands do not normally support ordinary vegetation but have plants specially adapted to the salinity of the soil known as halophytes. It may be added, however, that the suitability or unsuitability of saline land for agriculture depends upon its salt content. Certain plants and crops can withstand a fairly high amount of salt in the soil, notably date-palms and lupin. Cotton and rice can grow if salinity is low and cereals such as wheat and barley also flourish. Fruit trees, however, do not grow successfully on salt-impregnated lands. Citrus trees are particularly sensitive to salty land. Saline water has been successfully utilised to irrigate vines, cotton and lucerne in the Oran region provided that salinity not exceeds 3 grams per litre. This appears to be exceptional. In the Habra plain in the same region, over-irrigation has raised the water-table and impregnated the soil with alkali. Tens of thousands of acres have been rendered sterile by a salt content that exceeds 10%.

This last example indicates that if like West Punjab large-scale irrigation is expanded and practised long enough,
it may become a major factor in spreading waterlogging and salinity of the soil. This may affect the total area of irrigation. The existence of salty lands in the region of Relizane has limited the extent to which irrigation can be extended over the alluvial plain through utilising water from the Bakhadda dam.

Reclamation:— The saline lands cover very large areas, particularly in the lowlands of Oran. Various measures have been tried and their effectiveness may now be described.

1. Cultivation methods may be changed to reduce evaporation on one hand by planting trees and bushes and by frequent tilling to keep the soil permeable. Deep ploughed fallow has been found useful. The use of organic manure in large quantities counteracts the salinity and increases permeability. Lucerne and berseem have been grown under irrigation in several parts of Western Algeria with a markedly beneficial effect.

2. Chemical means:— Addition of other chemical compounds has often helped to cure the land. Calcium chloride or calcium sulphate are among the useful substances that render the soil more permeable and thus facilitate improvement.

3. Drainage has been found to be the most efficient means of improving salt-impregnated lands as by allowing a free flow of sub-soil water, it helps the draining away of the soluble salt.

At the experimental farm of Ferme Blanche in Algeria, the digging
of open trenches led to a progressive reduction of the salt content of the soil and the yields of cereals and forage crops were more than doubled by the fourth year of drainage.

Drainage also renders possible the removal of salts into the sub-soil by means of flooding the land.

A more detailed investigation of the possibilities of improving the extensive saline lands in Barbary is called for. Their utilisation offers great scope for the expansion of cultivation. The problem in its various aspects has been studied in greater detail in West Punjab and many of the methods evolved and discoveries made can be applied profitably to Barbary.

WEST PUNJAB

It has already been stated in the chapter on Soil and Vegetation that the alluvial West Punjab soils naturally tend to be alkaline. In many parts of the plain, the dry season is marked by the appearance of an efflorescence on the surface rendering it entirely unproductive or reducing yields. The salt which forms this efflorescence is locally known by several names such as Reh, Kallar or Usar. Most of the Kallar lands consist of white alkali - sodium chloride or sodium sulphate but the occurrence of black alkali or sodium carbonate is not uncommon. The former is known as Kallar Shor and the latter as Kallar Siah. Kallar siah is usually marked by a hard pan near the surface that gives the surface an unhealthy yellowish tint and is not suitable for crops at all. Kallar shor on the
other hand exists at the surface and can be used for cultivation after flushing. The concentration of these soluble salts near the surface depends upon the depth of the water table, the porosity of the soil, the state of subterranean drainage and lastly evaporation.\(^{(1)}\)

It may be remarked here that the salt responsible for soil deterioration in the province is sodium sulphate. Sodium chloride and sodium carbonate are present but in very small quantities. Sodium sulphate is precipitated from a solution of mixed salts at a temperature of \(-3^\circ\)C. This may mean that it was deposited at a time when glacial conditions prevailed over the province.

The hollows in the plain are marked by the formation of reh salts as water table is comparatively high and salts from the surrounding lands are washed down.

In the bet or riverain lowlands, good underground drainage and periodic flooding washes away any salts and alkalinity does not present a problem. It is in the more porous portions of the bar uplands that salinity is noticed through its effect on water from wells, as well as in the more widespread occurrence of kallar lands.

These conditions existed naturally and are at present in evidence even in unirrigated regions. The area of alkaline lands has, however, shown a remarkable expansion after the extension of irrigation in recent years. This has usually been explained as being due to the rise of the water-table bringing up with it the salts in the sub-soil which then accumulate as

\(^{(1)}\) K.S. Ahmad, Op. Cit.
Distribution of salts before and after a cotton crop at Jaranwala (West Punjab)

Distribution of salts before and after a rice crop at Jaranwala.

From: Taylor and Mehta
"Some Irrigation Problems in the Punjab."
water evaporates at the surface. This explanation was accepted universally till investigations were extended to areas in which the water-table is at a considerable depth below the soil surface and hence contact between the water-table and the soil becomes out of the question.\(^{(1)}\)

To investigate further the relationship between the rise of the water-table and the formation of salt efflorescence, a series of villages with water-table at varying depths was selected for observation. The depth of the water-table in these villages varied from 9-40 feet. The examination of the soil conditions showed that the soil crust was 10 feet in thickness lying above a grey sand in which the water-table was situated. The zone of salt accumulation was found to be situated at a considerable depth in good lands whereas in the deteriorated lands, it approached up to within 2 feet of the surface. There was no salt present at the surface. The conclusion from these observations over a number of years were that the salt layer in the crust was not due to the water-table which does not as a rule rise above the bottom of the crust and that the formation of the salt efflorescence could therefore take place without the rise of water-table.

The effects of the irrigated cultivation of cotton and rice on the distribution of salts were then investigated. As the accompanying graphs show in the case of cotton a zone of salt accumulation has formed. In the case of rice which received heavier irrigation the salt appears to have been washed down into the underlying sand layer. These findings have an

\(^{(1)}\) Taylor & Mehta Op.Cit.
important bearing on reclamation as it was proved that if the irrigation water supplied is sufficient to balance the loss by transpiration and evaporation, then the zone of salt accumulation remains stationary or moves down but if irrigation supplies do not balance the loss of moisture by transpiration and evaporation the salt zone moves upwards. In other words it is the intensity of irrigation which determines the position of the zone of accumulation in the soil.

It cannot be denied, however, that even if not always accompanied by a rise in the water-table, alkalinity in the soil does tend to increase following irrigation. The alkaline soils which have developed in the canal-irrigated tracts are known as thur and have been extending at the alarming rate of some 30,000 acres a year. The following record of deterioration over four years in some selected districts brings out the seriousness of the problem. (1)

<table>
<thead>
<tr>
<th>District</th>
<th>1938-39</th>
<th>1939-40</th>
<th>1940-41</th>
<th>1941-42</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sheikhurpna</td>
<td>29,631</td>
<td>7,387</td>
<td>14,102</td>
<td>N.R.</td>
</tr>
<tr>
<td>Gujranwala</td>
<td>6,364</td>
<td>4,364</td>
<td>N.R.</td>
<td>13,513</td>
</tr>
<tr>
<td>Lyallpur</td>
<td>3,224</td>
<td>1,895</td>
<td>3,029</td>
<td>5,380</td>
</tr>
<tr>
<td>Montgomery</td>
<td>933</td>
<td>278</td>
<td>4,465</td>
<td>6,383</td>
</tr>
<tr>
<td>Irfahpur</td>
<td>1,579</td>
<td>4,908</td>
<td>3,545</td>
<td>N.R.</td>
</tr>
</tbody>
</table>

The districts listed are among those most heavily dependent on irrigation, hence the extent of deterioration caused by the very foundation of their prosperity is particularly alarming.

(1) Calculated from Season & Crops Reports 1939-1942
N.R. means not recorded in the report.
Experiments on reclamation have been in progress for several years and it has been shown that if reclamation is attended to immediately after deterioration commences, it can be successfully achieved in a year. The longer it is postponed, the greater is the difficulty experienced owing to increased alkalinity.

The basis of reclamation as now practised in the province is the growth of rice. Before the rice is transplanted, the area is leached until the salt content is considerably reduced. The heavy irrigations given during the growth of the rice crop completely eliminate the salt from the soil. The alkalinity which develops on the removal of salt appears to be removed by the action of the roots of the rice plant. The carbon dioxide formed by the roots converts the sodium salts in the clay to sodium bicarbonate and the soil becomes permeable. In the initial stages when permeability is not fully developed, the nitrogen quantity available is small. The nitrogen balance can be restored if a leguminous crop such as berseem or senji follows rice. Following this, a normal rotation of crops is introduced.

Mehta\(^{(1)}\) classifies the alluvial soils of the Punjab into five types according to their alkalinity and ease with which they can be reclaimed: (alkalinity expressed in terms of pH)

Type 1: Good land capable of carrying normal crops.
Salt content below 0.2%, pH 8.5 or less

Type 2: Land giving rather lower yields, reclaimed by a single rice crop; Salt content below 0.2%,

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pH 8.5 to 9.0.

Type 3:— Land requiring reclamation by two years under rice; salt content below 0.5%, pH between 9.0 and 9.5.

Type 4:— Salt land that can be economically reclaimed (thur soils); salt content above 0.2%, pH below 9.0.

Type 5:— Land difficult and costly to reclaim (rakkai soils); may or may not have high salt content, pH above 9.5.

The geographical distribution of these soils cannot be determined except by extensive field studies and analysis of soil samples. Even then the exact distribution will remain a problem as "salty soils have a spotty distribution which has been described as a kind of smallpox on the soil" (i)

Growing rice under intensive irrigation has not proved efficacious everywhere and in the Montgomery district, alkalinity was cured only by scraping off the efflorescence, watering and ploughing the land and turning in cuttings of Bermuda grass (Cynodon dactylon). The grass is grazed for three years by sheep and cattle. It may then be ploughed and cereals followed by lucerne and cotton grown. (ii)

(i) Op.Cit. P.3
(ii) Ibid. P.13-14
The ultimate basis of agriculture is the soil, the top few inches of which provide most of the essential food to plants. Being exposed to wind and water, the soil has always been subject to some erosion. Under natural conditions undisturbed by man, there exists a delicate balance in the extent of erosion through the protective action of vegetation so that the soil-formative processes keep pace with soil removal. The interference of man and his animals upsets this balance resulting in the acceleration of erosion and the consequent impoverishment and even complete destruction of the top-soil. This interference has become intensified in recent times through the increase of population, the extension of grazing and cultivation at the expense of the natural forest cover, and careless or faulty methods of farming. Widespread erosion has resulted in many parts of the world, and many an eminent scientist has raised the cry of civilization in peril - no mere slogan but a dreadful possibility if the two trends of increasing population and destruction of productive area continue.

In the two regions under review, this problem is present in some of its severest forms and constitutes a serious menace to their agricultural prosperity. The area subject to severe erosion in Barbary has been estimated at over 20 million acres. In West Punjab, lands suffering from wind or water action occupies 6½ million acres.(1) The problem is particularly

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(1) Calculated from R.M. Gourie "Soil and Water Conservation in the Punjab" from table on P.146-147
serious in West Punjab where the pressure of population on the land(1) is very much greater, and the area already damaged or threatened by erosion constitutes a substantial area.

Travelling in the Potwar Plateau, one cannot help being impressed by the desolate wilderness of ravines which stretches away for miles, a result of long-continued soil denudation. In many parts of Barbary, notably in the Algerian Tell, the mountain slopes present an equally dreary aspect with their deep gullies and ravines. One of the primary problems in both West Punjab and Barbary is to reclaim the eroded regions on one hand and to conserve, through rational cultivation methods, the soil of those areas that are susceptible to erosion.

Before a detailed analysis of the causes of erosion in these regions, their effects and their cures, the principal processes of erosion may be described briefly.

EROSIONAL PROCESSES

The two active agents of erosion are water and wind.

1. Water erosion is the transposition of soil by rain water (including melting snow) running rapidly over exposed land surfaces. It is conditioned by factors of slope, soil type, land use and intensity of rainfall and is confined to sloping areas.(ii) Water erosion is most severe in mountainous regions denuded of vegetation. The following types of water-erosion may be noted:

(a) Rain-drop Erosion - When rain-drops fall on bare slopes they remove the loose particles of soil and also loosen

(1) See last chapter
the crumbs by their impact. Rain-drop erosion may increase by as much as 1200% with increase in the size of individual rain-drops. (1) Thus erosion in this manner is bound to be intense under torrential rains characteristic of Barbary and West Punjab.

(b) **Sheet Erosion** is the more or less even removal of soil in thin layers over an entire segment of sloping land. Often, there is a gradual change in the colour of the soil from dark to light as the humus-charged top soil is removed, a change accompanied by a progressive decline in crop yields. Steep lands and those subject to heavy rainfall are most liable to suffer. Ploughing is a deterrent to large-scale sheet erosion through furrowing but fallow or uncultivated land is stripped of its soil cover very rapidly. Sloping, unterraced fields also lose heavily. The loss of plant nutrients by sheet erosion varies from 3 to 31 times the amount of mineral elements extracted by harvested crops. (ii)

(c) **Rill Erosion:** Run-off water tends to concentrate in streamlets of sufficient velocity and volume to generate cutting power. Rill erosion is the result, marked by small incisions left in the land surface.

(d) **Gully Erosion** takes place when the concentrated run-off on an unprotected slope is large enough in volume and velocity to cut deep incisions or gullies into the surface. Prolonged rill erosion may have the same


(ii) Ibid, P.8
effect. Gullying is the arch-weapon of destruction of the soil and gives rise to those spectacular landscapes that are so striking a feature of badly eroded regions.

2. Wind Erosion develops on level or slightly sloping areas with an arid climate. It is most intense in relatively flat treeless regions where the sweep of the wind is unbroken by topographic irregularities, and loose soil or sand is removed from drier areas or from sandy beds of streams to arable lands over long distances. Thus wind erosion takes the form not only of soil removal but also its deposition over distant areas, resulting in the deterioration of land in both cases. In regions like Barbary and West Punjab where prolonged heat and drought tend to break up the surface soil into loose dust and sand, this danger becomes specially grave.

Most of these processes are in evidence in these two regions in varying intensities as the following account will show.

THE CAUSES OF EROSION:-

The entire responsibility for existing erosion cannot be placed on the carelessness or ignorance of the present occupants of the land. The practices and faulty methods that are today seen to cause soil erosion have been in vogue over centuries. That these practices are now causing more damage than ever is certainly true. The most fundamental reason for the present intensification of erosion must be
sought in the great increase of population which caused man
to encroach on the vegetation of marginal lands in order to make
a living by grazing his animals or by cultivation. The simple
statement that deforestation, overgrazing and careless
cultivation of slopes are the chief causes of erosion does not
penetrate to the mainsprings that are economic and social. Hence
even while studying these immediate causes, we must make an appeal
to their historical development, as well as to the social and
economic conditions prevailing.

**Historical background:** In the chapter on Soils and Vegetation
we have already reviewed briefly the progressive diminution
during historical times of the forest cover in Barbary through
the extension of cultivation, the consumption by pastoral
tribes and by large cities of considerable areas of wooded land.
We may also recall that this is not the first age which has
discovered the problem of erosion and worked out its solutions.
Soil conservation practices reached an astonishing perfection
during Roman times as countless ruins in central Tunisia and
south-eastern Algeria testify. The system of terraced
cultivation of olives, developed during Islamic domination, is
an ideal means of conserving both soil and water. These devices
were, however, either lost or not practised widely enough and
the reckless clearing of vegetation continued accompanied by
widespread denudation of the soil. The problem has dawned
upon us again in all its seriousness owing to the high stakes
involved - being the very survival of the race, rooted as it is
in the soil.
We may now make a historical survey of soil erosion in West Punjab. When the Aryan invaders from the steppes of Central Asia crossed the north-western mountains and came into the province, the greater part of the Potwar Plateau was covered with forests and cultivation was confined to the river valleys. The area was gradually cleared of its vegetational cover, a process which has continued till today - no suitable land is left for the expansion of the population. In an undulating region, soil was eroded quickly by gully erosion. As arable land began to be lost, the farmers tried to hold it by terracing and embankments but the quick run-off from the bare slopes destroyed these efforts so that today, the plateau is fretted with ravines over a considerable part. As agriculture was laborious and difficult large flocks of sheep and goats and herds of cattle were kept on the excellent pastures available in the forest. The increase in their numbers and the reduction in forest area lead to overgrazing so that widespread erosion was again the result. The Himalayan outliers in the Murree Hills were also largely deprived of their forest cover by clearings for cultivation and by overgrazing. There are records of the practice of shifting cultivation when selected portions of forests were felled, the land cultivation till sterile by erosion and then fresh fields created by burning. This practice was put a stop to long ago.

(i) Sir Harold Grover "Erosion in the Punjab, Its Causes and Cure" Lahore, 1946, P.11

(ii) Ibid, P.12
The main immediate causes may now be treated in relation to our two regions:

1. Deforestation: - This has been caused by the need to cultivate more land for an increasing population as has been stated before or by lopping. Lopping is a serious menace in West Punjab where despite strict forest regulations, wandering shepherds and herdsmen do great damage to the trees. "In Murree, the oak (Quercus dilatata) near Bhurban has been lopped to death in recent years and blue pine trees have replaced it whilst lower down the slopes are completely barren" (1) Extensive destruction of trees in the forests is also caused by sheep and goats and is inter-related with the much more grave danger from overgrazing. The role of forest fires that would be frequent at the end of a hot dry summer must have been considerable in causing deforestation in Barbary. As for West Punjab the writer has had occasion to observe some such conflagrations after a period of drought in the Murree Hills, causing extensive losses of the tree cover.

2. Overgrazing This has been a major cause of erosion in both West Punjab and Barbary where before the great development of irrigation and agriculture pastoral pursuits supported a large part of the population over the semi-arid regions covered with a bushy vegetation.

In Barbary, collective lands have always been grazed by large numbers of cattle, sheep and goats, not to forget the camel who can reach up to almost any tree. The large-scale

(1) Ibid P.10
This photograph from Algeria shows the erosion of the bare slope in the foreground while the ground further up is protected by compact brush.
Isolated trees and bushes are not enough to protect the land from erosion. This slope in Algeria has been eroded by rills.
clearings for cultivation and even more important, the 
extensive acquisitions for French colonisation have resulted 
in these animals being restricted to smaller areas so that 
whereas formerly different parts of the pastures were used every 
year, now there is no choice except to graze excessively within 
the same areas from year to year. This change in the case of 
the Sherarda has already been cited. The case of the Semi-

The Muslim cultivators in West Punjab particularly 
those in the Potwar Plateau and the sub-montane tract graze 
a much larger number of animals in the forests and collective 
lands (shamlat) than the vegetation can support. Grazing 
rights are possessed by farmers and professional graziers 
but there is no effective means of limiting the number of 
animals grazed. During the monsoon there is a flush of 
grass and there is enough to feed the cattle adequately but 
during the long periods of drought, the grass is grazed to the 
ground and the hungry cattle tear out the roots. When the 
*drought* is broken by storms of "tropical intensity", the 
soil is washed away from the bare pastures and they deteriorate. 
Good quality grasses are replaced by progressively poorer 
types like spear grass (*Heteropogon contortus*), lambh 
(*Aristide depressa*) etc. (i)

The sheep and goats graze not only the grass but also 
browse on bushes; the goat feeding on almost anything it can 

(i) Ibid P.14
Badly eroded landscape in Rawalpindi district. The original plateau surface can be noticed in the foreground as well as in the residual pieces of land standing among the ravines.

These Jand (trees show the extent of erosion in the Potwar region during their life-time. In 40 years a thickness of soil equal to the height of exposed roots has been removed since they first took roots.
Another wilderness of ravines in the Potwar Plateau. This is in the Attok District. Notice stratification revealed by gullies. White layers are the resistant clays while dark layers are lighter loams.
reach which gives it a considerable range for it is amazingly acrobatic and scales the most difficult slopes and eats everything that is not poisonous or very unpalatable.

The sheep and goats and the cattle also break the surface of the soil with their hoofs and the paths they habitually follow often become the starting points of gullies.

3. Faulty Methods of Cultivation: When studying these methods, we should remember that the peasant, rooted as he is in the soil and adapted to the environment through hereditary experience, does not act contrary to nature. Given a long enough time to settle, he instinctively takes steps to protect the soil of his fields. Thus regions wherein cultivation on slopes has been carried on for a long time show adaptations to the natural conditions by means of terraces and stone walls to restrain erosion. The peasants in many valleys in the Murree Hills in West Punjab have practised terraced cultivation for ages. In many parts of Barbary, notably the well watered valleys of the Middle and High Atlas, terraced cultivation has similarly been carried on for centuries. The writer visited some of these valleys south of Marrakech and found with what effectiveness the soil had been protected by the fellaheen who, unaware of all the technical details of angles and gradients, practised methods that worked and kept their fields in good production.

Faulty methods result when peasants habituated to one environment are transplanted to a different one and
Erosion of the deep alluvial soils in the Sahel region of Tunisia. The trees in the valley and on the higher ground are olives.
Soil Conservation in Algeria. In the basin of Wadi Mellah a check-dam has been constructed across a gully. Notice the generally bare hillside.
continue to practise the same methods as before. Much of
the unterraced cultivation of slopes now observed in the
Algerian Tell above the fertile valleys may be traced to the
fact that the native cultivators were deprived of their lowland
fields by colonisation and driven to plough the sub-marginal
hill-side land formerly reserved for grazing or lying unused.
Indeed this admission is made in an official publication of
the Algerian Government on the problems of the conservation
of the soil when it asks for cooperation of the colonists
"It should not be forgotten that the degradation of the
mountains is an indirect result of the colonisation of the
plains. It is only just that these rich and fertile plains
should contribute their share to the restoration of the
mountains in this way to repair the damage they have
indirectly and involuntarily inflicted" (1)

While colonisation is the main cause in Barbary, the
increase in the population has also driven the peasants
in both Barbary and West Punjab to till the sloping marginal
lands without any of the precautions necessary to conserve their
soil. Thus deforestation followed by unterraced cultivation
completes the ruin of these lands.

The social and economic causes behind careless or
faulty cultivation relate mainly to the land tenures and the
size of holdings as well as to social practices that drain
away the reserves of the farmer or cause heavy indebtedness.

(1) "Défense et Restauration des Sols", Gouvernement Général
de l'Alderie, Service de la Défense et de la Restaurations
des Sols, 1941, P.33
The recent F.A.O. survey of the problem (1) gives several possible economic reasons for the deterioration of the soil of which the following apply to the regions under consideration.

1. Size of holdings - The struggle to make a living from a small parcel of land leads to over-cropping or cultivation of steep slopes, both resulting in the deterioration or erosion of the soil. The writer came across several small holdings in the Shelif valley in Algeria and in the coastal lands to the north on which the land was already broken up considerably by incipient gullies. On inquiry, it was found that the sloping land had recently been tilled for cultivation due to the increase in the size of the family which now required more food than could have previously been produced by the fields on level lands.

Similar uneconomic exploitation of valley-sides without proper precautions against erosion is found widely in both Barbary and West Punjab. As the entire holding planted presumably with one crop, becomes bare after the harvest, torrential showers remove large quantities of the fertile top soil by sheet and rill erosion, developing, in extreme cases, into gullies. More varied land-use, possible on larger holdings provides a safeguard against this permanent waste of productivity.

2. Insecurity of Tenure - Attention was drawn in the chapter on Land-ownership and Tenures to the indifference

(1) Soil Conservation, an International Study, Washington 1948, 13-30
shown by tenants, at-will or temporary labour to the future of the lands worked. Large land-holders either do not find it possible or do not bother at all to supervise the exploitation of their properties. Changes in land-tenure can bring about a tremendous improvement in the care and maintenance of the land as has already been indicated in the chapter mentioned above.

Instances of land-deterioration through the insecurity of tenure are frequent in the Potwar Plateau where large land-holders are numerous. The practice of leasing land on khammes in Barbary is in general conducive to careful cultivation although if the lease changes hands too frequently, soil deterioration may set in through the lack of interest of the tenant.

**Heavy Taxation:** The burden of taxation may yet be another reason for over-cropping or encroachment on marginal sloping lands. The writer got the impression in Barbary that the small holder was heavily taxed. Large proprietors and colonists practising mechanised cultivation are accorded tax-reductions on the ground that they were incurring capital expenditure. The question of land-taxation is far too complicated to allow of more than this general statement as the writer could not undertake a detailed study which would be a subject for research by itself. In West Punjab, the taxes on the land are not excessive at the present time as they still stand at the pre-war rates while the prices of agricultural products have gone up 300% and more.
The F.A.O. survey lists price depressions (1) as an economic cause of soil deterioration through indebtedness of the cultivator or his failure to maintain the fields in proper condition through lack of interest. During the last World War, a sudden increase in price due to shortage was noticed in Barbary to have resulted in an extension of cultivation even to marginal and sloping lands by peasants anxious to reap the full profit from the situation.

Rural indebtedness was a serious evil in West Punjab till recently when the 1837 legislation curbed the moneylenders. Social practices mainly relating to marriage customs and similar festive occasions (birth of a son etc.) led to heavy expenditure quite beyond the means of the cultivator who borrowed money at exorbitant rates of interest. So high was the interest or so great the gerrymandering of the figures that the peasant might spend a life-time paying his earnings to the moneylender. The need to get one's livelihood as well as the interest or capital of the loan out of one's land frequently led to incessant cultivation of the soil to the point of exhaustion and encroachments on marginal lands.

Happily rural indebtedness is no longer the serious problem it was (11) in West Punjab but it must have caused considerable deterioration of the soil while it lasted.

Indebtedness caused by similar social customs or by successions of bad harvests is still widespread in Barbary.

(1) Ibid p.21 Most of the observations in this manual relate to large farms typical of the United States of America

Its detailed study is again beyond the scope of this work but its ill-effects on the soil should be noted.

It would appear from this survey of the causes of soil erosion and deterioration that almost all aspects of the cultivator's life - his methods of cultivation, his animals, even his social customs have a direct influence on the soil. The need therefore is not only for measures against erosion itself but also against its deeper causes.

The Rates of Run-off and Erosion

The main factors in the extent to which water run-off the land and the soil is removed were referred to under erosion processes, i.e. slope, soil type, nature of vegetal cover and intensity of rainfall. How far these different factors affect the rate of erosion has been determined by means of experiments conducted in the United States of America and in the Punjab. The percentage run-off under different types of vegetation and crops has been calculated to be as follows: (1)

- Forest 3 Wheat and oats 25
- Grassland 5 Maize and cotton 50

Experiments with sample trays in East Punjab disclosed the following figures (2) of soil removal according to quarterly periods of rainfall:

(1) M. Gosselin "La Defense des Sols Cultives contre l'Erosion" Tu.Agr. 1942, P. 43
<table>
<thead>
<tr>
<th>Period</th>
<th>Rainfall Period</th>
<th>Rainfall in inches</th>
<th>Grass</th>
<th>Scrub</th>
<th>Bare</th>
</tr>
</thead>
<tbody>
<tr>
<td>1937 July-Sept.</td>
<td></td>
<td>37.89</td>
<td>33.1</td>
<td>42.7</td>
<td>169.9</td>
</tr>
<tr>
<td>Oct.-Dec.</td>
<td></td>
<td>9.72</td>
<td>0.6</td>
<td>2.4</td>
<td>9.8</td>
</tr>
<tr>
<td>1938 Jan.-March</td>
<td></td>
<td>10.91</td>
<td>1.5</td>
<td>1.2</td>
<td>9.4</td>
</tr>
<tr>
<td>Apr.-June</td>
<td></td>
<td>9.01</td>
<td>2.7</td>
<td>3.3</td>
<td>51.9</td>
</tr>
<tr>
<td>July-Sept.</td>
<td></td>
<td>30.31</td>
<td>7.2</td>
<td>4.0</td>
<td>220.2</td>
</tr>
<tr>
<td>Oct.-Dec.</td>
<td></td>
<td>0.67</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Total 18 months</td>
<td></td>
<td>93.51</td>
<td>45.1</td>
<td>53.7</td>
<td>461.2</td>
</tr>
</tbody>
</table>

The loss of soil from the bare tray was about 10 times that from the grass and scrub-covered trays. The greatest loss of soil was recorded during the monsoon months. The approximate total loss per acre from bare soils could be 20 tons of soil for 18 months as compared to the loss of only 2 tons from the covered areas. It was also noticed in the course of the same experiment that the proportionate run-off from the bare trays tended to increase from 40% in the first six months to 50% during the next six months and ultimately reaching 60% during the last six months.

The erodibility of soils depends upon their absorptive capacity (greater run-off from impermeable soils causes greater erosion) the percentage of clay (heavy soils do not generally absorb plenty of moisture and are easily gullied) and the organic content which greatly enhances the water-holding power of the soil.
THE EFFECTS OF EROSION

The direct and indirect consequences of erosion are far-reaching in their effects on the landscape, water-regime of rivers, irrigation, crop-production and even the climate of a region amounting in their totality to its complete economic ruin. How serious these effects are in a region depends upon how far erosion is advanced. In Barbary and West Punjab, from the decreasing production of areas subject to sheet erosion or incursions of sand to the complete destruction of the productive capacity in other regions, we have all the gradations of the damage caused by this peril. The following account summarises the effects of erosion.

1. Loss of Soil and Fertility of Arable Land:— This effect has already been described under erosion processes and to some extent under their causes. It is not measurable quantitatively over a short period but its long-range influence in productivity is easily noticed. The loss of the soil is the loss of the capital of crop-production that cannot be replaced. Once the stream catchments become eroded, the fields further down cannot be saved even by embankments and terraces as the immediate run-off in the shape of floods breaks them down. "Hundreds of broken dams, embankments and weirs bear witness to the destruction which has occurred in the past in the cultivated uplands of the Rawalpindi Division (Potwar Plateau)." (1)

(1) Glover Op.Cit. P.17
The writer noticed several cases in Algeria where the stony sub-soil had been exposed by sheet erosion in the hill-side holding of a peasant, and the fields were producing miserable crops. Here and there gullies were developing as well. Similar effects are noticeable widely in the Potwar Plateau. In the Jhelum district there has been actual decrease in the arable area.

2. Inundation of Land in the Plains:— The denudation of the hills increases the violence of floods which bring down coarse sand and silt and deposit it over the fertile fields. This has been commonly experienced during floods both in West Punjab and Barbary. The soil lost by the hill-farmer thus does not always enrich the peasant in the plains as is sometimes supposed but often chokes up the cultivated fields with infertile rubble.

3. Silting up of Reservoirs and Canals:— The seriousness of this problem has already been pointed out in the case of Barbary where large irrigation works constructed at great cost have become useless over a short period of time. The problem, though eased in the case of West Punjab by the type of weirs employed, is nonetheless present in another form as the beds of the rivers are being raised and the canals being choked. In the case of the Upper Jhelum Canal, special arrangements have had to be made to prevent the torrents which come from the Pabbi Hills Gujrat from depositing their load of silt in the canal. (i)

(i) Ibid P.18
4. The Shortage of Fodder and Deterioration of Cattle:
As pastures deteriorate, the cattle get less to eat and become weaker. The numbers of cattle tend to decrease as also their quality. This has its effect on the quality of ploughing as animals are the chief means of tilling the land both in Barbary and West Punjab. It may also be added that if natural pastures were preserved, it would not be necessary to devote an increasing area to fodder crops so that more food could be grown for the rising population.

5. Shortage of Timber and Fuel as a result of erosion has an indirect effect on cultivation, particularly in West Punjab. Large quantities of natural manure available from cattle-dung is burnt to meet this shortage and thus denied to the heavily cropped fields. Shortage of timber means poorer housing for the peasant and his family.

6. Floods:— There is every evidence that floods in Barbary and West Punjab have been becoming more violent through the denudation of river catchments. Some of the indirect effects of floods have been described before, but the direct destruction caused by them is equally considerable. Fields and villages are carried away, cattle drowned and thousands rendered homeless by the floods which frequently come down West Punjab rivers, specially the Ravi and the Indus. The great fluctuations in their water regime during floods have already been described under Hydrography. Similar facts have been quoted before for the rivers of Barbary. Apart from the
direct damage to fields and settlements, dams have been destroyed by them so that the present reservoirs are being equipped with expensive devices to withstand their sudden force. Excess of water in one season, taking the shape of floods in one season, means shortage during the dry season. Preservation of vegetation could regulate this supply to the benefit of irrigation and general water supply for domestic use.

7. Lowering of the Water-Level:— With the numerous outlets provided to the sub-soil water to escape by deep gullies as also the smaller amount of percolation from the higher lands, water-level is bound to fall. This has been noticed widely in West Punjab and doubtless exists in Barbary as well. In the Potwar Plateau, terracing and embanking of ravined fields in the Gujar Khan area produced a rise of 15 feet in the wells. (1) Similar rises have been reported from the neighbourhood of other soil conservation works.

These mainly economic and agricultural consequences of soil erosion amount in effect to a lowering of the standard of living.

Far-fetched as it may sound, erosion actually brings about a change in the climate. When the trees disappear the earth gets heated up more quickly and strong convection currents hinder precipitation from clouds. The effect of vegetation on rainfall in Algeria was described in chapter on Soils and Vegetation wherein it had been proved

(1) Ibid p.22
by meteorological observations that deforested areas had, 8% less rain than those covered with forests within the same natural region.

The effect of wind erosion has recently been noticed particularly as **shifting sand** from the Thar desert advances to the irrigated lands fringing it. At the Indian Silvicultural Conference of 1945, Lt.Col. Westland Wright produced a map of the Punjab on which was entered the record of sand movement since 1870\(^1\) The indication is that desert conditions are steadily advancing in the direction of the great cities of Lahore and Delhi. Due to the disappearance of vegetation in the unirrigated lands of the desert, sand dunes formerly fixed by bushes have begun to move northwards. Incursions of sand usually take place during the dust storms of the summer. It should not be imagined that sand just swallows up the fertile land. "The actual process is a less spectacular but more insidious one of gradual decay from an ecologically stable forest destroyed to make way for cultivation whose fertility dwindles till the land is merged into the adjoining desert" \(\text{(ii)}\) The map opposite shows the regions affected by shifting sand. Similar incursions are frequent in the desert fringe in Barbary, particularly in Tunisia where the protective barrier of the Saharan Atlas does not exist. Shifting dunes are also a source of danger to agriculture on the Atlantic coast of Morocco and the entire coast of Tunisia.

\(\text{(i)}\) R.M. Gorrie "Countering Desiccation in the Punjab" G.R. 1948, P.30

\(\text{(ii)}\) Gorrie, Soil & Water Conservation in the Punjab" P.217
SOIL CONSERVATION:—

Soil conservation practice goes beyond the simple fight against erosion and indeed as one of the greatest authorities on the problem, H.H. Bennet has observed, "Soil conservation in the modern sense is not just controlling erosion; it means doing that and whatever else needs to be done to keep the land permanently productive" (i) He has also warned against several misconceptions about erosion, the most serious being the belief that soil conservation can be attempted successfully by individual farmers without technical assistance, a belief that appears to prevail even among soil-erosion experts, at least in Barbary. In Algeria, which is the only territory in that region in which soil conservation work has been going on for some time in an organised manner, the Service de la Défense et de la Restauration issued a manual for the use of the farmer, setting out the simple lines of elementary constructions and embankments to be undertaken and the nature of trees to be planted. (ii) This type of guidance may not lead to perfect results but it is certainly preferable to no guidance at all in face of the present inadequacy in numbers of technical staff to fight a problem of such great magnitude.

Modern soil conservation practice is of American origin. Some of its principles will therefore be described as evolved through the American experience (iii)

(i) "Soil Conservation in a Hungry World" G.R. April 1948, V.38, P.311-317
(ii) "Manuel Simple de Défense et de Restauration des Sols en Algérie"
We shall then take up the different territories in turn and see how these principles are applied, what adaptations or modifications affected to suit the local conditions.

1. The most important principle of soil conservation is the control of run-off. By the maintenance of vegetal cover, by increasing the permeability of the soil and by means of checks to run-off like terraces, diversion banks and ditches, the amount and velocity of run-off is kept low. Whether it is in the fields or outside the fields, the excess water is made to flow into natural channels.

2. The covering of steep or eroded slopes with permanent vegetation to delay run-off on one hand and to hold the soil together on the other. It is the steeper slopes which need greater initial care.

3. Means to be adopted by which a part of the cultivated lands is always under some sort of cover and no bare fallows are left exposed to erosion. This takes the shape of strip-cropping or suitable crop-rotations.

4. Contour cultivation even on very gently sloping soils as a safeguard against sheet erosion.

5. Control of gullies and streams.

6. Control and development of pastures by rotational or reduced grazing.

7. Removal of the social and economic handicaps in the way of the above improvements like small or scattered holdings, over-cropping, etc.
In addition, in conformity with the larger purpose of maintaining or even improving productivity, measures like the use of manures and the preservation of crop residues are adopted to conserve the fertility of the soil.

3. To provide for defence against wind erosion by means of shelter belts, fixation of sand-dunes and improved dry-farming.

Gorrie(1) divides the actual methods into two main categories - upstream and downstream engineering, the upstream works being those dealing with mountainous areas and catchments. This is a useful concept for conducting operations in the field.

Before any drive for soil conservation can succeed it is essential to awaken the populations concerned to its dangers. Surveys of the land should be made and the soils classified according to their degree of productivity and erosion. The task of conserving the soil on a large enough basis can only be undertaken by the State.

BARBARY

Due to its mountainous relief and special climatic conditions, Barbary is highly susceptible to erosion. How progressive diminution of the vegetation cover and the local economic and social conditions have brought this evil on in all its various forms has also been demonstrated.

The first country in which this problem attracted attention was Algeria where in 1384, the then Governor-General

(1) Op. Cit. P.20
advocated afforestation as a protection against floods and to regulate water flow. (1) An effort was made to re-afforest denuded regions and 24,000 acres have since been planted. But this action was hardly in proportion to the gravity of the problem and it was not till 1941 that the Service for controlling soil erosion (mentioned before) was established. Since then a general survey of the areas subject to various stages and types of erosion has been made and it has been established that 12,000,000 acres need attention. Most urgent is the necessity of controlling erosion in the large catchments from which water is collected in the great reservoirs.

The Manual of Soil Conservation issued for the lay farmer advocates certain measures and gives fairly detailed instructions as to how they are to be put into effect. It draws special attention to the danger of depriving sloping lands of their vegetative cover and by means of photographs (See opposite), demonstrates how scattered bushes and isolated trees are no protection against sheet erosion. It recommends that the natural cover may be preserved but wherever extension of cultivation and pastures is sought, the following steps are advocated:

(a) All plantations of fruit trees, vine etc. shall be made along contour lines. The stones extracted from the ground should not be thrown away but employed in making contour ridges. In brief whether it is by hedges, or rows of planted trees or stone ridges, the run-off should be controlled. Even where bush is cleared, it advocates leaving

(1) Documents Algériens - Le Reboisement en Algérie et la Restauration des Sols. Série Economique etc. 1945 No. 1
Soil conservation by the native population. The bare slope has been terraced along the contours, Fig. 1. A gully is visible in the foreground.
Terrasses established in the catchment area of the Hamiz Dam by the service de la Défense et Restauration des Sols.
lines of bushes every 75 feet or so along contours.

(b) It is possible to go one better than merely protect soils; one can restore soils by constructing terraces. These could consist of earthen embankments or low walls of stone with ditches behind them. On very steep slopes, steps could be created. The earth dug out to make the step should be deposited as an inclined bank. These can then be fixed with bushes, cactus or other small trees. Check-dams of various types are advocated for ravines to break the velocity of run-off.

The manual lists a number of fruit trees as useful for fixing the foundation of stone embankments, notably olives, figs, table vines, cherries etc. These are also recommended for planting on the earthen embankments above steps on a hill-side, thus offering a temptation to the cultivator, or at least a reward for his trouble.

The problem of soil erosion and deterioration is a serious one in Algeria from which the small Muslim peasants on the hill-sides are particularly bad sufferers. Re-afforestation is the best economic use of many a slope the writer saw scratched with the primitive ploughs but the human conditions created by colonization do not allow of this.

Happily the practice of terraced cultivation is being adopted widely and is especially popular in the Kabyle region.
The colonists have the means and the resources to practice all the methods the manual advocates to perfection.

The Government's efforts are mostly concentrated on preventing the silting up of reservoirs. Apart from the recent bench-terraces around the Wadi Fodda Dam, the catchments of the Hamiz Barrage and of Wadi Mellah have been terraced since 1940 by the Service des Irrigations. The collaboration of all interests concerned - colonists, local peasants and tribal groups with the administration has been solicited by a decree of 1941 which prescribes three steps to be taken by the Services de la Defense et de la Restauration des Sols (i) about treating threatened areas. The first step is a decision to start anti-erosion measures in a catchment area. The catchment is then declared to be a public utility and contour-cultivation and the construction of stone-ridges is enforced; grazing and lopping as well as new extensions of cultivation are prohibited. The pastures are regulated and growth of olive and other trees encouraged. The last step consists of the official measures for conserving the soil such as construction of steps, terraces, diversion ditches etc. The task of re-afforestation is still being pursued. Map shows those parts of Algeria where erosion is in progress and also the areas where soil conservation work is being done.

TUNISIA:-

The dangers of erosion have been known in Tunisia since long and particularly the fixation of advancing dunes

was undertaken as long ago as 1888 by the Forest Service in southern Tunisia. Since then the fixation of dunes has been the main preoccupation of the authorities, particularly along the north coast and in the Cap Bon region. Several types of grasses have been utilised particularly Ammophile arenaria and Saccharum biflorum. Once dunes have been fixed plantations of Aleppo pine, Canaries pine and Eucalyptus have been established which not only provide wind-breaks but also constitute a valuable economic resource.

The menace of water erosion has increasingly been recognised in recent years and a visit from Dr. Lowdermilk, Deputy Chief of the U.S. Soil Conservation Service in 1939 stimulated interest in soil conservation work on the lines followed in the United States. He advocated among other things the employment of tractors etc. already in use on the larger estates to construct contour-terraces. He noticed the ravages of erosion, as did the writer himself, among the olive-growing regions of the Sahel (see photo) and recommended terracing and more widespread use of the existing device - that of muskat.

The commencement of soil conservation work in Algeria in 1941 has since led to increasing efforts to organise the fight against erosion by means of setting up a

(i) "Les Forêts de la Tunisie" 1931, P. 30
(ii) M. Lesculoyer "Les Dunes de Tunisie" Unpublished 1944
separate department. Although this has not yet been achieved, a grant was made in 1947 and initial work commenced in the regions of Kairwan and Cap Bon. It is planned to make practical demonstrations to cultivators, to give technical assistance and lend machinery for undertakings by landed proprietors. At the same time closure to grazing has been applied in several regions, notably in Zaghwan south-west of Tunis and the preservation of forest ensured through several decrees.

It may be said in conclusion that the most imminent task in Tunisia is the prevention of wind erosion, as water erosion is not as advanced as in Algeria due to a less mountainous relief.

MOROCCO:

Morocco ranks second among the territories of Barbary from the point of view of erosion and the estimated area on which erosion is in progress is over 7,500,000 acres. Overgrazing is the greatest single cause although cutting of forests and careless cultivation are widely in evidence. The organisation of the fight against erosion has been undertaken after the last war and entrusted to a Conservateur of the Forest Service (Service des Eaux et Forêts) but the co-operation of the department of animal husbandry (Service de l'Elevage) and of other services concerned has been enlisted. Soil conservation work, consisting primarily of step terraces has been started in the Rif region around Wezzane as well as
in the Marrakesh region where the Nfis Barrage is in danger of being rapidly stilled up. The control of stream-beds has also been carried out in the plain surrounding Marrakesh. The work is as yet in its infancy and is hardly adequate to meet the requirements of the country. Coastal dunes in the region of Mogador have been fixed.

WEST PUNJAB

How far the province has been affected by water and wind erosion may be judged from the following estimated district-wise figures (1) of lands ravined, those in need of terracing and others at the desert fringe subject to incursions of sand. It may be added that Gorrie lists them as "Reclamable land", possibly implying that there are further areas so badly eroded that reclamation may be out of question.

<table>
<thead>
<tr>
<th>District</th>
<th>Gross Area</th>
<th>Requires Terracing</th>
<th>Ravines</th>
<th>Desert fringe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lahore</td>
<td>1,667</td>
<td>100</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sialkot</td>
<td>1,005</td>
<td>50</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Gujranwala</td>
<td>1,474</td>
<td>200</td>
<td>-</td>
<td>-</td>
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<td>Sheikhupura</td>
<td>1,479</td>
<td>200</td>
<td>-</td>
<td>-</td>
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<td>Gujrat</td>
<td>1,458</td>
<td>200</td>
<td>200</td>
<td>-</td>
</tr>
<tr>
<td>Shahpur</td>
<td>3,071</td>
<td>-</td>
<td>100</td>
<td>400</td>
</tr>
<tr>
<td>Jhelum</td>
<td>1,771</td>
<td>200</td>
<td>400</td>
<td>-</td>
</tr>
<tr>
<td>Rawalpindi</td>
<td>1,312</td>
<td>200</td>
<td>300</td>
<td>-</td>
</tr>
<tr>
<td>Attock</td>
<td>2,680</td>
<td>700</td>
<td>500</td>
<td>-</td>
</tr>
</tbody>
</table>

(1) R.M. Gorrie, "Soil and Water Conservation in the Punjab" P.146-147
<table>
<thead>
<tr>
<th>District</th>
<th>Gross Area</th>
<th>Requires Terracing</th>
<th>Ravines</th>
<th>Desert fringe</th>
</tr>
</thead>
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<tr>
<td>Mianwali</td>
<td>3,436</td>
<td>-</td>
<td>100</td>
<td>700</td>
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<tr>
<td>Montgomery</td>
<td>2,721</td>
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<td></td>
<td>300</td>
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<td>Lyallpur</td>
<td>2,249</td>
<td>-</td>
<td></td>
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<td>Jhang</td>
<td>2,169</td>
<td>-</td>
<td></td>
<td>100</td>
</tr>
<tr>
<td>Multan</td>
<td>3,604</td>
<td>-</td>
<td></td>
<td>500</td>
</tr>
<tr>
<td>Muzaffargarh</td>
<td>3,559</td>
<td>-</td>
<td></td>
<td>400</td>
</tr>
<tr>
<td>Dera Ghazi Khan</td>
<td>3,475</td>
<td>50</td>
<td></td>
<td>300</td>
</tr>
</tbody>
</table>

Total: 37,120

The problem is most urgent in the Potwar Plateau and the neighbouring sub-montane tracts wherein ravines alone cover 1,600,000 acres and are still extending. Another zone of danger is the desert fringe where the problem is one of wind erosion.

The Evolution of Soil Conservation Work:— As early as 1870-80, Baden-Powell prepared a soil conservation programme after seeing the ever-extending hold of this menace in the foothills. In 1900 a Land Preservation Act was passed to stem the process of erosion by controlling forest-cutting and grazing, by the training of streams and by the "levelling, terracing, drainage and embanking of fields." Thus it may be noticed that the fundamental principles of soil conservation had already been set out. Not much was done about the matter because of a lack of public interest on one hand and lack of

co-ordination between the government departments on the other. On the report of the Forest Commission pointing out the increasing gravity of the situation, a special branch of the Forest Department was created to conserve the soils of the forests, pastures and cultivated fields. The Soil Conservation Circle has done some effective work up till now but a much greater amount of popular and government interest is required to reclaim the badly ravined darrar lands, to prevent the washing away of the fertile soil from the sloping fields and to stem the advancing sea of sand from the south.

Soil Conservation in Theory and Practice:— It is now proposed to lay down the principles on which soil conservation work can best be planned for West Punjab conditions and to illustrate the theoretical solutions with what has actually been achieved in the field. The main guides in this survey are the recent studies by Sir Harold Glover and Dr. A.M. Gorrie, both of whom have contributed greatly to the organisation of soil-conservation work in West Punjab. Before the actual field operations can be undertaken some initial spade-work is essential on the following lines:—

**Propaganda:**— The peasant or the pastoralist whose lands are threatened by destruction are independent-minded individuals who, like all men, resent interference into their properties. The danger has got to be explained to them and persuasion used rather than compulsion. The most effective

(1) Both cited before.
means of propaganda is actual demonstration in the field. Once the landholders know the value of conservation methods, the task of organisation becomes much easier. Popular support can also be enlisted through acting through village representatives (panchayats) or local notables.

Official Co-ordination:— The field operations connected with soil conservation encroach on the domain of several government departments notably those of Forests, Agriculture, Irrigation etc. and need the assistance of several others, notably the Co-operative and Revenue departments. Apart from official co-ordination in conducting work in the field, Gorrie considers that the best way of planning soil conservation is to make comprehensive surveys through field parties consisting of several experts on different aspects such as climate, landscape, vegetation, agriculture and the social and economic background of the region as was done in the case of U.S.A.(i) It may be added here that the geographer, by reason of his general grasp of the essentials of all these aspects is admirably fitted to advise on such detailed regional studies.

The Organisation of Soil Conservation must take a catchment area as the natural unit. On this, then, the work can be sub-divided into the following categories:-

1. Water-shed management - "The first principle in all soil conservation work must be to start at the top"(ii)

These are usually steep marginal lands in which the main

(ii) Ibid, P.252
activity should concern the provision of an adequate vegetation cover and the restriction of grazing. Contour terraces may be required for very steep slopes.

This part of the work is almost entirely within the jurisdiction of the Forest Department. In West Punjab official closures of forests to grazing have been applied with great success. The most successful example of the reclamation of denuded hillsides is that of the Surla Forest in the Jhelum District.\(^{(1)}\) In 1938, 1000 acres were closed to grazing bousing and felling. With the help of a grant, 900 check dams were built along the principal gullies and ravines. Silt collected behind the dams on which were planted nara grass (Arundo donax), elephant grass and shisham (Dillbergia sissoo). The slopes were trenched. A complete transformation of the bare wilderness of ravines has taken place. Grass has covered the centre area and is stretching even on to the infertile clay slopes. Bhabar grass (Eulaliopis binata), a valuable product, is spreading naturally.

This was intended to be a demonstration area and its success is being followed up elsewhere. The methods adopted here have been tried at other places with equal success. The North Western Railway bought 1450 acres of denuded land in the Rabbi Hills and was able to restore vegetation by a similar closure.

Afforestation has been carried out on the Kalachitta Hills in the Potwar Plateau with species of trees imported

\(^{(1)}\) Glover, Op.Cit. P.59
from other regions.

2. Management of Pasturelands:— Partial closures of state-owned pasturelands have not been successful, therefore complete closures have had to be applied. Rotational closures have also been tried and the scheme proposed to ensure a long rest in each block.

Most of the pasturelands of the province are owned communally by villages and are known as shamilat. As the land is nobody's responsibility in particular it is habitually misused and overgrazed. Partition of shamilat has been tried among the individual proprietors. It has been successful in several parts of Jhelum district but has led to more intensive degradation in other areas. Voluntary closures under the supervision of panchayats or co-operative societies have been successful in restoring vegetation in several parts of the Potwar Plateau. The rational use of pastures, however, must remain a problem as long as the animal population is high and pastures limited. The growth of fodder crops is one solution but already the pressure of human population on the land is so great that this possibility is limited in scope.

The Control of Running Water and Gully-plugging:—

A considerable surface of the eroded lands is subject to inundations due to quick run-off from the denuded slopes. Torrent beds spread over large areas, engulfing cultivated lands. The headwaters of the torrents are usually in the shape of gullies which keep eating back. The torrent beds
Brushwood spurs built at 30° to the line of the torren in order to slow down its velocity and cause deposition. Notice the wide sandy bed with steep banks.
Valley of a torrent in the Potwar Plateau at the point where it emerges to the plain surface seen in the background. This is a good site for erecting a bund to prevent loss of soil from the valley as well as to safeguard the fields in the plain from being choked with silt.
cannot be effectively reclaimed unless their water-sheds are under control. Afforestation and grazing-closures have already been mentioned as steps in this direction. Gully plugging is another effective measure. This is achieved by constructing check-dams. They store debris behind them, check the velocity of the water, stop further cutting back and promote plant growth. Some of the deposits behind check-dams have even been cultivated as for instance in the Attock district.

Torrent-bed reclamation chiefly takes the form of the stream-bed being limited by earthen bunds behind which are planted *nara* and *sarkanna* grass as well as shisham trees. In the Jhelum district, the Murid village was partly destroyed by torrent floods but it has been protected now in the above manner and the plantation has already become a dense forest. (1) In the Gujrat district, 11,000 acres of torrent beds have been closed to grazing and shisham plantations established.

The larger problem of shifting river courses may also be considered here. The five rivers of West Punjab keep cutting into the fertile land along their banks. Every year as denudation in the catchments makes progress, floods become more violent. The meanderings of the rivers extend within the confine of their flood plains. The best that can be attempted in the province is to plant belts of forest for widths of 200-600 feet on the banks of dangerous streams. In Dera Ghazi Khan district, 300,000 acres of fertile lands

(1) Glover Op.Cit. P.60
Carefully aligned contour ridges in the Attock District to prevent soil loss and to conserve moisture. The land has been closed to grazing and is designed to become a fuel and grass reserve.
The Sil river has been trained away from its bank where it was under-cutting the fields shown on the left.
lie along the Indus which are not utilised for crop-production because of the menace of bank-erosion. Gorrie is of the opinion that if one-tenth of the tract along the river could be forested, the rest of the land would become available for cultivation with complete security. (1)

Contouring and Bunding: These methods are being considered mainly in relation to arable lands which may be divided into three classes according to their slope:

(a) Comparatively flat unirrigated land. Such lands are not considered susceptible to erosion but sheet erosion was proved to carry 130 tons of soil per acre per annum in a well tilled field with a slope of 1 in, 80.

(b) Gentle slopes of the sub-montane tract and the bare uplands of the Punjab Doabs. The need for contour terraces and contour ridges (wattbandi) is fully appreciated here but not practised consistently.

(c) Steep slopes where permanent cultivation is possible only with elaborate terrace walls i.e. in the Murree Hills.

Bunding of fields has been encouraged widely in the problem districts of the Potwar region. Means of enlisting popular support have been found by encouraging the natural sporting and competitive instincts of peasants. The Mangali in Attock district is a communal competition in which groups compete in raising watts and levelling fields to the rhythm of drums and the cheering of village crowds. Co-operative ravine

The value of communal effort in soil conservation. A large torrent has been dammed by a "mangli" (communal labour-cum-sports group) in the Attock District. Healthy competition between sportsmanlike Punjabis has been found a great help in safeguarding village lands against erosion.

A reclaimed torrent bed in Attock District is now under trees and fodder.
Bull-dozers levelling badly ravined land in the Gujrat District to make it suitable for cultivation. This particular enterprise was undertaken to train army drivers but the use of earth-moving machinery has been found an economical proposition for large scale reclamation.
reclamation societies have been established in villages and demonstration centres set up at numerous places in those areas where arable land is liable to serious erosion.

The American system of broad-based contour ridge is out of the question for the Punjabi bullock power. Strip-cropping, although useful for large properties, cannot be practised on the average West Punjab holding.

On the basis of experience gained in the Rabbi Hills with bull-dozers and other earth-moving machinery, Gorrie has become convinced that badly ravined lands can be reclaimed at an economical cost with mechanical equipment. Accordingly, several bull-dozers and terracers have been purchased and use has been made of demobilised soldiers with experience of such machinery. Owners of lands to be reclaimed have agreed to share the cost.

Measures against Wind Erosion:— Fixation of dunes by means of a vegetative cover on one hand and the establishment of shelter belts to prevent sterilisation of cultivated fields by sand are the two main steps against erosion and deposition by the wind. Saccharum grasses including local varieties such as kahi, kana etc. have been found suitable for planting on dunes and grown long enough, their roots penetrate deeply and hold the dunes. Shelter belts have to be at right angles to the direction of the wind. A single row of trees is hardly adequate, therefore, a row of smaller

(1) R.M. Gorrie "Rural Development in India" Progress in the Punjab, Empire Forestry Review, Vol. 26, No. 1 1947
The advancing desert in south western Punjab. These ploughed fields have been invaded by sand, which is already accumulating in low dunes in the background towards the left. This is a stage of dwindling productivity followed, unless checked, by incorporation into the desert.
such as agaves followed by tall cane grass and the belt of trees is advocated. Trees should be combined with maximum screening effect such as kikar (acacia arabica) and mesquite planted alternately.

The desert fringe of West Punjab is still largely unprotected and much greater efforts are needed to prevent further incursions of sand. The technique of dry-farming aiming at reclaiming this fringe must go hand in hand with measures to control the movement of sand.

**Future Possibilities:** Soil conservation has at present become one of the chief pre-occupations of the administration and the people are awakening to its dangers. Intensive regional surveys with the help of air photographs are advocated by Gorrie who further considers that the fight against erosion will only be successful when its methods have become a part of the regular routine of the peasant.
Chapter 14

DRY FARMING

If we compare the rainfall and irrigation maps of Barbary, we find that over the larger part of the region, agriculture is still a gamble on the rainfall. In West Punjab, too, 32% of the cropped area is unirrigated and much of it situated in the zone of inadequate and insecure rainfall. The practice of dry farming offers a means by which these areas can be made productive and secure.

Dry farming is a system of specialised farming, developed for semi-arid regions which aims at utilizing fully the water of rainfall by reducing evaporation to a minimum. It also conserves the water of two consecutive years to produce one good crop in those areas where one year's rainfall is not enough to mature a crop. It is thus complementary to irrigation. Furthermore, as has been indicated in the previous chapter, the technique of water conservation has much in common with the practice of soil conservation. For these reasons we are considering it after having studied both irrigation and soil erosion.

Development of the Technique:

Modern dry farming methods were developed in the United States of America and their development is credited to the industrious Mormons who were uprooted from their homes in the humid eastern part in mid-19th century, and had to grow their requirements in the semi-arid climate of Utah. The technique was found to be ideal for the western United States.

(i) Augustin Bernard "Le Dry-Farming et ses Applications Dans l'Afrique du Nord" Ann. de Geog. 1911, P.422
and through the experiments of several eminent agricultural experts, notably Campbell and Hilgard, was perfected into a science by the beginning of the 20th century. But the Americans can be credited with no more than the merit of conducting investigations methodically and enunciating the principles in a scientific manner. For dry farming is probably as old as agriculture. In many parts of the world there is evidence of people having adapted themselves to semi-arid conditions by adopting practices that conserved the moisture.

In Barbary, we have already noticed the perfection in cultivating arid and semi-arid regions attained to by the Romans. During the Islamic epoch, most of the great advances in agriculture took place among the Moors in Spain and later came to the Barbary lands. The most eminent of the Moorish writers on agriculture was Ibn-al-Awam. In his "Book of Agriculture", he describes in detail the practice of "qalib" or cycle of ploughings which envisaged four ploughings through the year, its object being to conserve moisture, to maintain the soil in a friable condition and to destroy weeds. As Bernard observes, this eminent writer set forthe eight hundred years ago almost all the principles of modern dry farming down to the soil mulch. Even in modern times, some of the methods of dry farming have been practised in many parts of Barbary, notably in the growth of olives in Tunisia and the cultivation of cereals in the Sidi Bel Abbes plain in Algeria.

(i) L.Olson & H.L.Eddy "Ibn-al-Awam", A soil scientist of Moorish Spain G.R. 1943, 100-109

In West Punjab, the practice of bunding or cultivation in terraced plots dates back to ancient times and is still the most effective means of soil and water conservation as has already been stated. Other practices such as interculture, harrowing, rotations and falling are also by no means new to the region.

The Methods of Dry Farming

We have already set forth the basic principle of dry farming. It seeks to prevent evaporation by increasing the absorptive capacity of the soil and creating a surface layer that will not allow evaporation. Repeated ploughing is advocated to facilitate deeper penetration of the moisture into zones beyond the effective range of losses by evaporation. Mulching and weeding are other steps preparatory to sowing.

Sowing by drilling is advocated so that the seed is deposited in the deep moist soil and ensures root growth before the soil dries up. Distance between plants is to be great enough to allow of later harrowing and interculture.

Alternate fallowing is combined with judicious rotations and those crops or varieties are selected that give high returns under semi-arid conditions. Wheat, barley and millets are the principal ones grown while peas and potatoes have been found useful.

Finally the practice of soil conservation is inseparable from dry farming as this system is practised in lands wherein

(i) Abstracted from N.V. Kanitkar "Dry Farming in India" The Imperial Council of Agricultural Research, Scientific Monograph No.15, Delhi 1944.
violent rains come after long intervals during which atmospheric weathering loosens the soil. Terracing is carried out on sloping lands. As developed in America, dry farming envisages the large scale use of machinery.

The Possibilities of Dry Farming:

One of the first American writers to set out the principles of the technique called it "the greatest discovery of the age" (i) There was a similar show of enthusiasm among other American experts who claimed that the system would bring under the plough most of the world's dry areas. Much of the optimism about its possibilities can be justified by its success but the system should not be understood to be able to reclaim deserts. As Bernard has maintained, "it is essentially the regions of transition between humid and arid conditions which can thus be transformed" (ii) Dry farming is therefore the system to be adopted in semi-arid lands without facilities for irrigation.

The larger parts of Barbary and West Punjab need water conservation under dry farming. The methods have, of necessity, to be adapted to the needs of the respective areas and the technique varied according to the resources of the cultivators. Mechanised dry farming cannot be practised except by a few larger proprietors and allowance has to be made for the deeply ingrained traditional methods in vogue.

(i) J.A. Widstoe, "Dry Farming, A system of Agriculture for countries under a Low Rainfall - New York, 1911, P.11
Dry Farming in Barbary

There are two distinct types of cultivators in Barbary, the European colonists and the native peasants. The former are already practising mechanised cultivation on the richest lands in Barbary and they do not as a rule have to have recourse to dry farming. The native peasant by reason of his poverty, his traditions and his methods is not taught new techniques easily nor do the official agricultural agencies attempt to improve his lot. Hence when the new dry farming methods first began to spread Bernard did not envisage a great scope for them in all parts of Barbary. (1) Tunisia alone, he forecast, would lend itself to complete transformation by dry farming because of the natural conditions. This was the ancient cradle of dry farming on account of a much greater proportion of its area being in the zone of less than 16" rainfall combined with the prevalence of lowland steppes. This forecast has certainly proved to be correct. But whereas Bernard could not foresee the large scale application of dry farming by the European colonists, actually the technique led to a southward expansion of colonisation in all parts of Barbary. The plateau of Sersou in Algeria has largely been brought under mechanised cultivation through the practice of dry farming. In Tunisia as well as in Morocco, the limit of European cultivation has been extended to the edge of the desert. Slowly, native landlords in particular and small peasants to a lesser extent, are also copying these methods.

(1) Ibid
The writer, during his work in the field in Barbary, conducted an enquiry into the principal features of dry-farming as practised in Tunisia. From this point of view, Tunisia can be divided into three Zones.

1. **Northern Tunisia** lies north of the 16" isohyet and does not need to practice all dry-farming methods. Only one crop is obtained every year which is alternately a cereal and a leguminous plant. During the dry season, superficial ploughing is done to destroy weeds etc.

2. The **Central Zone** lies between the isohyets of 12" and 16". A biennial rotation is practised with one year cereal, one year fallow with ploughing. After the harvest, the stubble is burnt to destroy parasites and to provide a powdery cover that may also serve as a fertilizer. A 6" to 8" deep ploughing is given in August followed by another in December, this time to destroy weeds and to render the soil friable. A further deep ploughing is given to the lands in February. Then follows a light ploughing in March-April just to stir the superficial layer and keep it open. Harrowing is carried out in May-June, sometimes accompanied by the application of super-phosphate. Finally a ploughing is given at the end of October before sowing.

Drought resisting and precocious varieties of wheat specially developed in Tunisia are grown. Such for instance are the Florence-Aurore (soft wheat) and Sindyouk Mahmoudi (hard wheat). The quantity of seed used is less than in the first zone and the seeds are well spaced.
3. The Region of Enfidaville gets only 8 - 12" of rainfall and the same rotation is used as above. The lighter soils of the region are preferred for cereals and the quantity of seed used is about half that used in the second zone so that wider spacing is provided between individual plants. Fallow is cultivated superficially up to a depth of 4" and the seasonal arrangement of ploughing is roughly the same as in the second zone. Barley is more important here than wheat, being a more hardy crop and practically no hard wheat is grown. Yields are very variable depending upon the rains after sowing (November) and before maturing (March).

The planting of olives in the Sahel under dry farming will be studied in a subsequent chapter.

In Algeria the practice of dry farming methods is becoming widespread. Frequent ploughings of fallow land are becoming increasingly popular and in 1939 25% of the total fallow area was thus ploughed. Over a period of ten years, the area of ploughed fallow has increased by 372,000 acres.(1)

It is not very certain, however, if all the principles of dry farming are used on these lands. It may be remarked that whereas 50% of the lands sown with cereals by Europeans were tilled while fallow, in 1939, only 10.8% of the native lands were so treated.

Cultivated fallow is extending in Morocco but no figures or details of methods are available.

(1) E. Vivet and P. Laumont, "La Production Agricole de l'Algerie" 1940 P.8-9
On the whole, one may generalise that modern dry farming methods with the extensive use of machinery are employed mainly by large landholders, Europeans and Muslims alike. The practice of maintaining a ploughed fallow has not spread among the small-holders because they prefer to retain the stubble after the harvest to feed their animals, on account of the grazings lands.

**WEST PUNJAB**

The possibilities of irrigation in West Punjab have almost been exhausted and no great expansion is envisaged that might cover the insecure tracts in the Potwar Plateau, and many parts of the Thal and Derajat tracts. Rainfall in the southern part of the Potwar region is less than 20" and is less even than 10" in the other areas mentioned. What is more significant from the point of view of cultivation, rains are extremely variable in their total amount and capricious in their periods of occurrence. This introduces a factor of insecurity even into the well-watered sub-montane tract where rainfall exceeds 20". Finally, the endangering of canal water supplies on account of the Partition of India is a recent complication which ought to be considered because large parts of the Bari Doab may find themselves dependent upon the inadequate rains if these supplies are cut off.\(^1\)

Dry farming therefore still has a large part to play in the agriculture of the province. In many parts, certain methods have been in vogue over centuries to conserve moisture in the soil. In the Potwar Plateau and Mianwali district fields are

\(^1\) This happened in 1948 at a crucial time before "kharif" sowings.
flat and terraced, bordered by peripheral embankments or watts which retain water in the fields. These are made with hoes and rakes or with the karrah (bullock-drawn scoop). Land is ploughed when in a friable condition (wattar) and frequent harrowing carried out between the growing crops. These practices, however, are not widespread enough nor are they systematised.

The need for instituting dry-farming research had long been felt in India to develop methods suitable for different parts of the sub-continent. First experiments were started in Bombay in 1923 after which regional stations were established. One of these is at Rohtak, in East Punjab and represents the typical conditions in the drier parts of the province in its temperatures, regime of rainfall and nature of the soil. N.V. Kanitkar has presented the results of several years of experiments with different methods in a monograph. They have yielded valuable results and in the following account, the relative efficiency of dry farming methods as compared to current practices will be demonstrated.

**Soil Moisture:**

The behaviour of the Punjab alluvial soils with regard to moisture does not favour retention under normal conditions. At the end of the monsoon, the distribution of

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moisture with depth is as follows:-

<table>
<thead>
<tr>
<th>Soil Layer</th>
<th>Per cent moisture</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1 ft.</td>
<td>9.17</td>
</tr>
<tr>
<td>1-2</td>
<td>15.08</td>
</tr>
<tr>
<td>2-3</td>
<td>16.26</td>
</tr>
</tbody>
</table>

In a year of drought the soil moisture in the surface layer is the same but decreases with depth so that the sowing of crops is impossible. The clayey soils of peninsular India are more retentive of moisture.

The effects of dry farming methods on soil moisture were compared with those of ordinary methods in 1937-38 and the results are shown in the following table:

<table>
<thead>
<tr>
<th>Percentage of Soil Moisture with Depth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soil Layers</td>
</tr>
<tr>
<td>1st foot</td>
</tr>
<tr>
<td>2nd foot</td>
</tr>
<tr>
<td>3rd foot</td>
</tr>
</tbody>
</table>

Water requirements of Crops:- Different crops require different quantities of water to produce a unit weight of dry plant and within the same crop, different varieties vary in their requirements. The evolution of strains with less consumption of water forms an important step in tackling the problem of crop production in semi-arid regions. The dry-farming experiments at Rohtak led to the working out of a transpiration co-efficient - the ratio of water transpired through the plant to the total dry weight of the plant. These may now be given in relation to different crops and varieties.

<table>
<thead>
<tr>
<th>Sorghum</th>
<th>304</th>
<th>Wheat 460-506</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bajza (ordinary)</td>
<td>303-550</td>
<td>Gram 501-612</td>
</tr>
<tr>
<td>Bajra (A 1/3)</td>
<td>323-448</td>
<td></td>
</tr>
</tbody>
</table>
Thus sorghum and bajra need the least amount of moisture. Of these crops, bajra was found to be best suited to the Punjab conditions which may explain its relative importance among the crops of the unirrigated north-western tracts. A dry farming technique has been evolved on the basis of the Rohtak experiments and the relative effect of a series of operations may now be studied.

1. Control of run-off and erosion by levelling, bunding (construction of low banks along contours) on relatively level land was tried. The kiara system (division of fields into bunded plots) was applied. The following figures of yields of barley and gram in pounds per acre show the value of this practice.

<table>
<thead>
<tr>
<th>Year</th>
<th>Rainfall in inches</th>
<th>Bunded plots Barley</th>
<th>Bunded plots Gram</th>
<th>Unbunded plots Barley</th>
<th>Unbunded plots Gram</th>
</tr>
</thead>
<tbody>
<tr>
<td>1936-37</td>
<td>22.32</td>
<td>1,356</td>
<td>376</td>
<td>1,044</td>
<td>266</td>
</tr>
<tr>
<td>1937-38</td>
<td>15.24</td>
<td>1,084</td>
<td>192</td>
<td>902</td>
<td>157</td>
</tr>
</tbody>
</table>

2. Preparatory Tillage: Various types of plough, modern and traditional were tried. The difference between various ploughs was not significant.

3. Surface Tillage during the monsoon months: The alluvial soils tend to dry up quickly and harden at the surface layer. Stirring of the soil with a desi (traditional) plough after each fall of rain was found to be an effective measure.

4. Fallowing had a very salutary effect on the yields of in grain and straw as the following figures illustrate

(i) From W. Burns "The Desert Edge of Indian Agriculture", Journal of the Royal Society of Arts, Vol. 79, 1940-41, P. 691
Yields in pounds per acre

<table>
<thead>
<tr>
<th></th>
<th>1937 (Rain-fall 17.43&quot;)</th>
<th>1938 (R. 8.24&quot;)</th>
<th>1939 (R. 10.20&quot;)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Grain Straw</td>
<td>Grain Straw</td>
<td>Grain Straw</td>
</tr>
<tr>
<td>After a fallow</td>
<td>923</td>
<td>4,480</td>
<td>17</td>
</tr>
<tr>
<td>After a crop</td>
<td>358</td>
<td>2,959</td>
<td>0</td>
</tr>
</tbody>
</table>

It may be noticed that the years 1938 and 1939 were years of severe drought during which production without fallowing was insignificant. The practice of bare fallow renders the land susceptible to wind erosion. Here the decision to maintain cover crops at the expense of moisture reserves must depend upon the gravity of the threat and wherever wind erosion is light a decision in favour of higher productivity through bare fallowing may be made. (1) One solution of the problem lies in establishing wind-breaks.

5. Manuring increased yields by 15-40% according to the amount applied particularly in the case of bajra.

6. The effect of interculture and mulching by means of hand implements (hoe etc.) raised grain yields by 30% and kept weeds out.

7. The rotations found most useful at Rohtak were to take one kharif crop one year and follow it by a rabi crop the next year. Two promising rotations were gram-bajra and wheat guara as two year rotation.

The success of these methods should lead to their application in all parts of West Punjab to the benefit of the cultivators and the lasting productivity of the soil. It is significant that methods developed at Rohtak do not require the use of machinery.

(1) Gorrie, Soil and Water Conservation in the Punjab. P.241-242
30 A view of the city of Kairwan from the tower of its famous mosque. This was the first city founded by the Arabs in Barbary and is renowned mainly as a religious centre. Note the large number of domes indicating mosques and tombs of saints. Flat roofed houses are typical. The town is also the regional marketing and administrative centre.

31 Weekly market or suq in the Dahra Massif at Rabelais. Butchers in the foreground along with sellers of sheep. Tents shelter more expensive wares and the administrators. This suq is held on Tuesdays (Suq-el-Tleta)
"AN AGRICULTURAL GEOGRAPHY OF SOME ARID REGIONS OF THE MEDITERRANEAN REGION IN RELATION TO THE PROBLEMS OF WEST PUNJAB."

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THESIS
presented to the University of Edinburgh for the Degree of Ph.D.

January 1950.
NOTE:—Due to an error on the part of the binder, the first ten pages of Chapter 19 (AGRICULTURAL REGIONS III) have been placed after page 648 in the concluding chapter. After page 591, please turn to page 592 after p. 648 and then come back to p. 602 which is in its correct place.
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ACKNOWLEDGEMENTS.

The persons who assisted me in various ways in the preparation of this thesis are far too numerous to be mentioned individually. I can only name a few to whom I am specially indebted.

Dr. C.J. Robertson and Dr. A. Geddes both gave much of their valuable time in guiding my research. Prof. A.G. Ogilvie's encouragement and advice is also acknowledged gratefully. The uniform courtesy and help accorded by Captain A. Hawkins, Secretary of the Royal Scottish Geographical Society and his assistants was of value during several months of work in the Society's Rooms. In London, the Librarian of the India House Library, Miss W. K. Thane provided every facility to me and later on permitted prolonged loans of several works of reference and maps.

During my study tour, Mrs. Geddes' letters of introduction were of great value. In Rome, Signor Sicardi, Assistant Librarian of the F.A.O. Library not only extended courtesy and help in the Library but also assisted in procuring literature. In Tunisia, I owe much to the continuous assistance of M. Murad Sharif who accompanied me most of the time.

M. Mohammad Badra, President of the Tunisian Chamber of Commerce, was responsible for most of the opportunities I got of visiting several farms in that country. He also gave me useful introductions in Algeria and Morocco. My special thanks are due to M. Mohammad Salah ben Hamouda whose farm at Mateur I visited and in whose car I travelled to Suisse and Kairwan.
In Algeria, M. Ahmad Toufiq el Madani, author and journalist provided me with much information and gave useful introductions. The assistance of the Service de l'Hydranlique et de la Colonisation is thankfully acknowledged in arranging an official tour of the plains of Affreville and Orleansville and visits to several irrigation projects. M. Kergomard, a cousin of Mrs. Geddes provided valuable literature and introductions and thanks are also due to M. Jacques Regnier, colonist at El Marsa for hospitality and later help through despatch of literature.

In Morocco, the help of several government departments, especially the Service de la Production Agricole is thankfully acknowledged in arranging official tours in the plains of Beni Amir and Marrakesh. M. Celerier, Agrege de Geographie, Institut des Hautes Etudes Marocains provided me with valuable guidance and much useful literature. Of Moroccan friends the assistance of M. Marnissi, President of the Moroccan Chamber of Agriculture, Fez and of the several leaders of the Istiqlal Party is gratefully acknowledge. M. Mehdi ben Barka accompanied me on a tour of the Gharb plain and looked after my programme most efficiently.

Of those who helped me by post from Pakistan, I am specially indebted to Dr. R.M. Gorrie for sending me numerous photographs and valuable literature on the problem of Soil Erosion in West Punjab. Dr. K.S. Ahmad, Head of the Department of Geography, West Punjab University, also gave me constant encouragement and advice.
Chapter 1

INTRODUCTION

This study of the agricultural geography of Barbary as a largely semi-arid part of the Mediterranean Region has been made side by side with comparable aspects in West Punjab. It represents an attempt to look at the problems and distribution of crop-production in these regions from a fresh angle by interpreting them in the light of the common features of their physical and human background. While no effort has been made to force the individual pattern of these wide-apart regions into an identical mould, the community of many of their problems has been demonstrated on the basis of a first hand survey.

**The Boundaries of Regions Studied** Barbary comprises the three French territories of Tunisia, Algeria and Morocco which are referred to in French literatures simply as "North Africa". The region has been called "Maghreb" or "Maghreb-ul-Aksa" meaning "the West" or "Far West" by the Arabs. Both the French and Arabic terms are unsuitable because while North Africa, as understood geographically embraces the entire region from Egypt to Morocco north of the Sahara, the Arabic term is simply a historical reminder of the fact that the region comprised the westernmost part of the Islamic countries and was also considered to constitute the western extremity of the known land-mass. The name Barbary belongs to the region by ancient tradition and is derived from the dominant race, the Berbers. Its use is sometimes extended to cover Tripolitania but throughout this study, it shall be applied to the region which covers the Protectorate of Tunisia, Algeria north of the
Saharan Atlas (comprising the three departments of Oran, Algiers and Constantine) and French Morocco. These territories constitute a geographical entity being linked by the Atlas ranges which dominate their relief. They lie between 28° and 38° North latitude and between 11°E and 12°W of the Greenwich meridian. Their areas are given as follows:

- Tunisia: 48,332 square miles
- Algeria: 80,117 square miles
- Morocco: 154,375 square miles

The Saharan parts of Morocco and Tunisia have also been excluded so that the Barbary of this study is bounded on the north and east by the Mediterranean, on the south by a line along the southern edge of the Anti-Atlas, and Saharan Atlas ranges continued into Tunisia along the north of the Great Shotts (Jerid and Ferjaj) and on the west by the Atlantic Ocean. Out of the region thus bounded, Spanish Morocco has been excluded.

West Punjab constitutes that part of the former Indian province of the 'Punjab' (meaning "the land of five rivers") which after the partition of the sub-continent of India in August 1947 between the two dominions of Pakistan and India has become a part of Western Pakistan. Map 54 gives the dividing boundary between the two parts of the former province. West Punjab includes a little over 16 of the 29 original districts and has an area of 62,046 square miles. It lies between 28° and 34°N latitude and 69° and 76° longitude east of Greenwich. The latitudinal range of Barbary and West Punjab, it may be noticed, is similar.

(i) Administrativey, Algeria embraces a large part of the Sahara. The essential Algeria however lies north of the Saharan Atlas and for the rest of this study, the name Algeria will refer to the northern three departments.
The Physical Bases of Comparison: Superficially, Barbary and West Punjab appear to be regions of contrast, the former largely mountainous with a Mediterranean climate and the latter consisting of an alluvial plain having a monsoonal climate. The contrast in orographic features is very real and has far-reaching affects on the amount of cultivable land as well as on other aspects of the physical and cultural landscape. It is in climatic aridity that a striking parallel exists and from the agricultural point of view this factor is of supreme importance.

Certain similarities in the geographical position of the two regions may be indicated. Both Barbary and West Punjab lie in warm temperate latitudes on the fringes of great hot deserts, the Sahara in the case of the former and the Thar Desert in that of the latter. In both cases, the deserts have constituted a real barrier between the peoples to their south and the north. The races of Peninsular India differ almost as much from those in the Punjab as the negroid races of Tropical Africa from the Semites and Hamites of Barbary. The position of the two regions at the two extremities of a continuous block of Muslim countries is also of interest culturally. That the two regions might come closer economically was foreshadowed by the participation of representatives from Barbary in the Islamic Economic Conference at Karachi held in December 1949.

Agriculturally, the main inherent weakness of the two regions has always been climatic aridity and as climate is the one element of natural landscape that is readily adaptable to quantitative analysis, a closer examination of this parallel can be undertaken.

Two original maps of Barbary and West Punjab have been
drawn on the basis of De Martonne's index of aridity $Ar = P(T+10)$. According to this formula, indices below 5 characterize the true deserts. In Barbary, the aridity line of 5 practically coincides with the southern limit of the areas to be studied. In West Punjab again, only a small region to the south-west has an index of below 5. It is striking that in both regions, the indices of aridity range from 5 to over 30, the areas having an index of over 30 covering limited tracts in the north. In both regions, the greatest developments in irrigation have taken place in areas having an index of below 20. The influence of the more complex relief in Barbary is reflected in the trends of the various lines of indices.

De Martonne's formula is based on a simple combination of rainfall and temperature. Some of the well-known classifications of climate which derive their basis from a more refined and elaborate treatment of meteorological data may also be applied. According to Köppen's classification a large part of West Punjab has a "hot Steppe climate with a dry winter" (BShw) while southern Barbary has a "hot Steppe climate with a dry summer" (BSAl). In Thornthwaite's classification the distinction has again been made between the summer and winter incidence of the dry periods in Barbary and West Punjab respectively, otherwise large areas in both are included in the DB (Temperate steppe) zone. Both Köppen and Thornthwaite accord northern Barbary a more humid regime than any parts of West Punjab. This is because of the factor of evaporation as measured indirectly. Rainfall in West Punjab occurs in summer, a period of high temperatures so that it is less "effective" than the predominantly winter rainfall of Barbary. These observations on major classifications are made from large scale world maps and it is probable that the parallel would be closer if the respective formulas of Köppen and Thornthwaite were applied.

(1) E. De Martonne "Regions of Interior-Basin Drainage", G.R. Vol.17, 1927
were applied in detail. New refinements are continually being evolved with regards to the classification of climate, and the availability of evaporation data would certainly facilitate a more definite comprehension of the real water-requirements of crops in relation to the losses of moisture by evaporation and transpiration as determined by climate.

The climatic parallel may be summed up as follows:

(a) Both regions show a passage from humid and sub-humid conditions in the north through a broad semi-arid belt to desert conditions in the south.

(b) Both regions have a pronounced periodicity of rainfall with a long season of drought occurring in the summer in Barbary and winter in West Punjab. Periodic drought and the insufficiency of total rainfall combined with high temperatures and consequently high evaporation are the main climatic hazards for agriculture in both regions. Apart from necessitating the development of irrigation and dry farming, high evaporation is responsible for the occurrence of many handicaps in the constitution of the soil - limestone and salinity. Soil-erosion is precipitated in both regions by the occurrence of rainfall in heavy showers during short periods. The climatic similarity is also reflected in the most important annual crops grown, these being wheat and other cereals.

**Cultural Factors** Agriculture and the associated modes of life are an aggregate of cultural as well as physical factors. It is in their cultural background that the two regions resemble each other most closely. Historical influences, present life and culture have all combined to produce a similar system of land-ownership and tenures and fundamentally identical problems with regard to the size
and sub-division of holdings, the traditional cultivation methods and the attitude to progress.

The history of both Barbary and West Punjab is a long tale of foreign invasions ending with the establishment of a European power. The impact of the west on these essentially eastern countries has had important repercussions on the increase of population, the improvement of communications, the linking up of their economies with that of the world and finally, most important of all, a slow evolution towards improved crops and production. In both regions, present life and culture is based on Islam, a religion which stands apart from all other creeds in the completeness with which it permeates every institution of a society and the enduring and even fanatical devotion to its tenets it inspires. The present native populations of Barbary and West Punjab retain few, if any, traces of the pre-Islamic days. Their system of landed property and of tenancy is rooted in Islam and their choice of crops is influenced by religious tradition, i.e. in their refusal to cultivate vines for wine-making in Barbary. Most of them are not only steeped in tradition but are also illiterate so that they are resistant to progress as brought by the westerner. Their poverty is their greatest handicap towards the improvement of agricultural standards. Small-holdings prevail. Thus the social and cultural problems of agriculture in the two regions may be said to be identical.

Recent developments in both regions have been initiated by western powers. The French policy in Barbary and the British policy in West Punjab up till 1947 can be broadly compared and contrasted in this study in their relative success in improving the standard
of agriculture. One important result of the influence of the west has been that the modes of life have been in evolution. The development of canal irrigation in West Punjab has spread sedentary agriculture to all parts of the province. A slower but nonetheless sure movement in the same direction has been in progress in Barbary though its cause is more the acquirement of land by Europeans than any comparable development in irrigation.

While any contrasts between the two regions will be pointed out in the subsequent chapters and local peculiarities described, it can be concluded from a discussion of physical and cultural features that there are adequate grounds for making a parallel study of Barbary and West Punjab.

The Scope and Arrangement of the Work. This study has been divided into four principal parts. In the first part the physical background has been described. The chapter on structure and relief purports to give only an outline in the context of which the other physical and cultural factors may be considered. Detailed descriptions of areas studied closely in the field or from large-scale maps has been given under agricultural regions. The account of climate, hydrography, vegetation and soil similarly treats only of essentials in relation to agriculture and its problems. The factor of variability of rainfall in Barbary has been given special attention and some correlations have been established, i.e. between autumn rainfall and the total area sown and between spring rainfall and the yields.

The second part treats of the cultural background. In this section, two aspects have been studied in special detail. European colonization in Barbary and its impact on the native cultivators
of Barbary has been discussed in relation to its history and development. The modes of life and settlement in Barbary have been described regionally after a detailed examination of physical, cultural and economic factors.

In the third part a number of outstanding agricultural problems have been examined in considerable detail with special reference to recent developments. The account of irrigation embraces the traditional and modern systems, their influence on crops and on the cultivators. Settlement of newly irrigated regions has also been examined in some detail. For Barbary the problem has been documented by studies in the field. Thereafter, water-logging and saline soils, soil erosion and dry-farming are treated rather generally mainly on the basis of documentary material. Attention has however been drawn to the most pressing problems to be faced today and the types of solutions that have been attempted.

The final part includes first an account of land-use and agricultural methods, followed by a brief description of the production and distribution of principal crops. Then, in the chapters on agricultural regions, all the factors described earlier have been integrated. Most of the micro-geographical studies made in the field and from 1:50,000 maps are incorporated into these chapters. The division of Barbary into agricultural regions and their detailed description with the help of sample regional and farm studies thus constitutes the principal result of this study.

A brief account of present attempts towards modernisation is followed by the Conclusion in which several constructive suggestions have been made in relation to the population problem
and the low standard of living.

Throughout the study, the emphasis has been placed on Barbary which was the region studied in the field and on which a large proportion of documentary research was carried out. West Punjab stands, as it were, in the background. A fuller understanding of the agricultural landscape and of the problems of agriculture which has followed the study of Barbary may later lead on to an attempt at a closer survey of West Punjab on the basis of field work.

**Limitations and Handicaps**

The ground that has been covered in the course of this study precluded the possibility of maintaining the same degree of detail or originality of approach. Certain aspects have had to be treated more briefly than was planned because of the absence or non-availability of necessary data or the impossibility of conducting an adequate amount of field work to provide details. The size of holdings in Morocco and Tunisia is a case in point. Details of various type of ownership of land and tenures is another. The technical side of certain agricultural problems such as soil erosion or saline and water-logged lands may show imperfections because while the study of the geographical and economic causes of these problems is within the writer's competence, the details of their solutions is not, and at best, a summing up of accessible documentary material has been attempted.

The most serious limitation of the study is the inadequacy of statistical matter which forms the basis of distribution maps. Five years' normals are an accepted
minimum in the compilation of such maps if they are to have a lasting value, especially in regions where production is so variable along with the climate.

This weakness in the case of Barbary arose partly out of the inadequacy of documentary sources outside the region itself and partly due to the pressing requirements of field work when the region was visited. Published data were scarce and their collection from departmental sources would have involved prolonged office work whereas the fundamental aim of travel in Barbary was to view the actual rural landscape and visit farms typical of different regions. The latest year for which alone detailed figures were available - 1945-46 - was abnormal in certain ways as is indicated by comparisons with quinquennial averages in an appendix at the end. The following redeeming features of the scheme adopted may however be given:

(1) For figures of total production of important annual crops by territories, five year averages have been taken. Details by statistical sub-divisions in any year would give a reasonably accurate idea of geographical distribution unless the abnormal conditions were strongly localised in limited regions. As far as the present writer is aware, the effects of the drought in 1945 were widespread in Morocco and Algeria.

(2) In any case the imperfections of official statistics as at present compiled are considerable and have been described in another appendix. The details of agricultural regions, the core of this work, are derived primarily from field work and from authoritative documentary, rather than from such inadequately

The year for which figures of detailed production were available - 1945-46, was abnormal as consequent upon the drought in 1945, the area sown under cereals was reduced in Morocco and Algeria as the following table will show.

<table>
<thead>
<tr>
<th></th>
<th>Morocco</th>
<th>1941-45</th>
<th>1945-46</th>
<th>Algeria</th>
<th>1941-45</th>
<th>1945-46</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wheat</td>
<td>1287</td>
<td>977</td>
<td>1649</td>
<td>1450</td>
<td>1375</td>
<td>1320</td>
</tr>
<tr>
<td>Barley</td>
<td>1599</td>
<td>1012</td>
<td>842</td>
<td>729</td>
<td>729</td>
<td>729</td>
</tr>
</tbody>
</table>

The Tunisian figures were normal. The areas of orchard or plantation crops remained constant so that the percentage of cereals in Morocco and Algeria was lower than normal.
recorded statistics. The map of Dominant Crops by statistical divisions may thus be compared to map of Dominant Crops as determined by field studies and documentary work to find out how limited is the utility of these figures.

For West Punjab, again only one year has been taken for statistical analysis. The year selected - 1944-45 - is however, a normal one as shown by the official comparisons made in the Season and Crops Report for that year with the averages. The calculation of averages for the province as a whole as well as the indication of trends over prolonged periods was difficult because the partition of the Punjab has rendered provincial statistics useless. The compilation of agricultural statistics for West Punjab ought to be undertaken all over again.

With regard to field work, it will be noticed later on that although small-holders form the overwhelming majority of agriculturists in Barbary. Only two of their holdings were visited as compared to 13 belonging to large native landowners and 9 belonging to European colonists. Even though the mode of cultivation by the small peasant is fairly uniform over Barbary, a closer acquaintance with his methods and crops in different regions would have been advantageous. Herein a limitation was imposed by the lack of opportunities. The small cultivator, being illiterate, is not accessible to the foreign visitor who does not speak his dialect. Even local officials and notables who guided the writer did not reveal more than a general conception of his agricultural methods and standard of life.

(i) See appendix on the year 1944-45 in West Punjab.
In a work covering such large areas and extending over a vast subject, imperfections of detail in content or presentation are bound to exist. No effort however has been spared to make it a useful contribution towards the understanding of the agricultural landscape and problems of the two regions.
Part I - Physical Background

Chapter 2

STRUCTURE AND RELIEF

Barbary constitutes a compact geographical unit and consists of a massive "island" of elevated ground wherein mountainous topography is dominant. West Punjab, on the other hand, is a segment of the great Indo-Gangetic Plain and only a sixth of its area has hilly landscapes this being the Potwar Plateau in the northwest. The last-named region which lies between the Himalayan outliers of Murree Hills and the Salt Range is comparable in many ways to the characteristic relief of Barbary. Similarly the extensive plains of western Morocco and eastern Tunisia present a comparable aspect to the land of five rivers, a parallel which is reflected in agriculture.

The landscape in Barbary abounds in contrasts wherein low valleys and plains alternate with high and rugged mountains; at the same time there are large elevated stretches of boundless monotony. West Punjab is remarkably simple physically with the exception of the Potwar region. To understand these striking differences in the topography of the two regions we must go to their geological origins. Such a study is specially important for Barbary in which geology has a profound influence on the water-regime of rivers as well as on soils, both factors of great significance from the agricultural point of view.
Looking at the geological map (see pocket at the end) one sees that the structural pattern of Barbary is intricate; yet the broad features are essentially simple. Two structural zones may be differentiated. The ancient African platform has tended to remain above water and has acted as a block against which the deep marine sediments of a long-sustained geosyncline have been folded during successive orogenic epochs. The latter zone also contains fragments of the ancient hypothetical Tyrrhenian continent in the Kabyle massifs along the coast of eastern Algeria.

Several phases of folding and faulting are responsible for the present aspect of Barbary. The sea which once extended to form the Saharan geosyncline has retreated steadily during geological time so that the northern ranges of the Atlas are younger than the southern ones.

The Pre-Cambrian and Hercynian mountain-building movements have not left any widespread traces as later movements were super-imposed on their domain. Their folds run generally transverse to the Atlas geosyncline and are in evidence mainly in south-western Algeria and in Morocco. It may be noted here that within the Atlas older rocks are progressively exposed from east to west.

As regards the Tertiary mountain-building movements and their different phases, there has been a long-continued controversy particularly with regard to the question whether
the Rif Mountains and the Tell Atlas belong to the same orogenesis. P.Russo (i) in a recent synthesis of existing opinion, shows that on the whole the idea of them being of contemporaneous origin is favoured. The High and the Middle Atlas as well as the Saharan Atlas belong to the earlier i.e. Pyrenean phase and show simple open folds. The High Plateaux to their north mark the extensive zone which remained a land surface and was not affected greatly by the last - the Alpine phase of folding which gave rise to the Rif Mountains and the Tell Atlas. The latter are both characterised by intense overthrusting and nappe-formation.

The climax of orogenesis was followed by a predominance of vertical movements which greatly modified the structure. The absence of extensive coastal plains in the north is explained by the series of fractures along the coast.

Denudation has been continuous since Miocene times and the beds of sediments laid down are largely undisturbed in the valleys and basins where they were deposited. In Morocco, the Atlantic has receded with the deposition of alluvium from streams coming down from the Atlas chains and a considerable coastal plain has been formed. Large inland lakes and basins have been integrated into river systems giving rise to striking hydrographical features to be

studied later. The Quaternary Ice Age has not modified the landscape except in the higher mountains, particularly the Moroccan High Atlas.

Summing up the structural features of Barbary, we get the three celebrated divisions from north to south: (1)

1. The Northern Mountain System consisting of the Rif Mountains and the Tell Atlas and including within it the continued depression behind these ranges, extending from the Sebu Basin to the Sheliff valley.

2. The High Plateaux extending east of the Middle Atlas in Morocco to the Tunisian Dorsal.


This generalised zonification has been adopted as a convenient guide and should not be applied too rigorously as both the eastern and western sections of Barbary present striking departures from this scheme.

WEST PUNJAB

West Punjab has a remarkably homogeneous structure over most of its territory. With the exception of a few Archaean fragments forming the Kirana Hills, the vast plain consists

(1) Ibid
of an immense thickness of alluvial deposits the exact depth of which it has not yet been possible to measure. In these, sandy and clayey beds alternate according to the shifting of the river beds while the sub-montane tract also has gravelly beds in the series, marking excessive floods. The deposits are all Pleistocene and Recent. A distinction may be made between the older alluvium known as bhangar which often contains limestone concretions (kankar) and the newer alluvium, khadir, lying along the flood plains.

The Potwar Plateau with its bordering ranges shows a structure comparable to Barbary, the Murree Hills to the north being intensely folded, the plateau itself showing a synclinal formation while the Salt Range to the south has acted as a "stable block". Some parts of the plateau are covered with a mantle of fine sub-Recent loessic material transported by the wind. Folding and faulting have sometimes combined in the Potwar region to give it the complexity typical of Barbary.

**RELIEF**

We may now proceed to study the landscape in detail and establish sub-division into natural regions. These have been established with special reference to their agricultural

(i) T. Login, Memoranda on the most Recent Geological Changes of the Rivers and Plains of Northern India Q.J.G.S. Vol.28, 1872

(ii) Wadia calls it a wedge over which folding occurred R.G.S.I. Vol.75
importance and their role in the rural set-up of the respective area.

**BARBARY**

The topography of Barbary shows striking variations not only in the disposition of mountains and plains but also in the intensity of the relief. There is a progressive diminution in the altitude of the Atlas mountains from over 13,000' in Morocco to 5,000' and less in Tunisia. Moreover the two Atlas ranges merge in the east so that the Sahara stretches further towards the north. From the Rif to Tunis the Mediterranean littoral presents a scarped face towards the north but the western coast of Morocco and the eastern coast of Tunisia are backed by large plains. Thus with the Atlas at its highest and its plains occupying considerable areas, Morocco contains the greatest contrasts in relief. Algeria is the most compact of the countries of Barbary wherein the three east-west zones are best defined. These plains are limited to narrow elongated valleys between lines of ranges parallel to the coast. Tunisia has neither the striking compactness of its neighbour nor the accentuated contrasts of Morocco.

The extent to which landscape has been shaped by fluvial erosion is greatly limited in Barbary owing to the generally semi-arid conditions. Features of the normal cycle of erosion are restricted to the northern Tell region.
Although rivers will be studied in a later chapter, it may be stated here that climatic and topographic conditions have been unfavourable to the development of a well-integrated drainage system and most river-valleys show youthful profiles. Geological origins are still the most potent factor in the existing landscape over the greater part of the region.

In the following classification into natural regions, political boundaries have largely been ignored as they bear no relation to the physical constitution of the country. The extreme east of Algeria belongs to the Tunisian chains while eastern Morocco is a prolongation of the Algerian High Plateaux and the Oran Meseta. Although a large number of existing works (1) and maps have been consulted and found very useful, the following classification has been worked out personally on the basis of field observations. It has been found convenient to devise several north to south segments. Several natural regions which, from the point of view of physical geography, are full of interest have had to be passed over with brief comments, in the interest of the real objective of this study. Such for instance are the High and Middle Atlas ranges of Morocco and most of the elevated Massifs in Algeria

For detailed list see bibliography.
MOROCCO (excepting eastern Morocco)
The following sub-divisions are proposed:-

1. The Sebu Basin and the Taza Gap
2. The Atlantic Lowlands
3. The Moroccan Meseta
4. The Middle and High Atlas and the Muluya Valley
5. The Sous Plain and the Saharan Fringe

1. The Sebu Basin and the Taza Gap

This region includes a great variety of features from the southern slopes of the Rif chain to the alluvial plain of Gharb. It includes that remarkable depression between the Middle Atlas and the Rif which is known as the Taza Gap. The entire region is drained by the Sebu, one of the largest rivers of Barbary, and has a length of 150 miles from east to west, the maximum width being 130 miles.

The broad surface configuration of the Basin may be likened to a half funnel of which the Rif on the north and the Middle Atlas and the Moroccan Meseta on the south are the sides. The Rif is an intensely folded zone which has an altitude of over 8000 feet. Most of it, however, lies in the Spanish zone. The southern slopes are drained principally by the Wargha and have a rugged relief which becomes subdued towards the east. The Taza Gap and the Sebu Basin mark an ancient (Miocene) arm of the sea which receded to a gulf gradually filled in by the sediments brought down by the Sebu to become the Gharb Plain. The Taza Gap is barely two miles across and
lie at an elevation of 2000 feet. To the south the Middle Atlas rises with an impressive steepness towering over the landscape. The northern slopes - those of the Rif - are gentler.

The regions of the Fes and Meknes plains occupy the bed of a Pliocene freshwater lake and fall gradually from 3000 feet in the south and south-east to 1500 feet in the north west. In the centre of the Sebu Basin there are several isolated massifs of which the largest is the Zerhoun rising to over 3500 feet. Further west, the Gharb plain extends to the sea and its northern part contains the meandering course of the Sebu. The southern part is largely occupied by the Mamora Forest uplands and climbs imperceptibly southwards to 1000 feet. Elsewhere the lowland lies below 50 feet above sea level and consists of a clayey alluvium. The Sebu has built up high natural levees (spill-banks) for itself and often flows higher than the surrounding plains which are inundated after a heavy flood. This coupled with the bad drainage owing to the consolidated coastal dunes has given rise to a number of large seasonal marshes or merjas that are dry except for the period of maximum flow of the river. The largest of these is the Merja of Beni Ahsen in the south.

2. The Atlantic Lowlands

A coastal lowland of varying width extends from Rabat to Mogador bordered on the south east by an escarpment 300 to 600 feet high. Across it flow the lower courses of the Bu Regreg, the Um-er-Rbia and the Tensift, the most important rivers of Central Morocco. The plain is narrow in the north but
broadens out in the regions of Shawia, Dokkala and Abda. (i)

Further south it narrows again as the mountains approach the coast. The lowland has very little relief and that too is caused by the outcrops of crystalline or secondary rocks, i.e. near Casablanca and Mazagan. The plain is everywhere below 900 feet and is bordered on the coast by series of dunes.

3. The Moroccan Meseta

This region has been so called because of the close analogy with the Spanish meseta. (ii) The peneplaned surface of the primary platform is covered by a thin veneer of Secondary and Eocene sediments. The whole region was largely buckled up with some fractures here and there during the period when the High and Middle Atlas were upheaved. The primary base-rock is now exposed principally in the Central Massif and the Massifs of Rehamna and Jebilet. The Central Massif has generally preserved the aspect of a peneplane though the upper waters of the Beth, Bon Regreg and Oum-er-Rbia have carved out a series of narrow basins with deep gorges.

Between these crystalline regions of rugged topography lie sedimentary plateaux and alluvial plains. South of the central Massif of Zaer Zayan lies the limestone plateau of Settat at an elevation of 2,000 feet and over. To its east is the Tadla plain lying between the Rehamna and

(i) See Sketch showing regional names in Morocco. in Map 60
the Middle Atlas. This is a large featureless expanse which is continued along the flanks of the Jebilet by the basin of Bahira.

Further south surrounded by the Jabilet, Middle Atlas and High Atlas lies the Haouz or the Marrakech Plain, a vast alluvial plain with a few undulations, drained by the Tensift. Both the Tadla and the Haouz plains lie between 1,000 and 1,500 feet.

4. The Middle and High Atlas and the Muluya Valley

Aligned north-east to south-west and separating eastern from western Morocco, the Middle Atlas is the principal watershed of Morocco as well as the source of most of its important rivers. Much of it is a plateau dissected by river gorges. From lower elevation of 4,000 in the valley of the Um-er-Rbia near Khenifra, it rises to heights of over 10,000 feet in the mountains of Bou Iblane and Bou Maser in the north-east. It is covered by valuable forests over large areas. The Beni Mguild region in the north is covered with recent volcanic lavas.

The High Atlas is the main chain of the Atlas ranges and acts as a barrier between the Sahara and Morocco. There is thus a striking contrast between the green northern and the bare southern slopes. Rising steadily from the coast and more abruptly from the Sous plain, the range reaches its most impressive heights south of Marrakech where it surpasses 13,000 feet. Typical young folded topography is encountered here with high steep parallel ridges rising above deep narrow
valleys. The Eastern High Atlas is separated from the western part by a depression and after rising to over 12,000 feet in Jebel Ayashi overlooking the Muluya, the chain loses height and dies away.

The Muluya Valley separates these two chains in its upper part but constitutes a region in its own right further down where it consists of a series of basins of fine alluvial deposits which were once occupied by lakes. The valley contracts to a gorge before opening out into the plain of Guercif which is structurally a continuation of the Taza Gap.

6. The Sous Plain and the Saharan Fringe

The Sous Plain is a depression between the High Atlas in the north and the Anti-Atlas in the south. It is open to the Atlantic but shut in by Jebel Sirwa (11,000') at the eastern end. The Sahara lying to the east and south of the Sous Basin is progressively more arid in these directions and in fact constitutes a region which lies beyond the scope of this study.

ALGERIA (including eastern Morocco)

In Algeria the three Zones of the Tell Atlas, the High Plateau and the Saharan Atlas are very well defined in the west but merge in the east with the effect that the Tell Atlas is taken to extend right up to the Sahara. This latter idea takes its origin not only in the changed physical make-up but also in the climatic regime which has given a canopy of
Photograph shows the Jurjura range with its top still snow-covered in mid-May, the steep upper limestone slopes bare and the gentler lower slopes wooded. Dense vegetation at the foot of the range is olives which occur as isolated trees in the middle distance. Cultivated fields are under hard wheat for the most part. Harvested soft wheat seen in a field on the left. Barren slope with tufts of grass lies along the railway embankment from which photograph was taken.
2 Close-up of a bare hill in eastern Morocco. Geological strata are exposed clearly showing alternating limestones and sandstones. Ruined houses seen in the centre. Notice the steppe-like vegetation.

3 The southern slopes of the Saharan Atlas north of Biskra. Photograph shows the el Kantara gorge as well as the oasis settlement at the foot with flat-roofed houses and palm trees. Foreground is blurred as picture was taken from a moving train.
luxurious vegetation to the upper heights of the Aures Massif at the very edge of the desert. From an agricultural point of view this conception is useful for the basic idea behind the appellation "tell" is one of a well-watered and productive region. We shall, therefore, treat the Tell Zone in two regions - western and eastern. This gives us the following natural regions which will further be sub-divided when they are studied in some detail:—

I. The Tell Zone:— i. Western Algeria  
   ii. Eastern Algeria

II. The High Plateaux

III. The Saharan Atlas

I. THE TELL: (i) The Western Tell

The relief of this section of the Tell Atlas has everywhere two characteristics - great variety of land forms and extreme youth. The latter feature is due as much to the geological history of the region as to the deficient rainfall under which the cycle of erosion slows down. The mountainous and plain regions alternate and give us five narrow bands of relief.

(a) The Coastal Mountains

(b) The Northern Plains and Valleys

(c) The Median Chain

(d) The Southern Plains

(e) The Interior Mountains
(a) The Coastal Mountains: This region includes the Sahel of Oran, the plateau of Mostaganem and the massifs of Dahra and Miliana. In the west the massif of Murjajo dominates the Bay of Oran, presenting a steep slope towards the north. The sandstone plateau to the east of Oran is 2,000 feet high which continues across the marshes of Macta into the plateau of Mostaganem. After the deep narrow valley of the Shelif, the plateau rises into the massif of Dahra aligned south-east to north-west. This is continued across the Damous river by the mountains of Miliana wherein heights of over 5,000' are reached. These massifs present a steep slope towards the north and the south but the topography is gentler in between where the surface often has a rolling aspect.

(b) The Northern Plains and Valleys: These comprise the plains of Mleta, Mekerra-Sig and Habra and the valley of the Sheliff. The plain of Mleta is a flat lowland to the south of the Sebkha of Oran, which is the centre of an interior basin. The lower plains of Mekerra-Sig and Habra constitute a rich alluvial lowland the northern part of which is covered with marshes.

The Sheliff valley occupies a depression between the Dahra-Miliana massif in the north and the Warsenis in the south. With a length of a hundred miles and a varying width which reaches a maximum of 40 miles near Relizane, it is divided by transverse ridges into three sections. The uppermost of these, the plain of Affreville, has a width of 6-8 miles.
Further down is the plain of Attafs and lastly the plain of Orleansville extends for 40 miles up to Relizane.

(c) The Median Chain: This extends from the mountains of Beni Snassen in eastern Morocco through the massif of Traras, the mountains of Tessala and Beni Shougran to the massif of Warsenis. It is broken through by a number of rivers, notably the Tafna, Mekerra, Habra and Mina through deep valleys which do not affect the continuity of the range.

The Beni Snassen mountains are a rugged mass rising to an elevation of over 5,000 feet while the Traras massif has an equally inhospitable landscape cut up by numerous deep ravines. Recent volcanic rocks occur extensively in the latter and provide an excellent black soil. The Tessala chain across the Tafna and further east the Beni Shougran range are both steep and bare and rise to over 3,000'. The massif of Warsenis to the south of the Sheliff depression is crowned by the limestone mass of Kef Sidi Amar which rises impressively to over 6,000 feet and has scarped slopes. Several affluents of the Sheliff rise in these mountains, the most prominent among these being the Sly and the Fodda.

(d) The Southern Plains: These occupy the tectonic depression which extends from the Taza Gap eastwards and include the plains of Angad, Marnia Gossels, Sidi Bel Abbes and Mascara. They are, generally speaking, high plains occupying an average height of 1,500 feet. The first mentioned
lies in eastern Morocco and the plain of Marnia is only its eastern continuation. The plains of Sidi Bel Abbes and Mascara occupy the sites of late Tertiary lakes since integrated into river systems. The plateau of Serscu to the south of the Warsenis massif may also be included within this region.

(e) The Southern Mountains:— The mountainous country lying along a line passing through Tlemcen, Daya, Saida and Frenda is higher than the coastal and median chains, being over 5,000' in elevation. The relief is strongly accentuated to the east of Tlemcen and everywhere limestone topography is so much in evidence that the region has been called the causses of Oran.

(ii) Eastern Algeria

Except up to the west of the Hodna depression, the clear differentiation between the Tell and the Saharan Atlas disappears here. The high plains of Constantine and Setif are sometimes compared to the High Plateau but the analogy can hardly hold. The landscape in the former is diversified by isolated ridges and peaks that rise abruptly from the plains whereas the latter is marked by great monotony. The saline shotts of the high plains are also of insignificant size as compared to the High Plateau. The height and the variety of relief of the Tell Atlas becomes very great and ancient crystalline blocks, jagged limestone ridges and high sandstone brows mark the dominating role of geology in the shaping of the landscape. Apart from the two plains of
Mitija and Bone at the two extremities, there is a general absence of lowlands. We may now divide the region into the following sub-regions:

1. The Mitija Plain and the Sahel of Algiers
2. The Blida Atlas, the Plateau of Medea and the Titteri Mountains
3. The Kabylie Massifs
4. The Bone Plain
5. The Chains of Biban and Hodna
6. The Constantine-Guelma Region
7. The Mejana and the High Plains of Setif
8. The Aures Mountains

(1) The Mitija Plain and the Sahel of Algiers

The surface of this plain which is 60 miles long and about 10 miles wide is remarkably flat. Several rivers emerging from the mountains on the south have formed alluvial fans of which the most notable are those occupied by Blida and Arba. The plain itself may well be a piedmont one and the position of the hilly Bouzarea peninsula behind Algiers suggests that it was once an island which has since become land locked. Marshes cover a section of the plain south of Algiers, though a large area has been drained.

The Sahel of Algiers or the Bouzarea region consists of an indulating surface that descends gradually towards the south and west.

(2) The Blida Atlas, the Plateau of Medea and the Titteri Mountains

The Blida Atlas rises boldly south of the Mitija
plain and attains steeply to a height of over 5,000 feet. The surface is rugged and has been deeply ravined by the streams. Eastwards the Blida Atlas merges into the Massif of Tablat which has a lower elevation. South of these prominent ranges lies the plateau of Medea which is an important watershed between the headwaters of the Shelif and the Isser. The Titteri Mountains further south have a much-ravined topography and are bare and rugged, the southern slopes being particularly badly denuded.

(3) The Kabylie Massifs

They represent a unique feature in the topography of Barbary and are thought to be the remnants of the ancient Tyrrenhian land-mass of which the other fragments are found in Sicily and Sardinia. The westernmost of these massifs is a well-defined physiographic unit bounded by the valleys of the Summam, Isser and Jemma and is capped by the "sierra-like"(i) Jurjura range which rises impressively from the valley of the Summam to attain to a height of over 7,000 feet. The coastal chain is separated from the main massif by the valley of the Sebao. The whole region is ravined deeply and both settlements and routes avoid the precipitous valley slopes to follow the crests of the ridges. The Summam valley separates the Kabylie of Jurjura from the two eastern massifs, those of Babors and Collo. It is a narrow alluvial plain which provides an entrance to the interior.

The Kabylie of Babors (also known as Little Kabylie) is a rugged mountain mass with steep scarped limestone ridges

rising to over 6,000 feet. The Kabylie of Collo stretches from Jijeli to Bone and is divided into two parts, the massifs of Collo and Edough by the Safsaf depression. The southern limit is formed by the Numidian Chain.

(4) The Bone Plain

This is an alluvial plain lying between the eastern end of the Numidian chain and the Edough Massif. It is about 60 miles long and up to 30 miles wide. Since it is almost entirely level there are extensive marshes. The region is drained by the Sebouse. The coast is fringed by a belt of fixed dunes that widen out towards the east.

(5) The Chains of Biban and Hodna

These lie roughly parallel to each other to the south of the Jurjura range. The word Biban (plural of bab) means doors and refers to the many deep gorges of which the most celebrated are the Portes de Fer. The Biban chain reaches a height of over 5,000' and is well-wooded in many parts.

The Hodna chain further south diverges south-eastwards to join the Aures Mountains and thus to unify the Tell and the/ Atlas ranges. It rises to over 6,000 feet and is divided into sections of streams draining to the Shott-el-Hodna. Here occur the small plains of Zana, Seriana and Bellezone.

(6) The Constantine-Guelma Region

The two centres of this region lie along rivers hemmed in by the Numidian chain on the north and the Perjone
The valley of the Isser south-west of the Jurjura range. The river flows as a braided stream in a pebbly bed. The low-lying ground on either side is under fodder crops and vines with cereals higher above. Scattered olive trees seen across the bed with bare and much eroded hills in the background.

Relief in the high plains of Constantine. Photograph shows a grassland steppe of plain surface with gentle slopes towards a stream-bed. Broken and bare hills rise to the south. Notice the grazing cattle.
In West Punjab, the practice of bunding or cultivation in terraced plots dates back to ancient times and is still the most effective means of soil and water conservation as has already been stated. Other practices such as interculture, harrowing, rotations and fallowing are also by no means new to the region.

The Methods of Dry Farming

We have already set forth the basic principle of dry farming. It seeks to prevent evaporation by increasing the absorptive capacity of the soil and creating a surface layer that will not allow evaporation. Repeated ploughing is advocated to facilitate deeper penetration of the moisture into zones beyond the effective range of losses by evaporation. Mulching and weeding are other steps preparatory to sowing.

Sowing by drilling is advocated so that the seed is deposited in the deep moist soil and ensures root growth before the soil dries up. Distance between plants is to be great enough to allow of later harrowing and interculture.

Alternate fallowing is combined with judicious rotations and those crops or varieties are selected that give high returns under semi-arid conditions. Wheat, barley and millets are the principal ones grown while peas and potatoes have been found useful.

Finally the practice of soil conservation is inseparable from dry farming as this system is practised in lands wherein

(i) Abstracted from N.V.Kanitkar "Dry Farming in India" The Imperial Council of Agricultural Research, Scientific Monograph No.15, Delhi 1944.
violent rains come after long intervals during which atmospheric weathering loosens the soil. Terracing is carried out on sloping lands. As developed in America, dry farming envisages the large scale use of machinery.

The Possibilities of Dry Farming:-

One of the first American writers to set out the principles of the technique called it "the greatest discovery of the age" (I). There was a similar show of enthusiasm among other American experts who claimed that the system would bring under the plough most of the world's dry areas. Much of the optimism about its possibilities can be justified by its success but the system should not be understood to be able to reclaim deserts. As Bernard has maintained, "it is essentially the regions of transition between humid and arid conditions which can thus be transformed" (ii) Dry farming is therefore the system to be adopted in semi-arid lands without facilities for irrigation.

The larger parts of Barbary and West Punjab need water conservation under dry farming. The methods have, of necessity, to be adapted to the needs of the respective areas and the technique varied according to the resources of the cultivators. Mechanised dry farming cannot be practised except by a few larger proprietors and allowance has to be made for the deeply ingrained traditional methods in vogue.

(I) J.A. Widstoe, "Dry farming, A system of Agriculture for countries under a Low Rainfall - New York, 1911, P.11
Dry Farming in Barbary

There are two distinct types of cultivators in Barbary, the European colonists and the native peasants. The former are already practising mechanised cultivation on the richest lands in Barbary and they do not as a rule have to have recourse to dry farming. The native peasant by reason of his poverty, his traditions and his methods is not taught new techniques easily nor do the official agricultural agencies attempt to improve his lot. Hence when the new dry farming methods first began to spread Bernard did not envisage a great scope for them in all parts of Barbary. (1) Tunisia alone, he forecast, would lend itself to complete transformation by dry farming because of the natural conditions. This was the ancient cradle of dry farming on account of a much greater proportion of its area being in the zone of less than 16" rainfall combined with the prevalence of lowland steppes. This forecast has certainly proved to be correct. But whereas Bernard could not foresee the large scale application of dry farming by the European colonists, actually the technique led to a southward expansion of colonisation in all parts of Barbary. The plateau of Sersou in Algeria has largely been brought under mechanised cultivation through the practice of dry farming. In Tunisia as well as in Morocco, the limit of European cultivation has been extended to the edge of the desert. Slowly, native landlords in particular and small peasants to a lesser extent, are also copying these methods.

(i) Ibid
The writer, during his work in the field in Barbary, conducted an enquiry into the principal features of dry-farming as practised in Tunisia. From this point of view, Tunisia can be divided into three Zones.

1. **Northern Tunisia** lies north of the 16" isohyet and does not need to practice all dry-farming methods. Only one crop is obtained every year which is alternately a cereal and a leguminous plant. During the dry season, superficial ploughing is done to destroy weeds etc.

2. **The Central Zone** lies between the isohyets of 12" and 16". A biennial rotation is practised with one year cereal, one year fallow with ploughing. After the harvest, the stubble is burnt to destroy parasites and to provide a powdery cover that may also serve as a fertilizer. A 6" to 8" deep ploughing is given in August followed by another in December, this time to destroy weeds and to render the soil friable. A further deep ploughing is given to the lands in February. Then follows a light ploughing in March-April just to stir the superficial layer and keep it open. Harrowing is carried out in May-June, sometimes accompanied by the application of super-phosphate. Finally a ploughing is given at the end of October before sowing.

Drought resisting and precocious varieties of wheat specially developed in Tunisia are grown. Such for instance are the Florence-Aurore (soft wheat) and Sindyouk Mahmoudi (hard wheat). The quantity of seed used is less than in the first zone and the seeds are well spaced.
3. The Region of Enfidaville gets only 8 - 12" of rainfall and the same rotation is used as above. The lighter soils of the region are preferred for cereals and the quantity of seed used is about half that used in the second zone so that wider spacing is provided between individual plants. Fallow is cultivated superficially up to a depth of 4" and the seasonal arrangement of ploughing is roughly the same as in the second zone. Barley is more important here than wheat, being a more hardy crop and practically no hard wheat is grown. Yields are very variable depending upon the rains after sowing (November) and before maturing (March).

The planting of olives in the Sahel under dry farming will be studied in a subsequent chapter.

In Algeria the practice of dry farming methods is becoming widespread. Frequent ploughings of fallow land are becoming increasingly popular and in 1939 25% of the total fallow area was thus ploughed. Over a period of ten years, the area of ploughed fallow has increased by 372,000 acres.\(^{(1)}\)

It is not very certain, however, if all the principles of dry farming are used on these lands. It may be remarked that whereas 50% of the lands sown with cereals by Europeans were tilled while fallow, in 1938, only 10.8% of the native lands were so treated.

Cultivated fallow is extending in Morocco but no figures or details of methods are available.

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\(^{(1)}\) E. Vivet and P. Laumont, "La Production Agricole de l'Algerie" 1940 P.8-9
Picture shows the gorge of the Rummel over 200 feet deep with the city of Constantine on both sides. Modern buildings are in the foreground, the older part of the city in the distance. Notice the horizontal strata in the gorge.

The Mateur plain in northern Tunisia. White patches are marshes formed on a flat surface during the very rainy spring of 1949. Scattered olive trees lie among fields of wheat. In the distance lies the isolated hill of Ashkel. One is never far from hills and mountains in the plains of Barbary.
On the whole, one may generalise that modern dry farming methods with the extensive use of machinery are employed mainly by large landholders, Europeans and Muslims alike. The practice of maintaining a ploughed fallow has not spread among the small-holders because they prefer to retain the stubble after the harvest to feed their animals, on account of the of grazing lands.

WEST PUNJAB

The possibilities of irrigation in West Punjab have almost been exhausted and no great expansion is envisaged that might cover the insecure tracts in the Potwar Plateau, and many parts of the Thal and Derajat tracts. Rainfall in the southern part of the Potwar region is less than 20" and is less even than 10" in the other areas mentioned. What is more significant from the point of view of cultivation, rains are extremely variable in their total amount and capricious in their periods of occurrence. This introduces a factor of insecurity even into the well-watered sub-montane tract where rainfall exceeds 20". Finally, the endangering of canal water supplies on account of the Partition of India is a recent complication which ought to be considered because large parts of the Bari Doab may find themselves dependent upon the inadequate rains if these supplies are cut off. (1)

Dry farming therefore still has a large part to play in the agriculture of the province. In many parts, certain methods have been in vogue over centuries to conserve moisture in the soil. In the Potwar Plateau and Mianwali district fields are

(1) This happened in 1948 at a crucial time before "kharif" sowings.
flat and terraced, bordered by peripheral embankments or **watts** which retain water in the fields. These are made with hoes and rakes or with the **karrah** (bullock-drawn scoop). Land is ploughed when in a friable condition (**wattar**) and frequent harrowing carried out between the growing crops. These practices, however, are not widespread enough nor are they systematised.

The need for instituting dry-farming research had long been felt in India to develop methods suitable for different parts of the sub-continent. First experiments were started in Bombay in 1923 after which regional stations were established. One of these is at Rohtak, in East Punjab and represents the typical conditions in the drier parts of the province in its temperatures, regime of rainfall and nature of the soil. N.V.Kanitkar has presented the results of several years of experiments with different methods in a monograph.\(^1\) They have yielded valuable results and in the following account, the relative efficiency of dry farming methods as compared to current practices will be demonstrated.

**Soil Moisture:**

The behaviour of the Punjab alluvial soils with regard to moisture does not favour retention under normal conditions. At the end of the monsoon, the distribution of

\(^1\) Op. Cit.
moisture with depth is as follows:-

<table>
<thead>
<tr>
<th>Soil Layer</th>
<th>Per cent moisture</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-1 ft.</td>
<td>9.17</td>
</tr>
<tr>
<td>1-2 &quot;</td>
<td>15.08</td>
</tr>
<tr>
<td>2-3 &quot;</td>
<td>16.26</td>
</tr>
</tbody>
</table>

In a year of drought the soil moisture in the surface layer is the same but decreases with depth so that the sowing of crops is impossible. The clayey soils of peninsular India are more retentive of moisture.

The effects of dry farming methods on soil moisture were compared with those of ordinary methods in 1937-38 and the results are shown in the following table.

Percentage of Soil Moisture with Depth

<table>
<thead>
<tr>
<th>Soil Layers</th>
<th>Cultivator's Method</th>
<th>Dry Farming Method</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st foot</td>
<td>7.17</td>
<td>10.82</td>
</tr>
<tr>
<td>2nd foot</td>
<td>8.43</td>
<td>12.42</td>
</tr>
<tr>
<td>3rd foot</td>
<td>10.27</td>
<td>13.07</td>
</tr>
</tbody>
</table>

Water requirements of Crops:— Different crops require different quantities of water to produce a unit weight of dry plant and within the same crop, different varieties vary in their requirements. The evolution of strains with less consumption of water forms an important step in tackling the problem of crop production in semi-arid regions. The dry-farming experiments at Rohtak led to the working out of a transpiration co-efficient - the ratio of water transpired through the plant to the total dry weight of the plant. These may now be given in relation to different crops and varieties.

Sorghum 304
Bajza (ordinary) 303-550
Bajra (A 1/3) 323-448
Wheat 460-506
Gram 501-612
Thus sorghum and bajra need the least amount of moisture. Of these crops, bajra was found to be best suited to the Punjab conditions which may explain its relative importance among the crops of the unirrigated north-western tracts. A dry farming technique has been evolved on the basis of the Rohtak experiments and the relative effect of a series of operations may now be studied.

1. Control of run-off and erosion by levelling, bunding (construction of low banks along contours) on relatively level land was tried. The kiara system (division of fields into bundled plots) was applied. The following figures of yields of barley and gram in pounds per acre show the value of this practice.

<table>
<thead>
<tr>
<th>Year</th>
<th>Rainfall in inches</th>
<th>Bunded plots Barley</th>
<th>Gram</th>
<th>Unbundled plots Barley</th>
<th>Gram</th>
</tr>
</thead>
<tbody>
<tr>
<td>1936-37</td>
<td>22.32</td>
<td>1,356</td>
<td>376</td>
<td>1,044</td>
<td>266</td>
</tr>
<tr>
<td>1937-38</td>
<td>15.24</td>
<td>1,084</td>
<td>192</td>
<td>902</td>
<td>157</td>
</tr>
</tbody>
</table>

2. Preparatory Tillage: - Various types of plough, modern and traditional were tried. The difference between various ploughs was not significant.

3. Surface Tillage during the monsoon months: - The alluvial soils tend to dry up quickly and harden at the surface layer. Stirring of the soil with a desi (traditional) plough after each fall of rain was found to be an effective measure.

4. Fallowing had a very salutary effect on the yields of
in grain and straw as the following figures illustrate (i)

(i) From W. Burns "The Desert Edge of Indian Agriculture", Journal of the Royal Society of Arts, Vol. 79, 1940-41 P. 691
(Yields in pounds per acre)

<table>
<thead>
<tr>
<th>Year</th>
<th>Rainfall</th>
<th>Grain</th>
<th>Straw</th>
<th>Grain</th>
<th>Straw</th>
</tr>
</thead>
<tbody>
<tr>
<td>1937</td>
<td>17.43&quot;</td>
<td>923</td>
<td>4,480</td>
<td>17</td>
<td>695</td>
</tr>
<tr>
<td>1938</td>
<td>8.24&quot;</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1939</td>
<td>10.20&quot;</td>
<td>403</td>
<td>904</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

It may be noticed that the years 1938 and 1939 were years of severe drought during which production without fallowing was insignificant. The practice of bare fallow renders the land susceptible to wind erosion. Here the decision to maintain cover crops at the expense of moisture reserves must depend upon the gravity of the threat and wherever wind erosion is light a decision in favour of higher productivity through bare fallowing may be made. One solution of the problem lies in establishing wind-breaks.

5. Manuring increased yields by 15-40% according to the amount applied particularly in the case of bajra.

6. The effect of interculture and mulching by means of hand implements (hoe etc.) raised grain yields by 30% and kept weeds out.

7. The rotations found most useful at Rohtak were to take one kharif crop one year and follow it by a rabi crop the next year. Two promising rotations were gram-bajra and wheat guara as two year rotation.

The success of these methods should lead to their application in all parts of West Punjab to the benefit of the cultivators and the lasting productivity of the soil. It is significant that methods developed at Rohtak do not require the use of machinery.

(1) Gorrie, Soil and Water Conservation in the Punjab. P.241-242
A view of the city of Kairwan from the tower of its famous mosque. This was the first city founded by the Arabs in Barbary and is renowned mainly as a religious centre. Note the large number of domes indicating mosques and tombs of saints. Flat roofed houses are typical. The town is also the regional marketing and administrative centre.

Weekly market or suq in the Dahra Massif at Rabelais. Butchers in the foreground along with sellers of sheep. Tents shelter more expensive wares and the administrators. This suq is held on Tuesdays (Suq-el-Tleta).
Mountains on the south. The St. Arnaud tract is the watershed between rivers flowing to the Mediterranean and those flowing to the interior. To the north of Constantine is the site of an ancient lake basin at a height of 1000-2000 feet above sea level. This area now has an undulating but deeply dissected surface and is dominated on the south by the faulted and deeply eroded mountains of Constantine, cut transversely by deep gorges. The most celebrated of these is the Rummel gorge, 200 feet deep above which stands the city of Constantine. The Guelma region consists of a number of depressions along the Sebouse. The relief in the region as a whole is mature.

(7) The Mejana and the Plains of Setif

The bare high plains of Setif extend westwards to those of Mejana and are bounded by the Guergour mountains on the north and the Hodna chain to the south. They lie at an elevation of 2500 to 3300 feet and isolated hills rise here and there to heights of up to 1000 feet above the plain. The southern part is an area of inland drainage. There is an imperceptible gradation from the seaward draining region of small crests in the north to the region of enclosed basins further south.

(8) The Aures Mountains

This folded massif contains the highest peaks in Algeria (over 7000 feet) and consists of a series of long straight ridges capped by weathered peaks and needles. It
dominates the huge arid high plains to its north as well as the Saharan landscape which stretches to the north, south.

II. THE HIGH PLATEAUX (1)

From the valley of the Muluya in eastern Morocco up to the Hodna depression extends a vast region of undulating high plains slightly crumpled here and there and bounded by the two main Atlas ranges on the north and south. Occasionally a line of mountains rises, island like to disappear in the vast steppes. The region has an altitude of 3000-4000' in the Department of Oran where two great Shotts, the Gharbi and the Sherquille entrenched in a depression. Further east, the chains of Zahrez and Sahari rise above the monotonous expanse and are covered with forests. The general elevation is reduced as we proceed eastwards and the plateau terminates at the faulted basin occupied by the Shott of Hodna. The arid cycle of erosion is seen "par-excellence" in the High Plateaux where the occasional heavy showers cause torrents to bring down huge quantities of debris which tends to choke the different basins. The entire region is generally one of inland drainage.

III. THE SAHARAN ATLAS

The Saharan Atlas commences near Figuig in Morocco and continues up till the depression of Ziban to the north-west.

(1) J. Despois is of the opinion that the term plateaux is a misnomer, and should be replaced by the term "High Plains", in this region as its present topography is largely a result of deposition (Op. Cit. P. 45) The writer has however, adopted the established term to distinguish it from the High Plains in the Tell Zone.
of Biskra. It consists of several discontinuous mountain ranges i.e. the Mountains of Ksour, Amour, Oulad Nail and Ziban. Its general trend is south-west to north-east and it often exceeds 6,000 feet in height. The evolution of relief is quite advanced and there are instance where inversion of relief has taken place, i.e. synclines stand out as the hills while anticlines have been eroded into valleys. The aridity of the climate has resulted in the chains being largely buried under their own debris. The Saharan Atlas often shows a marked escarpement to the south.

**TUNISIA**

Of the three broad relief zones adopted for Barbary, only one is really present in Tunisia - the Tell Atlas whose coastal and interior ranges are the chief mountain features of the country. Lowlands occupy a much larger proportion of the area (almost 80% if the Saharan section is included) and the general topography is of a reduced magnitude as compared to Algeria and Morocco. South of the Dorsal which shows some affinities with the Saharan Atlas lie the steppes that merge gradually into the Sahara. The Sahel, a plain of structural origin, stands out as a region unique in Barbary, being a vast coastal lowland with inland drainage!

The customary three-fold division of Tunisia into a northern, central and southern zone has much to recommend it as

(i) J. Despois, Op. Cit. P. 57
a way of facilitating a comprehensive view of the relief.

I. Northern Tunisia

This region lies between the Mejerda valley and the northern coast and may be considered in the following sub-regions:

1. **The Northern Tell:** The mountains of Mejerda, Kroumiri and the Mogods mark the continuation of the coastal range of the Algerian Tell and are aligned north-east to south-west. The northern slopes are generally steep although there are narrow coastal plains between the Kroumiri and the Mogod chains. The general height diminishes from over 2,500 feet in the west to about 1,500 feet eastwards where the relief is gentler. The western section drains into the Mejerda whereas the waters of the Mogods find their way into the inland basin of Garaat Ashkal. Relief is considerably developed because of the proximity of the sea on the north and the Mejerda Valley on the south which also acts as a base-level.

2. **The Beja Region** occupies the south-eastern slopes of the northern Tell and constitutes an undulating zone in which ridges rise here and there out of extensive lowlands. A range of hills 1500-2000 feet high separates this region from the Mejerda Valley. The region itself lies between 600 and 1250 feet.

3. **The Mateur Plain** This plain is a zone of inland drainage. It is diversified by the isolated hills of Ashkel
and Keshebta north of which lie the lakes of Bizerta and Garact Ashkel. The plain lies all round these and has been extending at the expense of Garact Ashkal which is being filled up by alluvial deposits.

4. The Mejerda Valley is the most highly developed feature of the fluviatile erosion and deposition in eastern Barbary and lies between the Northern Tell and the Central Tunisian highlands. After a deeply entrenched mountain course in Algeria, the river Mejerda debouches into its alluvial plain below Ghardimaou. The valley consists of a number of basins separated by hilly terrain. The upper basin below Ghardimaou is known as the plain of Rekba while the plains of Dakhla and Merja with their respective centres of Souk-el-Arba and Souk-el-Khemis form a large lowland region covering over 250 square miles. The sudden change of direction above Testour represents an elbow of capture of the drainage of the Dakhla plain by the lower Mejerda. East of Testour the river flows through a relatively wide plain. Below Jedida the river has a large delta covering 275 square miles, the only one in Barbary. There are historical records of the gradual extension of land outwards by deposition and the present position of the mouth of Mejerda is 12 miles below its position in the Carthaginian times.

5. The Lower Tell and the Region of Tunis

The highlands south of Mejez-el-Bab and Tunis are a prolongation of the Tunisian Dorsal ("backbone") and continue
into Cap Bon. They attain to a height of over 2000 feet and are drained by Wadis Siliana and Miliana. Between these two streams is a series of plains, those of Fahs, Bou Arada and El-Eroussa. Between the hilly Cap Bon and the highlands of Ressas lies the plain of Grombalia. The Gulf of Tunis is a region of former submergence which has been modified considerably by deposition.

II. Central Tunisia

South of the Mejerda Valley is a high mountainous belt, the High Tell of central Tunisia. Its southern boundary is another mountainous massif - the Tunisian Dorsal. Both these regions, particularly the latter have series of dome-like hills rather than continuous chains as a result of the combination of transverse folding and faulting movements. South-eastwards the country passes into barren steppes where isolated ranges break the monotony of landscape. These pass eastwards into the Sahel. The southern limit of Central Tunisia is marked by the great shotts.

1. The Central Mountain Mass including the High Tell and the Dorsal extends from the Mejerda valley to the massifs of Maktar and Thala in the south. The general trend of the relief is from south west to south east. The mountains attain to a height of 3000 feet. While the chains of Le Kef and Teboursouk prolong those of eastern Algeria, the Maktar and Thala massifs are a continuation of the Tebessa region in
south-eastern Algeria. To the south-west, the greatest heights in Tunisia are reached, exceeding 5000 feet. Alluvial basins divide the region as a whole into fertile basins and bare mountains. The basins often lie one above the other, marking the once enclosed lakes.

2. The Steppes:— South-east of the Central Mountains, the landscape opens out into vast stretches of plains out of which parallel and discontinuous chains rise abruptly. They show two general trends — north-east to south-west and north to south. Drainage is ephemeral and imperfectly developed.

3. The Sahel:— This lowland region extends from the Central Tunisian Tell to Gabes at the border of the Sahara. The western limit is ill-defined and the transition from the steppes imperceptible. The Sahel seldom rises above 600 feet but the drainage is so imperfectly developed that for 180 miles of the eastern coast, not a single watercourse reaches the sea. Solid rocks concealed beneath a mantle of recently-weathered debris characterise the surface. The landscape is marked by small limestone hills rising here and there steeply out of the sandy plains.

III. Southern Tunisia by its exclusively desert features does not come into the scope of this work.
WEST PUNJAB

The land of five rivers may be divided into the following regions:

I. The Potwar Plateau
   (1) Murree Hills
   (2) The Soan Basin
   (3) The Salt Range

II. The West Punjab Plains
   (1) The Sub-Montane Tract
   (2) The Central Plain and the Kirana Hills
   (3) The Thal
   (4) The Derajat Tract

I. The Potwar Plateau

Although, strictly speaking, the name Potwar is associated only with the undulating country between the Soan river and the Salt Range, current geographical usage applies it to the entire plateau stretching between the Indus and the Jhelum rivers up to the Murree Hills. The writer found it convenient in his recent regional study (1) to use the term more comprehensively still and include within it the Salt Range and the Murree Hills. This rather loose application (from the viewpoint of physical geography) is upheld by the hydrographic unity of the entire tract as well as the striking similarity in the human response and agricultural practice.

(1) Bhatty, M.A., "A Regional Study of the Potwar Plateau" Dissertation presented to the Punjab University, Lahore, for the degree of M.A. in Geography, 1947.
An aerial view of the Salt Range showing the southern ridge. Erosion of the sloping dipping strata of limestone has produced a spectacular scenery of sharp edged heights, steep slopes and gorge-like valleys. The West Punjab plain is seen faintly over the crest. Rare scrub clings to the sides.

Landscape in the Potwar Plateau. Low, bare rounded hills in the background. The dry sandy bed of a torrent can be seen winding in a gullied plain. In the foreground a rocky slope covered with scrub. Terraced fields can be seen to the right in the valley.
The Thai Desert with the Salt Range in the background. Notice the low sand dunes fringed by productive soil marked by abundance of trees in the background. This scene with the caravan of a wandering group, might well be from the Saharan fringe in Barbary.
The three constituting regions may, however, be studied separately:

1. The Murree Hills

They are outliers of the Himalayan system and consist of a series of parallel ridges which extend southwards with a progressive diminution in their elevation. The greatest height is near Murree itself and exceeds 7000 feet. These hills have the typical young-folded topography, the narrow valley between the ridges being as much as 2000' deep.

South of the Murree Hills are two more ranges of lesser magnitude - the Kala-Chitta and the Margalla ranges which attain to heights of 3500' and 2500' respectively.

2. The Soan Basin

This undulating tract stretches southwards right up to the Salt Range and is also referred to as the Soan syncline. Its surface varies in height from 1000 to 2000 feet and here and there rise ridges of bare rock of which only one assumes a considerable size - the Khaire Murat (Sandal shaped) running south-west of Rawalpindi. The general slope of the basin is from east to west and the Soan descends from a height of 1800 feet at its emergence from the mountains to less than 900 feet at its confluence with the Indus. The tract is broken up by innumerable deep ramifying ravines called Khaderas which give it a typical "badland" appearance. Erosion here has reached some of its extreme forms.
3. The Salt Range

Forming the southern rim of the Potwar region, the range extends in an irregular arc, concave towards the plateau, from the Jhelum to the Indus river. It consists of two almost parallel ridges with heights ranging from 2500 to 3700 feet between which lie a series of plateaux, separated from one another by the knots formed by the junction of the two ridges. The Salt Range presents a steep scarped face towards the south but the northern flank towards the plateau descends very gradually.

II. The West Punjab Plains

This vast alluvial expanse stretches south and east of the Potwar Plateau and is a monotonous lowland, everywhere below 1000 feet but for a few rocky fragments of the Kirana Hills. The plain slopes very gently towards the south-west, the gradient never exceeding 2 feet in the mile except in the sub-montane tract. Over the deep alluvium, wind-blown sand has been deposited, mainly in the south-west. The large gently sloping interfluves between the rivers are known as dvales and those in West Punjab comprise from east to west.

(a) The Bari Doab between the Ravi and the Sutlej.
(b) The Rechna Doab between the Ravi and the Chenab.
(c) The Chaj Doab between the Chenab and the Jhelum.
(d) The Sind-Sagar Doab between the Jhelum and the Indus.

Dr. A. Geddes has recently mapped the Punjab plain with contours at 50 feet. (i) These show the northern part of

(i) Map consulted with the kind permission of the author.
the plain consists of the alluvial fans of the rivers and that the shape of the doabs has been determined by the area and texture of deposits, the texture grading from coarse to relatively fine from the Indus eastwards and from the gorges downwards. The rivers deposited their load in the shape of fans on emerging from the mountains due to the slowing down of velocity. The outstanding example is of the fan of the Indus formed below Kalabagh on emerging from the Salt Range. It forms a great cone of very coarse and much-ridged material which constitutes a greater part of the Sind-Sagar doab.

According to Dr. Geddes' map, the coalescing fans of the rivers are in evidence up to the 700 foot contour after which the general seaward slope prevails. The stage of the deposition of fans and the plains was followed by a stage of incision and lateral erosion. It is this which has developed the two well-known major surfaces - the upper doab surface and the lower riverain surface broadly approximating to bhangar and khadir. The plain can be divided into sub-regions for a detailed study:

(1) The Sub-Montane Tract: - This includes the major part of the districts of Gurdaspur, Sialkot and Gujrat. The outer range of the Himalayas, the Siwaliks which lie outside the province, are fringed by a strip of gravelly deposits whose coarse soil absorbs moisture copiously by percolation. Further south is a band of slightly undulating country in which sandy beds of ephemeral streams known as
"chos" criss cross each other in a network. As the distance from the hills increases, this feature diminishes in importance. The beds narrowing down and joining up with the perennial streams. The unstable sands of the chos are sometimes spread by floods or wind over the neighbouring countryside, doing considerable damage to arable land.

(ii) The Central Plains (including the Kirana Hills)
These consist of the three eastern doabs extending from the Sutlej to the Jhelum. In each doab there is an almost imperceptible rise in the level of the land away from one river which then falls again, quite as gradually, towards the next one. These slight differences in elevation cause important variations in soil and sometimes even in land use. Each river meanders in a wide flood plain. Periodically, the land on both sides of a river is inundated by the late summer floods. The moist area fringing the river bed is divisible into two strips.

(a) "Sailaba" or "Kachchi" - the tract actually flooded and subject to changes in the course of the river.

(b) Dhaya or Khadir - the comparatively lower part of the doab along the rivers which is moistened by percolation and where the water-table is high.

After a further intermediate zone, the bar "uplands" are reached occupying the highest tract in the middle of the doab. They once constituted a desert prairie
with "rolling sand dunes patched with grass and...hard, unfruitful plains glistening with salt". The best-known of these tracts were the Ganji and Nili Bars in the Bari and Rechna doabs respectively, now transformed through irrigation.

Crystalline fragments of the oldest mountains in India, the Aravallis, emerge through the alluvium in four places between the Ravi and the Jhelum. These are the Kirana Hills aligned N.W. to S.E. and their elevation above the plain decreases from over 900 feet in the north-west south-eastwards. These bare, dark-coloured and stony hills present a striking contrast to the surrounding plains.

(iii) The Thal This is a sandy desert occupying the Sind-Sagar Doab south of the Salt Range with the exception of the southern part. The western or the Great Thal is a complete desert but eastwards, the sand hills open out and patches of arable land occur. The Powah is a narrow strip of upland on which villagers whose lands lie in the riverain tract seek refuge from the floods. South of the Salt Range, the Thal is a flat barren plain with a hard salt-impregnated soil. This part is known as the Chhach tract.

(iv) The Derajat Tract This includes the trans-Indus territory of south-west Punjab covering the Dera Ghazi Khan district. Its western boundary consists of the eastern slopes of the Suleiman Range which are generally low, bare and rocky, cut through by several passes. A high zone flanking these slopes is known as Pachad. The land along the Indus which can be irrigated by inundation canals is called Sindh after the vernacular name of the river and is separated from the Pachad region by a zone known as the "Danda" tract.

(i) K.S. Ahmad - Agricultural Geography of the Punjab
Chapter 3

CLIMATE.

With climate we come to what has always been recognised as the most fundamental factor in agriculture. Despite their contrasted seasonal regimes, West Punjab and Barbary show a comparable variability and deficiency of rainfall combined with extremes of temperature, conditions which are, as a rule, associated with a semi-pastoral life or irrigation agriculture. Human life in the major part of these two regions has since long been adapted to a semi-arid or arid habitat and one has to comprehend the facts of climate in order to understand it. So intimate indeed is the relation between climate and man that the extensive development of irrigation has produced an interesting chain of social reactions and changes which present a fascinating field of enquiry.

The study of climate thus assumes a special importance, constituting, as it does, the background for these far reaching human developments.

The development of irrigation on a large scale does not minimise the dominating role of climate with regard to agriculture. The effects of good or bad seasons are still reflected in the total agricultural production as later chapters will show. The ultimate source of irrigation water is once again the climate as also of the most serious problems of irrigation - floods and erosion.

A study of the vast field of meteorological phenomena is beyond the scope of this work. Thus even though
this account represents an endeavour to interpret the climate of these regions in terms of dynamic meteorology and the results of the latest researches have been considered, only those elements of weather have received emphasis which have some bearing on agriculture, the peasant and their problems.

**BARBARY**

In the simplest terms Barbary belongs to the transition zone in which the seasonal alternance of marine westerlies and the continental trade winds produce respectively a mild wet winter and a hot dry summer. This does not take into consideration the influence of air masses whose *lines of discontinuity* give rise to frontal disturbances which are responsible for most of the rainfall. The great complexity of relief is yet another factor which produces considerable variations of climatic conditions over short distances and hence those striking changes in the agricultural landscape one observes in travelling over the region.

Tunisia, Algeria and eastern Morocco form a continuous zone facing the Mediterranean in which the general alignment of relief is from east to west. Consequently most climatic gradations take place in a north-south direction. Western Morocco differs from the rest of Barbary being sheltered both from the Mediterranean and the Sahara by high mountain ranges and in that it owes many of its climatic features to the influence of the Atlantic. This influence has very often been exaggerated because Queney has recently
established the climatic unity of Barbary (1) by proving that the climate of the region as a whole is determined by the circulation of the atmosphere between heights of 10,000 and 13,300 feet where it is not influenced very much by relief. Furthermore, the essential features of the whole region such as the seasonal distribution of rainfall and of temperature are everywhere similar.

PRESSURE AND GENERAL CIRCULATION:-

The Rôle of Air Masses and Fronts

It has been customary to explain the weather conditions of a region in terms of the distribution of pressure over the region itself and the neighbouring seas. Thus during the summer, from May to September, there is a low pressure over the Sahara and the winds around it blow parallel to the North-East trades which prevail. All these winds being either continental or travelling from a cooler sea to the hot land, bring no rain. In winter, the pressure conditions are reversed: a high pressure exists over the Sahara while the westerly winds blow constantly over Barbary. These being oceanic and moisture-laden, cause widespread precipitation.

This ideal simplicity of conditions does not help us to understand the considerable divergence of weather from the seasonal "normals", nor does it account for the great variations from year to year. The recent advances in weather

(1) P. Queney "Types de temps en Afrique du Nord et au Sahara Septentrional" Travaux de l'Institut de Meteorologie, fasc. 3, Alger., 1943
knowledge which have introduced the concept of air masses have been incorporated into the latest works on the climate of Barbary. According to these, weather conditions in Barbary are only a part of much wider phenomena which result from the interaction of several air masses. These are briefly described as follows:

1. The cold polar air mass
2. The two anticyclonic masses covering respectively the Eurasian continent (continental air mass, disappearing in summer) and the North Atlantic (commonly referred to as the Azores High; maritime)
3. The masses of tropical air which flow between the two anticyclonic air masses. (i)

When polar air flows over Barbary, the temperatures are below normal and winds blow from the north-west. The air from the Eurasian mass is characterised by little cloudiness, a high daily range of temperature, very low humidity and winds that blow generally from the north-east. The tropical continental air mass covers Barbary during the summer when high temperatures and the development of storm clouds are noticed and some rainfall occurs on the southern slopes of the Atlas ranges. (ii)

The movements of these air masses is seasonal and

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(ii) Ibid, P.152
with them are associated the lines of discontinuity or fronts of which the two most important are as follows:-(1)

(a) The Polar Front between the polar air and the two anticyclonic masses.

(b) The Trade Winds Front between the N.E. Trades and the South West Anti-Trades which exists in the upper air and includes the so called Mediterranean Front.(11)

The types of weather in Barbary result from the position and activity of these two fronts.

The regime of the Polar Front occurs when this discontinuity occupies a position in Europe southerly enough to affect the climate of Barbary. This happens in autumn, winter and spring. S.S.W. to N.N.W. winds, associated with the Warm Front, bring heavy rains to the north of the Saharan Atlas and sandstorms to the south of it. Sometimes, these polar depressions, travelling in a North-South or N.W. to S.E. direction, take a direct W.E. course which produces a contact with the Trade Winds Front and torrential rains occur, mostly in Algeria.

The regime of the Trade Winds Front is in evidence when the Polar Front is confined to the north of Europe and the North Atlantic air mass extends its influence up to

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(11) R.Capot-Rey quotes Queney (Ibid) to say that "The discontinuity which appears sometimes in the western Mediterranean between the N.E. winds from Europe and the S.W. winds from Africa which is sometimes called the Mediterranean Front may be included in the Front of the Trades".
eastern Europe. If Trade wind Front is in the upper air, Barbary is swept by a N.E. or E. wind and the weather is pleasant in the interior and foggy near the coast. Again it may happen that the front is on the ground but is not active in which case the anti-trades blow over Barbary and the weather is hot and dry in summer, cold and slightly rainy in winter. Finally the front may be active on the ground. It is during such spells that heaviest rains are recorded in the High Plateaux and northern Sahara. The disturbances associated with the Trade Winds Front are most frequent in spring but do not occur at all in summer. No explanation of this phenomenon is forthcoming at present. (1)

Lastly it sometimes happens that the two fronts co-exist. Each has its own current of disturbances which may either neutralize each other or combine. In the latter case powerful storms are produced towards the east of Barbary. It is the combination of all these phenomena that makes weather conditions so variable.

TEMPERATURE:

The most important single factor with regard to the temperature is the sea. Mean annual isotherms are generally parallel to the coast, a fact which is particularly striking in Morocco where they run from north-east to south-west showing thereby that the influence of latitude has been negatived by that of the sea. The effect of the sea is most marked in winter and is as prominent on the eastern coast of Tunisia as on the western coast of Morocco. Thus "Tabarka, Mehdia and Jerba which spread over 3° of latitude have the same

(1) R. Capot-Rey, Ibid P.42
average temperature in January." (i)

The mean annual temperatures increase from the coast inland and in the case of Algeria and Tunisia, a general increase from north to south is also recorded, noticeable even on the eastern coast of Tunisia. Here temperatures increase from $65^\circ F$ at Bizerta to $67^\circ F$ at Gabes. In Algeria where the latitudinal trend coincides with the distance from the sea a greater difference is observed between the $64^\circ$ at Philippeville and $71^\circ$ at Biskra. The mean annual temperature figures do not constitute a factor of any importance in themselves. From that point of view the seasonal average and extreme temperatures are of much greater significance.

Everywhere near the coast, the effect of the sea tends to make conditions equable. This is again especially noticeable in Morocco where the cold Canaries Current gives rise to mild summers and a small range of temperature. The following figures for the Moroccan coast speak for themselves.

<table>
<thead>
<tr>
<th>Location</th>
<th>January</th>
<th>August</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rabat</td>
<td>54° F</td>
<td>74° F</td>
</tr>
<tr>
<td>Casablanca</td>
<td>54° &quot;</td>
<td>73° &quot;</td>
</tr>
<tr>
<td>Mogador</td>
<td>56° &quot;</td>
<td>67° &quot;</td>
</tr>
<tr>
<td>Agadir</td>
<td>59° &quot;</td>
<td>73° &quot;</td>
</tr>
</tbody>
</table>

In Algeria and Tunisia too, the mean January temperature on the coast ranges from $50^\circ$ to $55^\circ$ and frosts

(i) A.Bernard, *Afrique Septentrionale et Occidentale*, P.42
are extremely rare. The mean summer temperatures are similarly uniform and lie between 75° and 80°.

Inland, however, the oceanic conditions merge into continental extreme and with increasing distance from the sea the difference is apparent not so much in the mean temperatures as in the magnitude of seasonal and diurnal range. The contrast between the coast and the interior is more marked in winter than in summer. Thus whereas Rabat has a January temperature of 54°, Fes records only 39° and Marrakech 35° and at both of these places frosts are frequent. A similar difference in temperature during the summer will not have the same critical significance for crops.

In his recent work on the 'Climate of Algeria', P. Seltzer has drawn attention to a peculiar distribution of temperatures during the cold and the hot seasons, conditions which can be expected to continue to Tunisia as well. "During the cold season, the lowest temperatures are found along a zone approximately parallel to the coast which follows the chain of the Tell Atlas and traverses the high plains of Constantine. North and south of this temperature increases. It decreases, however, from east to west in the interior. During the hot season the temperature increases continuously from the coast inwards". In Morocco, however, the decrease is fairly

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(1) "Le Climat de l'Algerie", Alger 1946, P. 49
(ii) The hot season is taken to extend from May to October when the mean monthly temperature is more than the annual mean. The cold season covers the remaining six months when mean monthly temperature is lower than the main yearly value" Ibid P. 49
continuous even in winter. (underline)

Range of temperature:- The diurnal range of temperature increases from the coast inland being 7° and 9° respectively for January and July at Algiers whereas it amounts to 13° and 26° for the same months at Setif. (i) The range inland is much higher during the summer than in winter while it is always low near the coast and is always high toward the Sahara. (ii) The annual range of temperature also shows a general increase from the coast inwards although some sheltered valleys near the coast possess a marked degree of continentality. The Tunisian and Algerian littoral has an average range of 25°. The Atlantic coast of Morocco, being subject to the influence of the cold Canaries current, has a lower range which amounts to less than 15° in the regions of Mogador and Agadir.

The annual range of temperature is a very useful criterion for measuring the degree of continentality and the range of 36° has been widely accepted to mark the commencement of extreme continental conditions. (iii) In Tunisia and Algeria this lies along the south of the Tell Atlas although there are "islands" of extreme continentality, like the valley of the Sheliff, on account of their topographic situation. In Morocco, the 36° limit extends along the eastern and southern sides of the Atlas ranges although again there are pockets of continental conditions south of Marrakech and Tadla.

(i) Ibid P.44
(ii) A very high diurnal range of temperature is usually due to intense nocturnal cooling which constitutes a serious danger to the cultivation of certain early vegetables as well as fruits, particularly when accompanied by frost.
Bidault & Debrach
The Extreme Temperatures:— The study of monthly mean even though it constitutes a useful basis for the general study of climate, does not fulfil the requirements for the consideration of agricultural production. Many crops have critical limits and the suitability of a region for their cultivation can only be determined in the lights of the extreme temperatures recorded there in each season.

The lowest temperatures are recorded in the interior where they often fall below the freezing point - Fez and Constantine for example record 23°F and Cujda 19°. On the coast, however, they seldom fall below 32°.

The extreme maximum temperature is everywhere higher than 104° except for certain stations at high altitudes (i.e. Ifrane, in Morocco, 97°) and they reach over 120° near the desert or even at places like Orleansville and Taroudannt which are situated in low-lying valleys.

The hottest and coldest times of the year are not in mid-summer and mid-winter but occur a month afterwards.

RAINFALL

This is by far the most important element of climate both for crops and man and Bernard does not exaggerate when he states that rainfall "determines the great natural regions and their limits, the possibilities of cultivation and of sedentary life"(i) The terms, "Tell", "Steppe" and "Sahara" it may be recalled, represent essentially the degree of aridity in a region.

(i) Op.Cit. 4.
It is preferable when considering the rainfall conditions of Barbary to fix the starting point for the year at the 1st of September "because there is an almost complete absence of rainfall during the summer and the choice permits a study of rainfall during a complete vegetative cycle as well as an agricultural year. The total of rainfall according to the agricultural year facilitates its comparison with the yield of crops. (i)

**Annual Rainfall:**

A study of the annual rainfall map of Barbary will reveal the following characteristics:

1. The amount of rainfall increases with altitude but the increase is more marked on the slopes exposed to the rain-bearing winds. In this sense, the rainfall is orographic.

2. Over the whole of Barbary, rainfall decreases from north to south as also with distance from the coast. This is mostly due to the fact that since rainfall in Barbary is largely due to the depressions generated along the Polar Front, those parts which lie further away from the usual west-east path of these disturbances receive much less rainfall. (ii)

3. Excluding western Morocco, a decrease of rainfall is also noticed from east to west. The classic explanation of this phenomenon is the one given by A. Angot (iii) which is still

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(ii) Bidault et Debrache - Ibid P.155

(iii) "Etude Sur la Climat de l'Algerie", Annales du Bureau Centrale Meteorologique 1881
widely accepted. According to him the winds which come mostly from the north-west, cover a much longer distance over the Mediterranean in the case of the eastern half of the littoral of Barbary whereas those which affect the western part have already been deprived of their moisture by the mountains of Spain. This in the opinion of Seltzer\(^{(1)}\) does not agree with other observed facts. There is no increase in atmospheric humidity from west to east which should be an essential corollary of Angot's contention. He suggests that the reason for this feature of rainfall can be sought in the greater activity of depressions to the north of Tunis. Furthermore the Atlas ranges in Morocco largely deprive the passing cyclonic disturbances of their moisture so that western Algeria and eastern Morocco are in the rain shadow, not of the Sierra Nevada, but of the Middle Atlas.

Taken in the regional perspective, the tracts with moderate to abundant rainfall are very much limited being confined mostly to the higher altitudes in northern Morocco, eastern Algeria and northern Tunisia. The greater part of these regions has a rugged relief so that it may be said that the zones of higher rainfall are, in general, regions of minor agricultural importance. The most prominent exceptions are the Sebou Basin and the Mitidja Plain. The limit of such regions may be fixed at 20" of annual rainfall.

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\(^{(1)}\) Op.Cit. P.144
North Africa Rainfall Graphs

Marakesh

Constantine

Tunis

Algeres
PERCENTAGE VARIABILITY OF RAINFALL IN ALGERIA
By far the larger part of those regions which may be considered to be topographically favourable for agriculture have rainfall ranging from 8" to 20" and these constitute the main core of this study.

Among the regions that are completely arid, the most notable from our point of view are the Marrakesh and Tadla plains in Morocco which in several respects come closest to the similarly arid parts of West Punjab in respect of recent developments in agriculture.

**Seasonal Distribution of Rainfall**

The statistics of annual rainfall do not in themselves give the complete picture of the suitability of any region for crop production. Rainfall occurs in considerable quantities in spring, winter (1) and autumn but the summer season from June to August is absolutely dry and, combined with high temperatures, constitutes a wholly negative season for all forms of vegetative life. This is the feature, typical of the Mediterranean climate, which is the basis for the growth of xerophytic characteristics in the natural vegetation as well as the special development of vine and citrus fruits both of which are well-adapted to this régime of rainfall.

The seasonal distribution of rainfall is not constant but varies considerably from year to year, and has a governing influence on the yield of various crops, particularly cereals.

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(1) There is usually a short period of lesser rainfall in mid-winter, particularly in Morocco, dividing the rainy season into two, one of autumn, one of spring.
VARIATIONS IN THE RAINFALL OF ALGIERS FROM 1838 TO 1932 according to L. Petitjean.
Variations in the Annual Rainfall at Tunis and Gabes 1885-1920. The pecked lines show the mean annual rainfall at the two stations.

[Source: Geographical Handbook, Naval Intelligence Division, "Tunisia"]
The variability of seasonal as well as annual rainfall will be considered in the following paragraphs. Diagram 2 shows the rainfall regime of four stations typical of different regions. They record a double maximum one in autumn and one in spring.

VARIABILITY OF RAINFALL

The annual and seasonal rainfall varies a great deal from year to year. A glance at the graphs showing the annual rainfall of Algiers, Tunis and Gabes over a prolonged period will indicate that the rainfall is subject to violent fluctuations and rarely comes very close to the normal. The following figures of the lowest and highest rainfall recorded between 1913 and 1938 show the extreme variations for four stations, representative of different regions as well as of different quantitative groups.

<table>
<thead>
<tr>
<th>Station</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Max./Min.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algiers</td>
<td>20.4&quot;</td>
<td>45.4&quot;</td>
<td>2.24</td>
</tr>
<tr>
<td>Bessombourg</td>
<td>43&quot;</td>
<td>97.3&quot;</td>
<td>2.04</td>
</tr>
<tr>
<td>Setif</td>
<td>12&quot;</td>
<td>24.1&quot;</td>
<td>2.01</td>
</tr>
<tr>
<td>Casablanca</td>
<td>7.3&quot;</td>
<td>24.2&quot;</td>
<td>3.1 (i)</td>
</tr>
</tbody>
</table>

The average variations are also considerable and variability increases with aridity, i.e. the lower the average rainfall, the higher the variability tends to be. Taking Algeria (for which alone calculations have been made) variability reaches 20-30% in the semi-arid western part,

particularly in the low-lands, and increases even to a higher figure towards the Sahara. In the more humid parts of the country, it is generally less than 15%. It can be reasonably assumed that if the extreme maximum and minimum figures in other parts of Barbary are comparable to those in Algeria, the percentage of variability will also show the same distribution.

As significant as the variability of annual rainfall is the variability of its seasonal distribution. Whereas the ratio of recorded minimum to recorded annual maximum may be 1:3 or 1:4 at the most, in the case of annual rainfall, the rainfall of crucial months may vary from nothing in one year to several inches in the next year. The effect of this on agriculture is far-reaching and it is now proposed to establish some correlation between the area and yield of crop and the amount and distribution of rainfall.

VARIABILITY AND CROP PRODUCTION

The annual figures of the production and yield of wheat in Tunisia have been compared with the annual and seasonal rainfall at Tunis for a period of twenty years (1911-1930). Before the results can be discussed, it is necessary to establish that variability at Tunis is representative of conditions in the rest of the country. In this respect the comparison of rainfall


(ii) Variability has been calculated by taking the average rainfall to be 100 and then taking the mean of variations in both directions between 1913 and 1938, and their relationship has been worked out. Seltzer p.129. Same principle was adopted by Williamson A.V. and Clark G.T. for India. The variability of the Annual Rainfall of India, Quarterly Journal of the Royal Meteorological Society, Vol. 57 1931.
at Tunis and Gabes over a 35 year period on graph 5 is quite convincing. Broadly speaking the years of rainfall below or above the normal are similar although the extent of fluctuations varies. Tunis may be accepted as more representative also because over two-thirds of wheat in Tunisia is produced in the northern part.

Graph 6 shows the annual rainfall and the total annual production of the two kinds of wheat along with their yields. It will be noticed that any striking rise or fall of the annual rainfall is accompanied by a corresponding rise or fall although there are some years when a decrease in the rainfall has been accompanied by an increase in both total area and production. Thus in 1918, rainfall was over 50 millimetres (2") below 1917 yet the area and production both went up considerably. These anomalies are explicable by considering the seasonal distribution, in others, of course, political and economic factors must be taken into account.

A detailed study was made of the area cultivated and the yields obtained by Europeans as well as Tunisian cultivators in relation to the monthly distribution of rainfall. Through drawing a number of graphs it was discovered that the Tunisian cultivators' figures for hard wheat approximate more closely to certain features of the seasonal distribution because of their rudimentary methods. Although the corresponding European figures do show a relationship to these features of seasonal rainfall, this relationship is neither so close nor so constant.
Graph showing annual rainfall at Tunis (black line) 1911-1920 and the total area under wheat, both hard and soft (red line) and the total production (discontinuous black line).
Relationship of the September to November rainfall at Tunis and the area devoted to hard wheat by Tunisian cultivators, 1911-1930.

Relationship of the March-April rainfall at Tunis and the yields of hard wheat obtained by Tunisian cultivators, 1911-1930.
For example, the European yield of hard wheat in 1914, a year of very low and ill-distributed rainfall which is reflected in the Tunisian yield of less than a quintal per hectare, was higher than in 1917 when the Tunisian yield was 2.7 in response to a higher and better distributed rainfall. Two graphs are reproduced, one showing the relationship of autumn (September to November) rainfall to the area sown by Tunisians with hard wheat and the other of the yield of the same crop in relation to the early spring (March to April) rainfall. Soft wheat had to be excluded from the comparison because the Tunisian figures are not recorded before 1918 and also because it was cultivated mostly by European colonists.

The relationship between the autumn rainfall and the area sown with hard wheat by Tunisians is very close firstly because this is a crucial period for the crop itself and secondly because the Tunisians cannot plough the drought-parched lands unless they are softened by rain. If rains come late or are inadequate, the sowings are reduced considerably. This stands out prominently in the graph. The relationship between early spring rainfall and the yields obtained is even more striking and almost all the ups and downs of rainfall are followed by the yields.

How the seasonal distribution of rainfall is even more important than the annual total is proved by the following example. (1) It also shows the ideal distribution

(1) P.Seltzer - Op. Cit. 148-149
Seasonal Distribution of Rainfall at Algiers During Two Consecutive Agricultural Years (September to August)
of rainfall - that for 1924-25 as illustrated.

The two consecutive agricultural years 1923-24 and 1924-25 had the same total rainfall at Algiers, 27.3", but the seasonal distribution was very different as may be noticed from the accompanying diagram. The result was a great difference in the yield of cereals for the two years. The spring rains of 1924-25 gave rise to exceptionally high yields, whereas the rainfall of 1923-24, being confined mostly to the autumn and winter, the yields were extremely poor. Here are the figures for the yields of the two types of wheat recorded at Maison-Carree (which lies within ten miles of Algiers and showed the same distribution of rainfall):

<table>
<thead>
<tr>
<th></th>
<th>1923-24</th>
<th>1924-25</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hard Wheat</td>
<td>4.7</td>
<td>21.3</td>
</tr>
<tr>
<td>Soft Wheat</td>
<td>1.3</td>
<td>23.8</td>
</tr>
</tbody>
</table>

Attempts have been made to establish some system of cyclical variation in the amount of rainfall on the basis of obtainable data. Unfortunately for agricultural forecasts no method has been found in the ups and downs of the annual
rainfall curve so that variability must continue to be an erratic factor.

**INTENSITY OF RAINFALL**

The agricultural value of annual rainfall figures is further diminished by the occurrence of rainfall in torrential localised downpours during brief periods, causing serious damage to crops and irrigation works through erosion. These are usually associated with thunderstorms.

Some of the heavy falls of rain recorded over short periods are given below:

<table>
<thead>
<tr>
<th>Place</th>
<th>Amount of Rainfall</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tunisia</td>
<td>A</td>
<td></td>
</tr>
<tr>
<td>Tunis</td>
<td>3.8&quot;</td>
<td>11th November 1911</td>
</tr>
<tr>
<td>Sousse</td>
<td>6.2&quot;</td>
<td>16th October, 1912</td>
</tr>
<tr>
<td>Gabes</td>
<td>4.1&quot;</td>
<td>20th October, 1911</td>
</tr>
</tbody>
</table>

**Algeria**

<table>
<thead>
<tr>
<th>Place</th>
<th>Amount of Rainfall</th>
<th>Date</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algiers</td>
<td>6.4&quot;</td>
<td>12th November, 1935</td>
</tr>
<tr>
<td>Fort National</td>
<td>3.3&quot; (in half an hour)</td>
<td>13th September, 1931</td>
</tr>
</tbody>
</table>
It has been noted in the correlations of torrential rains with the seasons that on the whole, the rains of the winter are less liable to be torrential than those of the summer. (i)

Various attempts have been made to find out what is the optimum intensity of rainfall from the point of view of agriculture. If the precipitation is too light, the rain water evaporates as quickly as it falls. The effects of heavy downpours have already been indicated. Seltzer quotes one investigation which concluded that the fall of 1 millimetre per hour is ideal as losses by evaporation and run-off are the least in this case. In fact such an intensity is rarely encountered and rainfall tends to be usually in excess of this. "INVISIBLE PRECIPITATION":

Apart from the visible rainfall several parts of Barbary benefit from the nightly condensation of moisture following unhindered radiation through the cloudless skies. These play a significant role in south-eastern and southern Tunisia, otherwise a region of very scanty rainfall. Here the maritime N. and N.E. winds bring plenty of moisture during the autumn and in the summer. The air is particularly rich in moisture during the dry summer, a season when the intense heat is followed by considerably cooler nights due to free radiation and there is widespread condensation in the shape of dew.

(i) P. Seltzer Op. Cit. P. 154
(ii) Ibid P. 149
The annual amount of water thus available through this invisible precipitation has been estimated to be equivalent to 10" - 20" of rainfall according to the number of cloudless nights. It is this factor which has been responsible for the successful extension of olive-orchards southwards in Tunisia.

The importance of nightly condensation in agriculture has not been measured in other regions in the same way, but is obviously a major factor particularly in the Atlantic plains of Morocco where the air is heavily laden with moisture and enables such crops as maize to flourish in a region that gets only 10-15" of rainfall.

Snow and Frost:— Snow seldom occurs on the coast but is more common inland where snowfalls may occur as early as October although the heaviest ones take place between November and April. The depth and the duration of the snow cover depends mainly upon altitude. From 2000 to 3000 feet it may lie for a week or two; from 3000 to 6000 feet for a month and above that height for several months. As the highest altitudes in Barbary occur in Morocco, snow cover is much more important here and persists on the High Atlas up till July in favourable years. Eastwards, with the reduction in altitude, the role of snow is much less. Over the Jurjura range snow often persists till May.

(i) G. Ginestous "Aperçu Climatologique", E.C.M. "Tunisie" P.93
Snow has an important regulating influence on the water of wadis and rivers. Like rainfall, snowfalls vary greatly in magnitude from year to year.

The number of days with frost depends upon altitude and distance from the sea and with increase in either or both, there is a corresponding increase in the frequency of frost. Near the coast, frosts are rare. They occur most frequently on the High Plateau and in the interior mountains where the number of days with frost may exceed 50. Frosts occur mostly in winter.

Thunderstorms and Hailstorms:— Thunderstorms are a local phenomenon that record their highest frequency in May and June and again in September. They are associated with development of convection currents in the superheated dry summer air. A connection may also be found between these periods and the movement of the polar front which retreats early in summer and advances towards its end. The frequency of thunderstorms has been recorded in Algeria and Morocco; in the former the number of days with thunderstorms varies from less than 20 in the north-eastern Algeria to over 30 in the higher parts of eastern Algeria and the High Plateau; in Morocco, the frequency of 25-30 days with thunderstorms is recorded in the higher mountains.

Hailstorms are also a local phenomenon and occur almost exclusively from December to March. The distribution of their frequency is analogous to that of thunderstorms,
being the highest in eastern Algeria and central High Plateau where it exceeds 10 in the year. Hail occurs in Morocco mostly along the southern part of the coast and in the Middle Atlas.

The Sirocco: This is a hot dry wind which blows sometimes from the Sahara over Barbary with withering effect on vegetation and humans alike. Temperatures may rise to more than 110° and the relative humidity greatly reduced. It is rare in winter and occurs mostly near the coast as a result of depressions in the Mediterranean. In summer when it is most frequent, particularly in July, it is most often encountered in the interior and is associated with depressions developing over the Sahara. The exact origin of the sirocco has not been clearly established. Although very often a föhn effect accentuates its normal attributes of heat and dryness accentuated relief is by no means necessary to give it its peculiar character.

The sirocco is known as "guebli" (southern) in Tunisia and Algeria, and as sherqui (eastern) in Morocco. Its frequency varies greatly and is greatest in zones accessible from the Sahara. Thus in Algeria the number of days with sirocco amount to over 40 on the High Plateau but seldom exceed 20 near the coast. In Tunisia, the sirocco blows 30-40 days a year east of a line joining Tunis and Gafsa while westwards, the frequency is 20 to 30. The duration of the sirocco varies from an hour to several days and there is no factual foundation for the belief that the
sirocco blows for 3, 6 or 9 days. It has been noticed that among neighbouring stations, the lower ones have a higher frequency of days with sirocco.

WEST PUNJAB

The climate of West Punjab is determined by its special position in the Indian sub-continent far removed from the oceanic influence and results from the monsoonal circulation of the entire landmass south of the Himalayas.

The mechanism of the Indian monsoon has usually been explained as a gigantic land and sea breeze. Although this analogy has an illustrative value it over-simplifies the problem. Far from being the result of a single physical condition, the monsoon is "produced by a combination of circumstances involving considerations of temperature, pressure, humidity, geographical relationships between land and sea, the rotation of the earth and lastly but probably the most important, the distribution of mountain ranges". (1)

The development and the change of the monsoon may now be taken up briefly. We may adopt a slightly modified version of the seasonal division adopted by the Meteorological Department of India.

1. The Season of the (a) Cold Weather Season - January to March
   North-East Monsoon

   (b) Hot Weather Season - April to June

2. The Season of the (c) Rainy Season - July to September
   South-West Monsoon

   (d) Season of the Transition from

No.199 Vol.47, 1921, P.152
Summer to Winter Monsoon - October to December.

A. Cold Weather Season:— The highest pressure of the year is established over north-western India (including West Punjab) from which pressure decreases slowly towards the south. The winter (north-east) monsoon is fully established though the winds are generally slight. The weather is clear and sunny but for periodic shallow depressions which appear from the north-west. Most of these have been traced back to the Mediterranean while others are probably formed as secondaries over Persia and Arabia under the influence of primaries further west. (i) These depressions bring about some rainfall which although not of any considerable amount constitutes a boon for the winter cereals, and determines the nature of their yields. These rains occur in light showers which make their agricultural utility much greater than if they were to come down as heavy downpours most of which would be lost as immediate run-off. West Punjab benefits particularly from these cyclones being among the first regions in their path. Murree receives 6" of rainfall in January and February and here are some more figures:—

(i) "The examination of available evidence shows that on an average, about seven out of every ten disturbances which affect North-west India in the winter months, December to April, are continuations of depressions from southern Europe". Walker G.L. and Hem Raj, "Cold Weather Storms of Northern India" M.I.M.D., Vol.XXI, Part III, 1913, P.P.H. This is important evidence of the influence of the Mediterranean on the climate of West Punjab.
Rainfall - January to March

<table>
<thead>
<tr>
<th>Location</th>
<th>Rainfall (&quot;in&quot;)</th>
<th>No. of Rainy Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lahore</td>
<td>2.35</td>
<td>6.4</td>
</tr>
<tr>
<td>Rawalpindi</td>
<td>7.12</td>
<td>12.1</td>
</tr>
<tr>
<td>Lyallpur</td>
<td>1.27</td>
<td>3.4</td>
</tr>
<tr>
<td>Multan</td>
<td>1.21</td>
<td>3.5</td>
</tr>
</tbody>
</table>

Rainfall is highest in the north-west and along the foot of the mountains while S.W. Punjab gets the least. Heavy snowfalls over the mountains add to the reserves of snow for the rivers and provide irrigation water at the commencement of the hot season.

The sudden falls of temperature associated with the rear (the cold front) of the depressions are very often harmful to the crops. The number of these depressions recorded during the cold season in three consecutive years and their monthly distribution is as follows:

<table>
<thead>
<tr>
<th></th>
<th>1940</th>
<th>1941</th>
<th>1942</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>10</td>
<td>11</td>
<td>9</td>
</tr>
<tr>
<td>February</td>
<td>9</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>March</td>
<td>9</td>
<td>9</td>
<td>6 (i)</td>
</tr>
</tbody>
</table>

They vary greatly in their intensity and the consequent weather conditions.

Mean temperature is roundabout 50° in West Punjab during January but rises continuously towards March. Under the free insolation of a predominantly anticyclonic regime,

(i) Indian Weather Review, Annual Summary, 1940-1942
great diurnal ranges are recorded - from 25° to 30°. Night
frosts are common in January and early February and are the
severest in the Potwar Plateau. The lowest temperatures
recorded are everywhere below 30°.

B. Hot Weather Season: - By April, when temperature reaches
60°, the hot weather has already begun. There is a steady fall
in pressure and in May, the high pressure disappears
altogether, replaced by a deep low centring around Multan. (i)
Winds which are northerly or north-easterly in April, become
variable till the S.W. Monsoon sets in. The main reason for
this variability in wind direction is the importance that
local pressure conditions assume, resulting in a large number
of storm phenomena. These are caused by the occurrence of
local fronts between "the surface-heated continental air....
and the monsoon air"(ii) which is being drawn in by the low
pressure. The most usual form they take is that of thunder-
storms which bring rainbursts of short duration over a region.
The same atmospheric phenomenon gives rise to hailstorms
earlier on in the year (from January to April) with maximum
frequency in March and the severe dust-storms which characterise
the pre-monsoon period. Besides these, local whirlwinds
are of common occurrence on days with uninterrupted insolation.
Ascending currents of air catch up dust and give the impression

(i) Miller, A.A., Climatology, London, 1944, P.139
(ii) "The Indian South-West Monsoon and the Structure of
Depressions" Ramanathan K.R., Ramakrishnan, K.P. M.I.M.D.
Vol. XXVI, Part.II, 1938, P.13
of whirling pillars of sand. These are known as dust-devils.\(^1\)

All of these phenomena have a considerable influence on the crops of the areas affected.

This season is one of small rainfall which, in view of the very high evaporation associated with continuous heat, does not mitigate the general conditions of drought and the parched appearance of the land. Rainfall occurs in any considerable quantity only in the sub-montane tract.

Rainfall - April to June

<table>
<thead>
<tr>
<th>Location</th>
<th>Rainfall (&quot;in.)</th>
<th>No. of Rainy Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lahore</td>
<td>2.92</td>
<td>5.9</td>
</tr>
<tr>
<td>Rawalpindi</td>
<td>5.32</td>
<td>10.2</td>
</tr>
<tr>
<td>Lyallpur</td>
<td>2.23</td>
<td>5.2</td>
</tr>
<tr>
<td>Multan</td>
<td>1.24</td>
<td>3.1</td>
</tr>
</tbody>
</table>

The rainfall is due to western disturbances and local thunderstorms. The monthly total of western disturbances recorded in the years 1940-42 is as follows:

<table>
<thead>
<tr>
<th></th>
<th>1940</th>
<th>1941</th>
<th>1942</th>
</tr>
</thead>
<tbody>
<tr>
<td>April</td>
<td>10</td>
<td>9</td>
<td>6</td>
</tr>
<tr>
<td>May</td>
<td>11</td>
<td>7</td>
<td>9</td>
</tr>
<tr>
<td>June</td>
<td>5</td>
<td>0</td>
<td>1</td>
</tr>
</tbody>
</table>

The temperature rises rapidly through April and May to reach a maximum of over 92.5°F everywhere in June. S.W. Punjab forms a segment of one of the hottest regions in the

\(^1\) For further treatment of the storms and frequency figures see end of chapter
world and records a temperature of over 95°F. The diurnal range continues to be high, being 20°-30°F. The mean minimum temperatures are generally over 80°, the mean maximum temperatures around 105° while the highest temperatures recorded in any year are between 110° and 125°F.

For all vegetative life, this is a difficult period. Hot winds during the day, locally termed "loot" have a withering effect on the vegetation. Clay soils become hardened and weather conditions sap human energy and enterprise. Both earth and man mark time waiting for the summer monsoon.

C. The Rainy Season: Even as the heat reaches its climax and assumes an intensity which becomes intolerable, the monsoon bursts. There is a slight divergence of opinion as to the exact circulation of air connected with the south-west monsoon. It has been consistently associated with the existence of a highly developed low pressure in north-western India which draws in the oceanic winds including the trades winds south of the equator. The latter undergo a rotational deflection towards the north and take the south-west direction. The actual direction of these monsoon currents is controlled by relief so that most of them come as south-east winds in West Punjab, the Arabian Sea branch being much less effective as a rain-making agency.

Wagner, a German meteorologist, has emphasised in view that "the south-west monsoon represents a stationary system of cyclonic disturbances reaching up to the average
height of the Himalayas between two air masses, one continental belonging to the westerly winds of the middle latitudes, and the other maritime. He considers that the continental air is warmer than the monsoon air at the surface and up to 1 km, but colder above and that a considerable part of the rainfall in the Gangetic plain is due to cyclonic convergence. The observations of upper air movements on which this view is based give it a stamp of authenticity. On the other hand, the prevailing pressure conditions and the winds associated with them during most of the season point obviously to the traditional explanation of the monsoon.

The weather observation data recorded by the Indian Meteorological Department provides the conclusive evidence and it is noticed that the two conceptions are not in conflict. The general seasonal circulation of the surface winds conforms to the popular idea of a gigantic sea breeze modified by relief and other physical factors. But the pulsatory character of the rains with intervals of hot dry weather is associated with the activity of depressions generated along the "monsoon front".

Most of West Punjab is included in a part of the Indian sub-continent which has the lowest pressure in the world in July and is not too far from the sea. On the theory of pure indraft, this region should receive the heaviest rainfall.

and yet it is the driest part of India. Simpson\(^{(1)}\) vouchsafes the following explanation for this aridity:

(a) The small amount of moist maritime air reaching this part.

(b) The hot dry upper air current flowing from the west which prevents condensation.

(c) The low humidity at the ground caused by the high temperatures, the high temperature itself being a result of clear skies and uninterrupted insolation.

Dr. Ahmad\(^{(ii)}\) has put one of these points to a statistical test - the one dealing with the low humidity of the winds in this region. He has proved that the mean precipitation per rainy day in the Punjab is 0.94" as against 0.89" in Bengal and 0.88" in Bombay. This would appear to disprove the above assertion. But calculating rainfall per day during the monsoon for the drier part of the Punjab, Simpson's contention is undoubtedly correct when applied to the region it is really meant for:

Rainfall per rainy day (July to September)

<table>
<thead>
<tr>
<th>Location</th>
<th>Rainfall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lyallpur</td>
<td>.78&quot;</td>
</tr>
<tr>
<td>Multan</td>
<td>.70&quot;</td>
</tr>
</tbody>
</table>

Furthermore, heavy rainfalls during short periods are characteristic of the semi-arid and arid parts of northwestern India, a feature which reduces still further the agricultural utility of the monsoon in these regions.

\(^{(ii)}\) K.J. Ahmad, Op.Cit. P.92
### Rainfall (July to September)

<table>
<thead>
<tr>
<th>City</th>
<th>Rainfall (in)</th>
<th>No. of Rainy Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lahore</td>
<td>14.19&quot;</td>
<td>14.2</td>
</tr>
<tr>
<td>Rawalpindi</td>
<td>18.11&quot;</td>
<td>22.4</td>
</tr>
<tr>
<td>Lyallpur</td>
<td>8.8&quot;</td>
<td>11.2</td>
</tr>
<tr>
<td>Multan</td>
<td>4.1&quot;</td>
<td>5.5</td>
</tr>
</tbody>
</table>

The normal rainfall for this season constitutes two-thirds of the annual rainfall, the principal rainy months being July and August.

**Correlation of Rainfall:** Various meteorologists have worked out statistical correlations between the monsoon rainfall of a year and the preceding conditions of pressure, temperature and rainfall (notably Unakar, Blanford, Walker and Eliot). The purpose of these is to establish a basis for forecasts of rainfall which is so vitally important for agriculture. Some of these suggested relationships may be mentioned in passing.

Large snow accumulations on the Himalayas have an adverse effect upon the monsoon. (i)

Walker (ii) has discovered that well-developed high pressure in the preceding winter is followed by a good monsoon. He also established that high pressure in South America has the same influence.

Eliot (iii) has proved that if south-east trades bring heavy rainfall in their region, the Indian monsoon is also very

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(iii) Imperial Gazetteer of India, Vol. I, 126-127
fruitful.

Despite these established relationships, one may add, it has been found exceedingly difficult to determine the nature of the south-west monsoon in advance. In any case most of West Punjab belongs to a critical region in which even a good monsoon seldom causes enough rain to mature crops without irrigation.

Both the date of the commencement of the monsoon and the amount of rainfall associated with it vary a great deal from year to year. In general, the monsoon sets in around the 1st of July in the eastern section and a fortnight later in the western districts.

The effect of the monsoon on temperatures is to bring them down though they rise again towards the end of September. At Lahore, for example, the mean maximum temperature falls from 106.7° in June to 99.9° and similar falls are recorded everywhere. Temperature is higher towards the south-west where rainfall is less. The intervals of damp heat in between spells of rain are found most uncomfortable by man and beast. The general effect of the rain on the countryside is to bring it to life.

D. The Season of the Retreating Monsoon

This quarter of the year has the "most settled weather of the year.... The serenity of the climate is seldom disturbed". (1) The low pressure conditions are replaced by

(1) H.F. Blanford, The Climates and Weather of India, Ceylon and Burma. London 1889 P.
a weak high pressure in October which becomes intensified as the season proceeds. North-easterly and north-westerly winds prevail. The activity of the monsoon had already begun to subside in September and later ceases to cause rainfall altogether so that October and November are about the driest months in the year. The western depressions commence their activity about this time, reaching their highest intensity in December which is also the wettest month of this season.

Rainfall (October to December)

<table>
<thead>
<tr>
<th>City</th>
<th>Rainfall (in)</th>
<th>No of Rainy Days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lahore</td>
<td>.62&quot;</td>
<td>1.8</td>
</tr>
<tr>
<td>Rawalpindi</td>
<td>1.37&quot;</td>
<td>3.5</td>
</tr>
<tr>
<td>Lyallpur</td>
<td>.73&quot;</td>
<td>1.9</td>
</tr>
<tr>
<td>Multan</td>
<td>.34&quot;</td>
<td>1.1</td>
</tr>
</tbody>
</table>

The number of western depressions recorded during this season is as follows:

<table>
<thead>
<tr>
<th></th>
<th>1940</th>
<th>1941</th>
<th>1942</th>
</tr>
</thead>
<tbody>
<tr>
<td>October</td>
<td>5</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>November</td>
<td>6</td>
<td>8</td>
<td>2</td>
</tr>
<tr>
<td>December</td>
<td>8</td>
<td>8</td>
<td>6</td>
</tr>
</tbody>
</table>

The temperature falls steadily through October, November and December to come down to the conditions that prevail in the cold season. The diurnal range is high, 30-35° and the temperature decreases latitudinally towards the north.
The date of commencement of winter frost has a great agricultural significance as it determines the distribution of American cotton. The usual date is after the end of December but frosts have been recorded as early as the 8th of December (at Rawalpindi, 1932). On the whole the frost sets in sooner and is most frequent on the Potwar plateau and the sub-montane tract.

**Annual Rainfall:** The annual rainfall map (No. 64) shows that rainfall decreases from the north-east to the south-west, the isohyets following the strike of the mountains. The highest rainfall is recorded at Murree which is situated at a height of about 7,000 feet. The sub-montane tract has central Punjab from 10-20" whereas the arid south-west and the tract to the south of the Salt Range records less than 10" of rainfall. Modest as these figures are, they do not show the other hazards of rainfall which makes it so much less useful for crop-production.

The most serious drawback is, as in the case of Barbary, the variability of rainfall. The same features, i.e. the lower the rainfall the higher the variability and also the concentration of rain in a few rainy days are again noticed prominently. Map (ii) shows the highest percentage of variability in the south-western districts, over 30%. Regions of higher rainfall also have more dependable rains, the

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(i) Dr. Ahmad, Op.Cit.

percentage of variability here being less than 20%.

The relationship of variability to optimum crop conditions is not easy to establish for the biological effectiveness of the rain is dependent upon "the configuration and vegetational covering of the land upon which it falls, the rate of evaporation obtaining and the capacity of the soil to receive and accommodate moisture to the advantage of the plant"(i) Given the predominantly uniform conditions over the alluvial plain of the Punjab, rainfall is the supreme factor from the agricultural viewpoint and over a greater part of the province variability combines with rainfall deficiency to make irrigation more or less essential.

Cyclical Variation of Rainfall:-- Dr. K. S. Ahmad has come to the conclusion (ii) that there is some statistical proof for the general belief that the quantity of rainfall in the province is subject to a triennial rotation. Years of markedly low or heavy rainfall tend to occur at intervals that vary from 2 to 8 years but more frequently at shorter interval of 3 years.

Thunderstorms and Hailstorms:-- Both these phenomena originate in a similar manner and the essential condition for their formation is the production of rising currents of moist air on a sufficient scale to make the air unstable. This may happen by strong surface-heating by contact with the heated ground which gives rise to convection currents

(i) Ibid, P.44
in the hot summer afternoons. Thunderstorms that occur in this manner are very localised in character. Distinct from these "heat thunderstorms are the 'depression thunderstorms' caused by mechanical uplift of moist warm air by the undercutting of cold heavy air. These are usually associated with western disturbances."

<table>
<thead>
<tr>
<th></th>
<th>Lahore</th>
<th>Rawalpindi</th>
<th>Murree</th>
<th>Khushieb</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>0.5</td>
<td>0.3</td>
<td>0.7</td>
<td>0</td>
</tr>
<tr>
<td>February</td>
<td>0.8</td>
<td>0.9</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td>March</td>
<td>2.7</td>
<td>1.9</td>
<td>3.2</td>
<td>1.6</td>
</tr>
<tr>
<td>April</td>
<td>3.3</td>
<td>3.7</td>
<td>5.3</td>
<td>2.3</td>
</tr>
<tr>
<td>May</td>
<td>3.4</td>
<td>2.7</td>
<td>4.3</td>
<td>1.9</td>
</tr>
<tr>
<td>June</td>
<td>3.5</td>
<td>3.8</td>
<td>7.1</td>
<td>1.5</td>
</tr>
<tr>
<td>July</td>
<td>4.2</td>
<td>6.2</td>
<td>7.1</td>
<td>2.3</td>
</tr>
<tr>
<td>August</td>
<td>4.0</td>
<td>6.0</td>
<td>7.4</td>
<td>1.2</td>
</tr>
<tr>
<td>September</td>
<td>2.4</td>
<td>6.3</td>
<td>5.4</td>
<td>1.6</td>
</tr>
<tr>
<td>October</td>
<td>1.4</td>
<td>2.6</td>
<td>3.3</td>
<td>1.1</td>
</tr>
<tr>
<td>November</td>
<td>0.3</td>
<td>0.3</td>
<td>0.9</td>
<td>0.1</td>
</tr>
<tr>
<td>December</td>
<td>0.5</td>
<td>0.1</td>
<td>0.3</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>27</td>
<td>35</td>
<td>46</td>
<td>14</td>
</tr>
</tbody>
</table>

It will be noticed that the highest annual frequency is recorded in the Potwar Plateau where the two maxima in April and June-July are connected with "depression thunderstorms".

(1) Frequency of Thunderstorms in India, I.M. Department, Scientific Notes, Vol.1 No.5
and "heat thunderstorms" respectively.

Hailstorms occur when vertical air currents in a thundercloud have sufficient velocity and extent to bring about a freezing of the moisture and its precipitation as hail or ice. Hailstorms are most common between January and June with the maximum frequency in March. They are encountered more often at the elevated stations such as Murree and Rawalpindi.

Dust storms:— They resemble the thunderstorms in their origin and are a consequence of the strong convection currents set-up after the intense heating of the summer mid-day. Large quantities of dust are raised up and carried over long distances to be deposited over land with a stifling effect on the vegetation. Their frequency is on the whole greater towards the west than the east. They are most common from April to August.
HYDROGRAPHY

The water resources of a semi-arid region whether in the shape of surface drainage or of underground reserves play a decisive role in its agricultural prosperity. These resources are determined by climate, relief, the natural vegetation as well as by the nature of the geological strata. In reflecting these conditions the rivers and the distribution of sub-soil reserves in West Punjab and Barbary show a contrasted aspect. We shall first consider the rivers and other features of surface drainage and then study the sub-soil reserves of water.

SURFACE DRAINAGE

By virtue of its mountainous relief and a general absence of extensive lowlands, Barbary is naturally unsuited to the development of large rivers. West Punjab on the other hand possesses a celebrated system of rivers which draw their never-failing supplies of water from the Himalayan snows and glaciers. The general aspect of the West Punjab drainage is essentially uniform, all the waters flowing across the alluvial plain into the Indus. The cardinal fact about Barbary, however, is its diversity and one comes across water features varying from the perennial Atlantic rivers through the shorter and torrential Mediterranean streams to the large interior basins of inland drainage. Finally, whereas consequent upon their having considerable catchment areas and a large volume
of water, the West Punjab rivers are well-developed and mature streams, the shorter rivers of Barbary are still characterised by youthful features and an irregular profile.

As regards the water regime of the rivers, the contrasted effect of the Mediterranean and the Monsoon climates may be noted. The combination of great summer heat with complete drought produces a negative season for the rivers in Barbary when they run dry. A similar regime subsists in West Punjab in the hot season but is ameliorated by the melting of the Himalayan snows. As for the winter season, reduced evaporation and a high percentage of run-off makes the low precipitation more effective than it would be on parched lands during the summer. From the point of view of river flow, therefore, West Punjab enjoys a great advantage over Barbary, an advantage that is reflected in the type and development of irrigation works. We may now take up the two regions one by one:

**BARBARY**

Apart from those features of the drainage of Barbary that have already been pointed out, the important role of geological structure should be specially noted. In the absence of permanent glaciers and the comparatively minor role of snow-cover, the moisture-retaining capacity of the rocks has a great influence over the periodic fluctuations in the water-regime. Limestones at the headwaters of a stream tend to
regulate the flow as for instance the Summam in Algeria draws a constant supply of water from the massive Jurassic limestones of the Jurjura range. The Sebu in Morocco presents an interesting contrast in the water regime of its northern and southern tributaries. The Rif slopes drained by the Wargha consist of clays and marls from which run-off is immediate and the heavy winter rains cause disastrous floods. Summer finds this part of the basin completely dry. The Middle Atlas limestones, the source of the southern tributaries of the Sebu, provide a more regulated supply so that these, notably the Rdom and Beth are less liable to floods and maintain a constant flow. (i)

As the study of the long profiles (see diagrams) will indicate, most rivers in Barbary are characterised by the occurrence of definite "steps" in their courses, marking the points where a formerly closed basin was captured by the stream. These are a testimony to the youth of the rivers that have not attained to profiles of equilibrium.

One climatic factor, not measured quantitatively so far, as the greatest significance from the point of view of river volume in Barbary and this evaporation. It "accounts for much the greater part of the precipitation which falls on the rivers ... and the average volume of rivers equals at the most a twentieth or thirtieth part of the total volume of rainfall." (ii)

(i) W. Fogg, "The Sebu Basin" Scottish Geog. Mag. 1931, P. 80
(ii) A. Bernard, Op. Cit. P. 52
The nomenclature of the surface-drainage of Barbary presents quite a problem. The local inhabitants call them "wadis" which literally means a valley. This is apparently a result of the water regime under which the majority of the streams flow only periodically during rains and are dry valleys for the rest of the year. But even the native inhabitants make a distinction between perennial and seasonal streams as one of the main tributaries of the Shertiff is called "Nahr" or River Wassel in distinction from Wadi Twil, the other major source. This difference is unfortunately not brought out in the naming of many other rivers that, in addition, carry different names in different sections - a result of the isolation of different communities due to the complex relief. The writer has therefore raised those wadis that have a perennial flow and large catchment areas to the dignity of rivers while the seasonal streams have been termed wadis.¹ This is also uniform with the nomenclature in West Punjab where a similar distinction exists between rivers and "nalas".

We may study the surface hydrographical features of Barbary in four groups:

1. The Atlantic Rivers
2. The Mediterranean Drainage

¹French geographers i.e. Bernard, Despois, etc, tend to accept the local nomenclature to distinguish the drainage with great seasonal contrasts from the European rivers. The writer believes however that perennial flow with some volume puts a river into a separate category from the torrential streams and is reflected in its utility for irrigation. Most barrage reservoirs have been constructed across "rivers" and not wadis.
3. The Closed Basins.

4. Saharan Water-Courses.

I. The Atlantic Rivers

These constitute the best-developed river systems of Barbary drawing their waters from the highest mountains in Barbary - the High and the Middle Atlas on which snow lies for six to nine months. The existence of alluvial plains of considerable dimensions is a testimony to the importance of deposition. The chief systems are those of the Sebu, the Bu Regreg, the Um-er-Rbia and the Tensift.

(a) The Sebu

This is the only river in Barbary approaching a profile of equilibrium. Originating in the Middle Atlas and after receiving the drainage of the Taza Gap, it flows through alluvial terraces in the Fes-Meknes plain. Further down it is joined by its larger tributaries from the north and south, named previously. At its confluence with the Wargha it is only 45 feet above the level of the sea and has 180 miles to run. Here it flows in tortuous meanders above the general level of the plain so that periodic floods inundate the lowlands on both sides.

The merjas of the plain of Sebu are a feature peculiar to it and constitute unhealthy marshes in winter and a valuable grazing ground in the summer. The typical merja consists of two parts, the "hydra" and the "beach".(1) The hydra

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PROFILE OF THE SEBU, according to J. Clerier and A. Charton.

Regime of the Sebu.
Profile of the Um-er-Rbia.

Outflow of the Um-er-Rbia, after Y. Le Moigne and J. Bourcart.
is the depressed part wherein the depth of the water may be as much as 9-12 feet in winter and some water may persist even through the dry summer. The beach is completely dry in summer-time but may be inundated to a depth of three or four feet in winter. It is covered with a variety of forage plants providing extensive pasturelands to transhuming tribes.

The main causes for the formation of the merjas are the impermeability of the clayey silt that covers these regions; the barriers to natural drainage in the natural levees of the Sebu and the coastal dunes; and lastly the inability of the intermittently flowing tributaries of the Sebu to maintain a constant base-level. They cover over 220,000 acres in the lower Sebu plain and the largest of them is the Merja of Beni Ahsen.

The volume of water in the Sebu averages between 1050 and 1400 cusecs, the minimum being 360 cusecs while at flood time it may exceed 70,000! (i)

The Bu Regreg:- is a much smaller river with a length of only 110 miles and a very small and irregular volume of water. Along with its tributaries it drains the Zaer-Zaian plateau. The headwaters of this stream are supposed to have extended much further up but were probably captured by the Um-er-Rbia. (ii)

The Um-er-Rbia:- With a length of 355 miles and a large and rich catchment area, the Um-er-Rbia is the most

powerful of the rivers of Barbary. Rising high in the Middle Atlas, it traverses the Tadla plain flowing East-west but changes its direction to N.E.-S.W. After receiving its largest affluents, the El-Abid and the Tessawt, it cleaves through the Rehamna massif and meanders its way through the Abda-Dukkala plain to the sea. It is a very heterogeneous stream with two steps in its profile to mark local base-levels of captured basins. The river which along with its tributaries drains the larger part of the southern Middle Atlas and the northern High Atlas, maintains a constantly high volume which varies from 1400 cusecs in July to over 7,500 cusecs in April. The river is less liable to the violent floods that characterise the Sebu.

The Tensift has a total length of 140 miles and drains the Marrakesh region and the northern slopes of the High Atlas.

II. The Mediterranean Drainage

This group comprises a large number of streams stretching from the Muluya in eastern Morocco to the Mejerda in Tunisia. Even the longest rivers like the Sheliff and Sebouse are "more of torrents than of rivers"(1) full only in times of floods and discontinuity of surface drainage is a general characteristic. Gautier(II) has divided them into two groups:

(1) Those which have their whole course in the Tell.

(2) Those whose sources are in the High Plateau.

The Rivers of the Tell Atlas

The important rivers in this group are the Mejerda, the Sahel (Summam), Isser, Habra, Sig and Tafna.

The Mejerda is the longest of the Tellian rivers with a length of 260 miles and is also the principal river of Tunisia draining most of the country between the coastal ranges and the Dorsal. Its source lies in the eastern Algerian High Plains and after a deeply-entrenched course it enters into its lowland valley below Ghardimaou. It receives tributaries from north to south, the most notable being the Mellegue which also rises in the Algerian High Plains. Mejez-el-Bab is the gateway to the plain of Tunis across which the river meanders on to the sea, and has built up a large delta, the only one in Barbary.

The Sahel (or Summam) and the Isser are two small rivers rising south of the Jurjura range and are 125 and 142 miles long respectively. Gautier has called the Isser the "heroic type" (i) of river which crosses successively all the chains of the Atlas at right angles and debouches towards the coast by the celebrated gorge of Palestro.

The rivers of the Mitija plain, Mazafran and Harash show antecedent features when they cut through the Sahel in gorges.

The Sig and Habra, chief rivers of the Sahel of Oran,

(i) Ibid P.355
11 The Um-er-Rbia south of the plain of Beni Amir. Photograph taken in mid June when volume of water is approaching its summer minimum. Notice the hydro-electric plant on the left bank with some associated buildings further to the left. Bushy natural vegetation on the right.

12 Gorge of the Tafna river below the Beni Bahdel dam in Algeria. Stratification is clearly exposed. Scattered low scrub on the sides of the gorge as well as the heights in the distance.
Nadi el Kebir north of Blida. It is on the alluvial fan of this stream that Blida has developed. Photograph taken on a rainy day in late May. On the slopes of Blida Atlas vegetation is luxuriant and some conifers can bee seen on the right. Valley slopes are steep as the stream just emerges here from its mountain course.

The Isser and the Jurjura range seen faintly in the distance. The river flows in a broad flood-plain with steep valley sides covered with scattered brush. There are no signs of cultivation in the flood-plain because of the shifting bed of the stream as well as its liability to floods.
are different from all other Tellian streams. They have a very youthful profile in which the plains of Mascara and Sidi Bel Abbes respectively introduce steps of regular slope. The Macta marshes into which both rivers empty lie at the centre of a vast stretch of interior drainage extending from Rio Salado to the Sheliff. There are several inland basins of sizes ranging from insignificant "dayas" to the large Sebkha of Oran which is 40 miles long.

The Tafna with a length of 110 miles is the fastest of the Tellian rivers and the one with the steepest gradient. Below Beni Bahdel where a barrage has been constructed it cleaves the interior Tell Range through a deep gorge.

Several of the coastal streams are saline (hence the frequent occurrence of the name Mellah, meaning salty) The salinity of these has been ascribed to the outcrop of triassic rocks which abound in salt and gypsum. The presence of a soluble sub-soil may also be a reason for the general depressed nature of the Oran region.

(2) Rivers of the High Plateau

With the exception of the Muluya, the rivers of this group show a marked step in their profiles where the river leaves the high plateau (See profile of the Shelif) The most important rivers are the Sheliff and the Muluya.

(i) Ibid P.362
PROFILE of the SHELIF after Gautier.

REGIME of the SHELIF at CHARON, (after Yacono.) mean of 1927-1935.
Profile of the Mejerdia.

after Gautier.
The Shelif with a length of 434 miles is the longest river of Barbary. Of its two main head-streams, the Twil ("long") rises in the Saharan Atlas to that the Shelif is the only river rising in this range to reach the sea. Below Boghari, the river which had a north-south direction so far takes a sudden turn and flows east-west through an ancient depression which it has filled with its sediments. Despite its great length, the Shelif has a volume comparable to that of the smaller Mejerda, averaging 630 cusecs but rising to over 350,000 cusecs during the highest floods.\(^1\) In the dry season it consists of a series of marshes joined by tiny trickles.

The Muluya connects three basins in its course marking the sites of Pliocene lakes and after a deeply entrenched course through the mountains of Beni Snassen, enters the sea through a coastal plain.

III. The Closed Basins

Most of the high plateau is a region of closed basins which are known by several names, i.e. shotts, sebkras, zahrez and gueraa.\(^2\) They owe their origin to the lack of dominant slope towards the plains, the nature of rocks and their arrangement which favours absorption, evaporation and stagnation, and above all to the arid climate. Masses of debris brought down by the torrents after downpours only help

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\(^1\) M.R. Martin "Les Grands Barrages et les Irrigations en Algerie", 1947, P.9

\(^2\) A. Bernard Op. Cit. P.54
The Mejerdha above its delta. The river flows between high well-defined banks fringed here on the right by the wind-breaks of a fruit plantation. The beginning of a gentle undulation in the landscape is seen on the left in the distance. Photograph taken in early May when volume of water is fairly high.

A tributary of the Mejerdha photographed from the train in the Mejerdha valley. Notice the low bare hills in the background. Land on the right is cultivated in the distance and fallow in the foreground. The stream flows between high vertical banks and is incised below the surface of the valley.
The Sebkra Kelbia in Tunisia north-east of Kairwan. It is a shallow depression filled with water. The white glistening salt can be noticed at the edges. In the centre the beginning of a path used in summer when it is completely dry to collect salt. Outline of low hills in the background.
to choke the plateau up with deposits. The Sebkhas or shotts which are full of water only for a short period in winter consist usually of a saline crust or reddish mud.

IV. The Saharan Water-Courses

These are the usual ephemeral streams of the desert type bringing down a mass of sediments after a shower but losing themselves in the sands.

WEST PUNJAB

The water regime of the rivers of the Punjab has been subjected to a detailed and comprehensive analysis in relation to the Himalayan snows and glaciers by K.Sain. The relative proportion of the glacier areas in the river catchments can be gauged from the following table.

<table>
<thead>
<tr>
<th>Name of river</th>
<th>Glacier area in square miles</th>
<th>Percentage of glacier area to total catchment area</th>
<th>Mean elevation of glacier area above mean sea level in feet</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indus</td>
<td>14,415</td>
<td>12</td>
<td>20,500</td>
</tr>
<tr>
<td>Jhelum</td>
<td>142</td>
<td>1</td>
<td>18,000</td>
</tr>
<tr>
<td>Chenab</td>
<td>1,475</td>
<td>13</td>
<td>19,000</td>
</tr>
<tr>
<td>Ravi</td>
<td>100</td>
<td>3</td>
<td>17,000</td>
</tr>
<tr>
<td>Beas</td>
<td>277</td>
<td>5</td>
<td>19,000</td>
</tr>
<tr>
<td>Sutlej</td>
<td>2,468</td>
<td>11</td>
<td>20,000</td>
</tr>
</tbody>
</table>

(i) The Role of Glaciers and Snow in the Hydrology of Punjab Rivers, Kanwar Sain, Central Board of Irrigation, Pub. No. 36, 1946

(ii) This does not include the areas covered by seasonal snows
Putting it in another way "so enormous is the aggregate amount of water locked up in the crystalline state in the glaciers and ice caps on the Himalayas that if it were all released by melting and flowed down the Punjab rivers, most of the Punjab and Sind plains would be submerged" (i)

The science of snow-surveying as well as the study of the run-off in the rivers in relation to the rainfall are still in their infancy in this part of the world. One river, the Chenab, has however been studied carefully over a period of 20 years (1923-42) with the help of 12 rain-gauge stations and the discharges measured regularly. The results obtained from this study are shown in diagram *The run-off from May to October is appreciably greater than the total precipitation and even the total annual run-off exceeds the annual rainfall. When the losses of rain-water by absorption and evaporation are taken into consideration, it becomes obvious that the glaciers are responsible for a material contribution to the run-off.

K. Sain rejects the prevalent belief that snow-cover is an important factor in flood causation and holds the reverse to be true. Snow cover acts as a flood deterrent in two ways; by the "sponge effect" by which water is absorbed and held and the "surface detention effect", by which deep snow

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(i) Ibid Page 1
regulates the water-supply by acting as a restraining obstacle. He advocates large-scale snow-surveys to make stream-flow forecasts more accurate.

The volume of water in the rivers is subject to very great variations (see graph) and the proportion of maximum recorded discharges at floods to minimum discharge is remarkably high as can be noticed on the following table. (i)

<table>
<thead>
<tr>
<th>River</th>
<th>Site</th>
<th>Minimum Cusecs</th>
<th>Maximum Cusecs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sutlej</td>
<td>Rupar</td>
<td>2,918</td>
<td>250,000</td>
</tr>
<tr>
<td>Beas</td>
<td>Nowshera</td>
<td>2,800</td>
<td>325,000</td>
</tr>
<tr>
<td>Ravi</td>
<td>Madhopur</td>
<td>1,300</td>
<td>200,000</td>
</tr>
<tr>
<td>Chenab</td>
<td>Khanki</td>
<td>3,884</td>
<td>600,000</td>
</tr>
<tr>
<td>Jhelum</td>
<td>Rasul</td>
<td>4,500</td>
<td>500,000</td>
</tr>
<tr>
<td>Indus</td>
<td>Attock</td>
<td>18,000</td>
<td>1,000,000</td>
</tr>
</tbody>
</table>

The heavy variations in discharges are most disconcerting to the irrigation engineer and if they could be adequately predicted, the task of distributing irrigation supplies would become much easier. Cultivators too could then plan their crops more efficiently. K.Sain draws attention to the fact that from April to June, critical months for water-supply, the main source of run-off is snow which could be forecast much more accurately than the empirical rains. (ii)

The general characteristics of the Punjab rivers are broadly similar. Their general tendency is to hug their right bank. Nearly always, therefore, it is easier to carry irrigation water from the left rather than the right bank. Nearly all the rivers shift their courses and flood their banks over a considerable portion of their course, the area covered gradually increasing towards the sea. So long as these inundations remain within reasonable limits, they do little harm and much good. New silt fertilizes the land and winter crops flourish on the water absorbed during a late summer flood. Crops are sometimes protected by bunds (embankments) particularly in the regions irrigated by inundation canals in the south-west of the province. There is considerable evidence that the intensity of floods in the Punjab rivers has increased. As long ago as 1872 an irrigation engineer pointed this out and gave the same reason as is generally given today; being "centuries and centuries of bad and unsettled government when everyone cut down trees but no man planted any\(^{(i)}\)"

The relative size and importance of the Punjab rivers may be observed in the following table:\(^{(iii)}\)

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\(^{(i)}\) K.S.Ahmed - Agr. Geog. of the Punjab P.53
\(^{(ii)}\) T.Login, Op.Cit.
\(^{(iii)}\) Hayden and Burrard "Geography & Geology of the Himalayas" P.175
<table>
<thead>
<tr>
<th>Himalayan area in the basin (Sq.miles)</th>
<th>Total discharge of water (Ravi as unit)</th>
<th>Ratio of discharge to area, taking Ravi as unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indus</td>
<td>103,800</td>
<td>9.0</td>
</tr>
<tr>
<td>Sutlej</td>
<td>18,500</td>
<td>3.5</td>
</tr>
<tr>
<td>Jhelum</td>
<td>13,000</td>
<td>5.5</td>
</tr>
<tr>
<td>Chenab</td>
<td>10,500</td>
<td>5.5</td>
</tr>
<tr>
<td>Beas</td>
<td>5,600</td>
<td>2.5</td>
</tr>
<tr>
<td>Ravi</td>
<td>5,600</td>
<td>1</td>
</tr>
</tbody>
</table>

The Indus is the greatest of the Punjab rivers. It rises in Tibet from a ring of lofty mountains near Lake Mansarorar, flows through Kashmir, N.W.F.P., Punjab and Sind into the Arabian sea. The total length is 1800 miles and the basin drained is estimated at 372,700 square miles.

The Indus traverses a mountain course of over 800 miles during which it receives the drainage of several large rivers like the Shyok, Gilgit, Zanskar, Dras and Shigar so that it is a mighty river by the time it enters the province above Attock. Here it receives the Kabul. Flowing through the narrow gorges of the Potwar plateau, it is joined by the Soan at Makhad, bringing the entire drainage of the plateau. The Indus emerges on to the plain at Kalabagh where it has a large alluvial fan.

South of Kalabagh the river flows through almost desert country where cultivation is almost entirely dependent upon irrigation. The Indus is, however, a turbulent and unmanageable river which shifts its course frequently, the only
permanent banks it possesses being those at Kalabagh. It is a braided stream with a network of shifting channels and, as is characteristic of Punjab rivers, has a steep right bank. Just above Mithankot, it receives the waters of all the Punjab rivers. The lower course lies in Sind.

The Jhelum rises in Kashmir and flows for about 250 miles as a rapid torrent hemmed in by precipitous gorges. It emerges on to the plain eight miles above the town of Jhelum and flows as a braided river. Sandy islands know as "bels" stud its wide bed. The Jhelum is subject to destructive floods but usually subsides in good time for the riverain land to be sown with winter wheat. Dr.Ahmad believes that the Jhelum rises earlier than the other Punjab rivers because it is more dependent on the melting snows and less on the summer rainfall than they are. This is difficult to understand as only 1% of the Jhelum's catchment is permanently covered with glaciers. It is probable, however, that periodic snow, not covered in the glacier area, makes a substantial contribution to its waters.

The Jhelum occasionally has slight winter floods due to the rainfall brought by westerly depressions.

The Chenab Its sources lie in the Lahaul region of the Himalayas. It enters W.Punjab in the Sialkot District.

(i) Dr. K.S.Ahmad - An agricultural Geography of the Punjab, P.51
Regime of the Chenab at Marala in relation to the measured precipitation over the Catchment Area.
It begins to rise in March but the annual inundation which follows affects only a narrow fringe along the river. Owing to the sandy nature and loose texture of the soil on its banks, the moisture percolates far inland. Water-table is consequently high. The Jhelum joins the Chenab at Trimmu.

The Ravi has its headwaters on the south-western slopes of the Pir Panjal and the northern slopes of the Dhauladhar Mountains. Leaving the Himalayas, after 130 miles in the mountains, it flows in the plain in a comparatively narrow flood-plain with a tortuous channel. It begins to rise in May, reaching a maximum in August but is an insignificant stream in winter.

The Sutlej drains a large part of the Punjab Himalayas. After entering the plain and being joined by the Beas at Subraon it follows the characteristic Punjab slope and has different names in different parts, i.e. in Montgomery it is called Nili (blue) while in Multan it is called Ghans. Changes in its bed have been very frequent.

SUB-SOIL RESERVES

The underground water-reserves of Barbary and West Punjab play a considerable role in their traditional systems of irrigation particularly through wells. Map shows the water-table of West Punjab as at present. Over a larger part of the riverain tracts, the water-table lies within 15 feet
of the surface. Further away from rivers the depth of the water increases but due to percolation in the alluvial sandy layers, underlain by impermeable clay ones, water is everywhere present at smaller or greater depths. Water seepage from canals have raised it at several places to such a point where it has become a liability rather than an asset for agriculture. On the whole, however, the existence of underground supplies reasonably close to the surface gives rise to intensive farming rendered possible by well-irrigation. The sub-montane districts and the riverain lands were irrigated long before the present system of canals brought the bar uplands under cultivation.

Due to the mountainous relief and the complex nature of the geological strata, the distribution of underground water reserves in Barbary is uneven. In general low-lying valleys and basins with deep alluvial deposits have sub-soil reserves derived from percolation. The Haouz and Gharb Plains in Morocco; the lower part of the Mejerda Valley, the Cap Bon region and the region of Kairwan in Tunisia are cases in point and here well-irrigation is practised. Existing knowledge of this invaluable water resource is however very imperfect in Barbary and no exact idea of the possibilities of utilising them can therefore be formed. The underground reserves of the closed basins are now being studied in Algeria where even the possibility of doubling the total
irrigated area by tapping the basin of Shott es-Sherqui has been envisaged.
Chapter 5

SOIL AND VEGETATION

Whereas the role of the soil in crop production is well-known, the natural vegetation of a region does not appear to be related directly to agriculture. In the study of the geographic relationships between environment and crops, however, natural vegetation provides us with an invaluable index of the biological response to natural conditions. It has been said that the "climax vegetation of a region is a better integration of climatic conditions than any numerical data". (i) For soils, too, vegetation has a deep significance. The more distinct soil types are almost always associated with quite distinct types of vegetation and over limited tracts "this association is often more pronounced than that between soil and climate". (ii)

The study of natural vegetation serves a very practical purpose for agriculture in two ways. Firstly the problem of soil erosion is intimately connected with the nature and history of the vegetation cover of any region. Secondly, in regions of expanding agriculture such as those we are studying, the index value of natural vegetation can serve as a very useful basis for land-use planning.

As Shantz and Zon have observed "The suitability

(ii) "Soil, Vegetation and Climate", Imperial Bureau of Soil Science 1934, P.7
of virgin land for various crops is usually indicated very clearly by natural vegetation. After a correlation is established between different forms of natural vegetation and various agricultural and forest crops, it provides a means of dividing the country into natural regions of plant growth which can be used as indicators of the potential capabilities of the virgin land for agriculture and forest production"(i)

Natural vegetation is determined not only by climate but also by the soil conditions, both past and present. In fact this close inter-relation of soil and vegetation is the basis for their joint consideration. In view of this and the primary importance of the soil for agriculture, it is only fair that soil should be studied first.

THE SOIL

The soil has been defined as "the uppermost layer of the solid crust of the earth; it consists of rocks that have been reduced to small fragments and have been more or less changed chemically together with the remains of plants and animals that live in it or on it."(ii)

The older concept of the soil which looked upon it as a static body with unchanging physical and chemical properties has given place in recent years to the view which regards it as a living and highly dynamic entity evolving continuously under the influence of climate, vegetation, relief

(i) "Atlas of American Agriculture" Washington 1924
(ii) Sir A.D. Hall, "The Soil" P.1
and the parent material. In the early stages of its development, the character of the soil is determined largely by the character of the parent rock. Hence many mountain soils approximate closely to the nature of the surface rocks. As the development of the soil proceeds, climate and vegetation become the dominating influence and mature soils often show striking uniformity within the same climatic province even if there is a wide diversity of geological features.

The Properties of Soil and their Importance:– The two important physical properties are soil texture and soil structure. Soil texture refers to the mechanical constitution of the soil with reference to the size of the soil particles which range from gravel and coarse sand to fine clay. Although this attribute has an important bearing on the capacity of the soil to hold moisture and on drainage, a property of greater importance from the agricultural point of view is the structure of the soil which determines the condition of tilth and aeration.

Of the nine chemical constituents of the soil essential to the plant (hydrogen, oxygen, nitrogen, sulphur, phosphorus, potassium, magnesium, calcium and iron) nitrogen, phosphorus and potash are the most important as they vary considerably in quantity from soil to soil. Semi-arid regions like West Punjab and Barbary are capable of fixing nitrogen
very rapidly from the air. The role of leguminous crops is particularly significant in restoring nitrogen because of the bacteria which flourish in their roots. The soils of Barbary and West Punjab are fairly rich in phosphorus and potassium. The former region has great reserves of mineral phosphates.

**THE SOIL TYPES OF BARBARY (See Map 66)**

Despite its predominantly agricultural economy, Barbary has not so far been subjected to a comprehensive soil survey. Most of the existing literature on soil types is fragmentary and gives an incomplete picture of the characteristic of the soil in relation to crop production. The one notable exception is V. Agafonoff's work on the "Soil Types of Tunisia" (1) based on an extensive field study and analysis, the classification adopted being the modern genetic one. In view of the regional unity of Barbary and the essential similarity of natural conditions, an attempt has been made to state a possible distribution of soils in other regions in the light of the Tunisian analogues as well as any local studies.

It is always interesting to refer to the local "classification" of soils for the peasant possesses an intimate knowledge of their qualities through his own

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experience as well as that of his forbears. Most peasants are also able to give a broad distribution of these soils over the countryside and know what crops can be grown most advantageously on them. They make a clear distinction between heavy clay soils or "tin" and light sandy soils or "reml".

In the regions with an adequate rainfall, the cultivable soils with a dark colour are called "tell" in Algeria and Tunisia and "tirs" in Morocco. These soils are ideal for wheat and conserve water so well as to yield good crops even in years of drought. The mountain soils, stony and difficult to plough are referred to as "jebel" (the word also meaning mountain). The reddish soils of the semi-arid regions are termed "hamri", soils which yield good crops of barley in years of good rainfall but which do not retain moisture very well and provide very meagre pasturage. When they are not deep and are mixed with gravel they are called "haroucha". (i)

When later on this native classification of soil types is compared with the genetic types, some striking points of similarity stand out to which attention shall be drawn at appropriate places. This is ample proof that modern scientific studies are only a more exact and precise amplification of facts long since known and appreciated by "ignorant" people through their practical experience.

Numerous geological classifications of soil types exist which do not commend themselves from the practical

(i) J. Despós "L'Afrique du Nord" Paris, 1949, P. 74
standpoint except possibly in the case of young mountain soils of regions of deficient rainfall. These have been left unclassified by Agafonoff\(^{(i)}\) in the case of Tunisia thus, acknowledging in a way, the predominance of geological factors. Most young mountain soils are skeletal and vary with the geological formation. Others show semi-developed types approximating to the soil associated with the rainfall conditions that prevail.

The low valleys and plains are covered with alluvium brought down from the mountain slopes by streams. These soils become progressively fine-grained away from the mountains and if the slope is insufficient, they tend to occur as marshy expanses along the lower courses of streams (i.e. near Oran and the now drained marshes of Mitidja and the plain of Bone in Algeria and those of Sebu in Morocco). Where there is an excess of evaporation over precipitation, alkaline salts, mostly those of sodium, rise to the surface and render them unproductive. The reclamation of such soils constitutes one of the main problems of agriculture and shall be taken up in detail in a later chapter. Alluvial soils are found along the valleys of the principal streams as well as in ancient lakes which during the hydrographic evolution of the region, became filled up with silt. The distribution of such basins has been described under hydrography. These soils are rich

\(^{(i)}\) See Soil Map of Tunisia based on "Carte Pédologique de la Tunisie" by V. Agafonoff and L. Yankovitch, scale 1:800,000
in the mineral ingredients of plant food and are generally cultivated.

We may now proceed to study the distribution of "sedentary" soils or soils which have developed under the natural conditions in situ and hence come properly under the genetic classification.

Podzols: These soils occur in regions where percolation is in excess of evaporation, i.e. where annual precipitation exceeds 24". They are leached of the bases in the upper layer so that the humus is acidic in reaction. Most of this region is covered with coniferous forest. "The soil profile of the Tunisian podzol corresponds fairly exactly to the typical Polzol of Russia" (1) The thin top layer rich in humus is underlain by a greyish yellow horizon leached by the percolating water. The salts accumulate in a lower layer with a darker colour acquired from the hydrated oxides of iron. One then passes to the C horizon of the parent rock.

The podzols are found in northern Tunisia, north eastern Algeria and in parts of the Rif and western High Atlas. Soils of the western part of Cap Bon in Tunisia and the northern Moroccan littoral have a tendency towards podsolization although the rainfall here is generally between 16 and 20". This is due to the high atmospheric humidity.

The podzols proper are not very rich from the point of view of agriculture and only those plants which are adapted to humid soils poor in lime can succeed. With the help of

(1) L.Yankovitch, Etude Pedologique de la Tunisie, 2 partie La Tunisie Agricole. Op.Cit. page 100
fertilizers however, vegetables (haricot beans, potatoes, beet-root) and citrus fruits can be grown in those regions which are free from frost while the mountainous tracts can produce apples, pears, cherries and late vegetables. The drier podzols can be cultivated with cereals, fruits and vegetables with the application of fertilizers.

Rendzinas: They result from the influence of a calcareous parent-rock on the soils of the podzol zone. These soils have a dark brown or black colour, the decalcified A and B horizons have together an average thickness of 16" and rest directly on the parent rock without any intermediate substratum or C Horizon. These soils are very rich in humus and in Tunisia, they have the highest humic content of all soils. The rocky fragments of limestone increase in quantity with depth. This soil type is to be distinguished from the "terra-rosa" which is typically associated with the Mediterranean and is similarly associated with limestone rocks because the latter are much poorer in humus. 

The north of Tunisia south of the podzol zone, the eastern Tell Atlas and most of the soils called "tirs" in Morocco particularly those to the south of the Bob Regreg are of this variety. Towards the south where rainfall is below 20" a thin superficial crust of limestone is observed to prove that evaporation is higher in this region.

(i) L. Yankovitch, Op.Cit. 101

(ii) J. Despois, Op.Cit. P.78
These soils vary in texture from the light variety formed over hard limestones to the heavier soils over marly strata and are rich in nitrates, potassium and phosphoric acid. They are cereal-growing soils par excellence and rotations are practised with leguminous plants. Forage crops such as lucerne, maize and sorghum are also grown. Deeper soils can be utilized for fruit cultivation.

A drier rendzina occurs in regions with a rainfall of 16-20" but the decalcification of A and B horizons is less marked and they have a smaller quantity of humus and clay. These soils are well-suited to cereals with a rotation of fallow every alternate year.

**Soils with a crust**

Wherever annual precipitation is less than 20", evaporation tends to be in excess of percolation. The vegetation is poorer and thinner than in the more rainy tracts and produces less humus. The salts and lime of the sub-soil move upwards and tend to form a crust of varying thickness. These soils are either red or brown in colour being progressively browner with increasing quantities of lime. The top layer is clayey with some gravel in it and rests directly on the crust which is harder towards the top. The origin of the crust is a subject of controversy, some contending it was formed by the upward movement of lime which was then covered by deposits brought by wind and water, others holding it was formed by downward movement at the foot of the roots.
of plants.

The northern (i.e. wetter) parts of this soil zone have their crust at considerable depth, the top layers are largely decalcified and the soil colour is red. As the rainfall decreases towards the south, the soil becomes greyish-brown or brown with a thicker, harder and shallower limestone crust. As a group these soils are of good quality, somewhat lacking in nitrogen and phosphates, they are rich in potash. Wherever the crust is too near the surface, the roots cannot penetrate easily. They are found between the Mejerda and the Dorsal proper in Tunisia; in Algeria on the southern side of eastern Tell Atlas and in the High Plains of Constantine as well as in the plateau of Sersou; in Morocco in the major part of the Atlantic plateaux and plain south of Rabat. These soils are well-suited to the production of cereals.

The Soils of the Steppes:—Rainfall here is below 15" and the vegetation a poor grassland so that soils show a light colour, indicative of poverty in humus. The distinction between the soil and the sub-soil becomes difficult. These soils are generally rich in the mineral content of plant food and reveal their fertility when cultivated under irrigation. They all include wind-blown materials, dust and sand. Fine loessic sand occur extensively while in basins, deep deposits of fine alluvium are to be found although they tend to be over-rich in chlorides. The soils round the sebkhas,

(1) L.Yankovitch Op.Cit. P.103
MAP OF THE SOIL TYPES OF TUNISIA
(From Desio's simplification of Agafonoff)
Diagramatic Representation of the Occurrence of Different Types of Soils in West Punjab According to Mechanical Composition.
known as chotts contain too much salt to be cultivable. This group of soils occurs in South Tunisia, the region south of the High Plains of Constantine and in the High Plains of Western Algeria and eastern Morocco; and finally in the Sous and the part of Morocco south of the High Atlas.

THE SOILS OF THE WEST PUNJAB

Except in some part of the Potwar Plateau, the soils of West Punjab are alluvial and show no relation to the underlying geological structure. This similarity of origin under more or less uniform conditions of climate leaves only one basis for their classification - that of mechanical constitution, depending on the size of particles. This feature is of fundamental importance for the agriculture of a semi-arid region as it determines the behaviour of the soil with regard to water supply for the crops. The characteristics of different groups have already been stated and the nomenclature of various combinations indicated on Diagram 17 which also shows the physical nature of the soils of West Punjab.

It will be noticed that there is a predominance of sandy and medium loams in the province. Most of these are excellent soils for cultivation, sufficiently retentive of moisture and not difficult to work. Sandy soils dominate in the Thal. But even soils with a high content of sand can become very productive if a sufficient supply of water is available. The correct estimate of the mechanical texture of soil in terms of productivity can only be made in the light of
rainfall; water supply and other factors. "A soil of a certain texture behaving as a loose sandy soil in a district with deficient rainfall may behave as a loam in another area with a medium rainfall and as a heavy loam in heavy rainfall"(1)

The following generalisations may be made with regard to the distribution of West Punjab soils:

(a) The soil is more sandy near the hills and gets progressively clayey further away.

(b) In the "doabs" of Central Punjab considerable variations occur from the lee or riverain tract where sand predominates to the bar uplands where the quantity of sand diminishes to such an extent that even patches of stiff clay may be encountered. On the Ganji Bar, extensive tracts of hard stiff clay give place towards Multan to low sand dunes and the soil is less cultivable.

(c) The Thal consists of sand-hills (tibbas) with occasional patches of hard level clayey soils and tracts of ground impregnated with salt.

(d) In the Derajat region, soil varies from a rich loam to an alluvial clay as we pass from the mountains to the Indus.

In the Potwar Plateau, a mantle of fine loessic silt occurs in certain parts to the east of Rawalpindi, the angular particles of which suggest violent wind transport.

It is confined to the northern half of the plateau.

The soils of the alluvial plain of West Punjab were studied in relation to their natural vegetation in a monograph under the auspices of the Punjab Irrigation Research Institute. (1) This study undertaken to determine the suitability of different types of soil for irrigated cultivation has yielded some very useful results. The following features are noticed to start with:

a. The occurrence of Kankar (an accumulation of calcium carbonate in nodular form) is an important feature of the alluvial soils of the Punjab. It occurs in those tracts where a highly alkaline surface soil (another common feature in the province) is underlain by a fluctuating water-table containing calcium bicarbonate.

b. While the podzol profile is fairly well-developed in the wetter hills, the alluvial soils of the plains are of so recent an origin that a well-developed soil-profile is not present. However, due to the arid climatic conditions, certain characteristics are developed, chief of them being a high content of soluble salts, alkalinity and zones of deposition of calcium carbonate (kankar).

c. Last but most significant of all, the soils of many parts of West Punjab tend to contain sodium salts or are alkaline. The saline soil type, locally known as "Thur" is

(1) R.C.Hvon and M.L.Mehta "A Study of the Soil Profiles of the Punjab Plains with reference to their Natural Flora" Lahore, 1937
characterised by a high percentage of sodium salts and is permeable to water. In winter, a white efflorescence consisting of sodium sulphate, sodium chloride and small quantities of sodium carbonate appears at the surface over large areas. The alkaline soil, locally known as "Rakkar", is impermeable to water. Both these types are useless for agriculture unless specially treated and reclaimed.

Soil profiles of areas under Jand, Wan, Okan, Karai and grass (the principal vegetational species) were studied, the soil samples analysed physically and chemically and the following conclusion arrived at:

Soils where Jand is the principal natural flora growing under Doab conditions are good soils for cultivation although they are high in sodium salts and the water-table may rise too high. Kankar is generally present.

Wan soils are lighter than those under Jand and are apt to feel the shortage of water supply more severely, i.e. water-retentive capacity is low. They are suitable for general cropping.

Okan flourishes as well on saline soils as on others. The presence of this type should therefore indicate the necessity for the analysis of samples to determine salinity before any opinion can be given on agricultural possibilities. Even on a soil that is not excessively salty, it indicates a type less productive than that under Jand or Wan.
Karai is a common tree in "rakhs" (open plain forests) and generally indicates a soil that will produce indifferent crops when brought under irrigation on account of large sections of sand in the soil profile precluding normal movement of moisture.

Grass grows under a wide range of conditions so that it cannot be considered as a reliable indication of soil quality.

There are still large tracts under one or other type of vegetation and these conclusions can be a useful guide whenever their utilization is contemplated. This study also reveals the value of vegetation as an index of the quality of soil.

The problem of alkaline and salty lands is a fundamental one from the viewpoint of agriculture and will be treated in a later chapter.

**VEGETATION**

In the regions we are studying, the vegetation changes with climate from forest associations through transition zones of brush and small trees to grassland associations. It is proposed to establish types of vegetation from the ecological point of view as such a classification shall be useful in indicating the potentiality of land for crop production. The groupings adopted have been verified by personal observations.
and the principal species in each vegetation type have been mentioned mainly to facilitate their identification by a layman in the field.

The Role of Forests:-

The role of forests is mainly protective: they conserve soil and moisture. In climates marked by periods of intense drought and where torrential rains tend to strip the land of its productive top layer, their value to agriculture cannot be exaggerated. For irrigation works, they act as regulators of water supply. They have a beneficial influence on the water table which is kept fairly high under forest cover. In recent years there has been increasing realisation of their salutary effect on the climate and the following experiment in Algeria gives convincing proof that they help to improve the rainfall:

"The Algerian Forest Research Service created 12 meteorological stations in 1915 in forested regions to study the climatology of forests as well as of special varieties of trees. Over a period of twenty years (1915-1935) comparisons were made with other stations situated in identical regions but away from forests. It was proved that the presence of an important forest cover tends to increase the average rainfall by a proportion which is of the order of 8%" (1)

Forests supply the domestic wants of human beings and in Barbary, many tribes subsist to a considerable extent

(1) E.C.M. "Algerie", "Les Forets" P.368
on the reserves of vegetation existing in forests. In West Punjab, more forests would make large amounts of cattle-dung which is burnt now as fuel, available as manure.

The Role of Brush and Grasslands:-

They possess some of the valuable attributes of forests like the protection of soil from erosion and a more limited regulating influence on water supply. They have played a more important role as the habitat for large sections of the population which subsisted on them before the coming of irrigation. Vast tracts of such vegetation in the West Punjab doabs and the steppes and plains of Barbary supported nomadic tribes. The persistence of their tendency to clear the forests for an increasing population both of men and herds is at the root of soil erosion. Furthermore the whole outlook of these people, now practising irrigation agriculture in large tracts has been shaped by the grassland habitat the study of which is consequently of great interest.

BARBARY

The general impression one gets in travelling over the region is one of bareness, of the absence of well-preserved natural vegetation. This impression is somewhat misleading as there are still large reserves of forests particularly in the well-watered sections of the Atlas regions. Deforestation over several centuries, however, has reduced the vegetation
cover to a point where it is no longer adequate enough to preserve an equilibrium with agriculture. Before going into the human destruction of forests, it will be well to study their distribution in the light of natural conditions.

Apart from the principal factors affecting vegetation like relief, exposure, climate and soils, the nature of geological strata has a considerable influence on the distribution of forests. This influence is most noticeable in the Tell Atlas which has the typical immature mountain soils with the parent rock exercising its effect in a marked degree. As Semple has observed "Ancient forests have been more likely to persist on soils of disintegrated limestone and crystalline rocks especially when mingled with clay and on volcanic soils because they are retentive of moisture. The porous limestone soils which are very arid, when once deforested, never recover in the dry sections of the Mediterranean lands but deteriorate into a maquis".

The vegetation types adopted follow those of Shantz and Marbut(i) but have been modified greatly on the basis of more recent studies and observations in the field. On the whole, excepting the Middle and High Atlas ranges in Morocco, the vegetation decreases in quality from north to south and from east to west. This coincides with the distribution of rainfall. The principal forest types are as follows:

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(i) "The Vegetation and Soils of Africa", American Geographical Society, Research Series, No.13, 1923
1. The Wet Mediterranean Forest or Oak-Conifer Forest
2. Mediterranean Scrub Forest or Temperate Brush
3. Dwarf-palm - Temperate grass
4. The Steppes

1. The Wet Mediterranean Forest or the Oak Conifer Forest

These forests occur on high land in those parts of the Atlas mountains which receive a rainfall of more than 20" and have a short drought period of 3-5 months. The principal varieties found are the lebanese cedar and the juniper trees at greater heights and the cork-oak, evergreen oak, the Portuguese oak and the Aleppo pine lower down. The distribution of individual species in gregarious stands depends upon soil, rainfall, temperature and altitude. It should be of interest to relate their occurrence to the natural environment.

The cork-oak forests are amongst the best defined, being limited to the regions of siliceous rocks (sandstone, gneiss etc.) with abundant rainfall and temperatures not subject to extremes. The soil type usually found associated with them is the podzol. They occur principally in the Numidian chain in eastern Algeria, and in northern Tunisia and northern Morocco. These forests are often dense with an impenetrable undergrowth. There are also some "drier" cork-oak forests of a less luxuriant nature in the Oran Tell and in the forest of Mamora in Morocco.
The humid plains of the Tell region contain ashes and elms while the mountain valleys exposed to fogs and oriented toward the sea support deciduous oaks (the Portuguese and Afare oaks)

The evergreen oak is the most common species in Barbary excepting Tunisia. It occurs in Morocco in the Riff and in the Middle and High Atlas, between 2000 and 9000 feet occupying a third of forested land. Its occurrence and persistence over large areas here and in Algeria is due to its adaptability, its resistance to drought and to mutilation. A gnarled and more resistant species of it is found in the mountains of Aures and Hodna and the southern slope of the High Atlas, mixed with juniper trees in the more arid parts.

The Aleppo pine resists drought and heat to a still greater extent and covers the Biban chain, the Tablat Massif, the foot of Warsenis in Algeria, occurs in the Saharan Atlas, particularly in the Aures, as well as in the Tunisian dorsale but is rare in Morocco. This is the only tree in Barbary which is still expanding its area and is often used for afforestation. The "thuya" is a conifer which is resistant to drought but succumbs to cold. Hence it is restricted to the lower heights and is found widely in Morocco, Algeria and Tunisia. The junipers (particularly the red juniper) are the hardiest species of the lot and are found at both the extremes, in the hotter and drier parts of the Saharan and High Atlas as well as
Low coniferous forest in the mountains of Eastern Algeria. The land to the left has been cleared and cultivated.
Chir pines (Pinus Longifolia) in the Murree Hills. The Younger trees have been planted by the Soil Conservation Service. Mountainous landscape is dimly seen through the trees.
at greater heights.

Agricultural potential: The principal crops which can flourish in this vegetation zone are olives and vine, especially at lower altitudes, temperate cereals - wheat, barley, oats; also maize, sorghum, tobacco and alfalfa.

The Mediterranean Scrub Forest or Temperate Brush

Occurring between the oak-conifer forest and the Mediterranean grasslands, it covers generally hilly land with a rainfall of 16" and over and a long drought period of 3 to 5 months. It is characterised by a dense growth of bushes and small trees which go under the popular name of maquis. The soils are brown with reddish sub-soils and although usually deficient in lime, are still productive of good cereal and fruit crops. This type of scrub forest covers a larger area than the forest proper, one reason for this being that this is the vegetation which replaces the climax vegetation once it has been destroyed. The trees found most often associated with these transitional associations are wild olive and lentick although where this type of vegetation becomes degraded, the jujube tree is found extensively.

Agricultural Potential: This area has been used by man for grazing domestic animals although the brush is often too thick and the grasses too insignificant for good grazing land.

Under cultivation with or without irrigation, this region has become most productive. Vine, olives and temperate fruits - citrus, apricots, pears, peaches, plums and apples: vegetables and cereals are grown with success. Other potential crops include alfalfa and tobacco.

3. Dwarf-palm - Temperate Grass

This open grassland, often thickly overgrown with dwarf palm or with shrubs, occupies the low hills, valleys and plains of Barbary with a rainfall of 12-30" and a drought period lasting from 2-6 months. The soils are brown to red in colour with a calcareous sub-soil. Most of this region is now given over to agriculture. This vegetation region usually looks bare during the rest of the year but in spring there is a luxuriant growth of herbaceous plants. The jujube tree occurs fairly extensively over the region. These grasslands have long since formed the habitat for transhumant tribes but have now largely come under the plough through irrigation or dry-farming.

Agricultural potential:

These regions are specially suitable for the production of cereals - wheat, barley, oats, rye, maize and sorghum. Commercial crops like tobacco and alfalfa can also be grown. Temperate fruits and vegetables flourish under irrigation.

4. The Steppes

This region includes most of the dry mountains and plateaux in Barbary with a rainfall of 8" to 16" and varies in
the aspect of its vegetation cover from the characteristic alfa cover of the High Plateaux to the argan forest of southwestern Morocco which is unique in the world. The alfa is a perennial grass which is remarkably resistant to drought. It grows in tufts and is useful for grazing camels, though it does not appear to please cattle. Sandy soils are occupied by a grass known as drinn which also forms excellent pasture for camels. The large salty expanses around the shotts support halophytic vegetation.

The largest area of steppes occurs in Algeria. Some of the alfa areas here represent the final stages of degradation of red juniper or Aleppo pine forests but others are true climatic communities. (1)

The argan tree covers over a million acres in Morocco and flourishes on the most inhospitable soils under conditions of extreme heat and drought in veritable communities. Apart from this, other trees are rare in the steppes, jujube being one which occurs sporadically.

*Agricultural potential:* This region is essentially grazing land which can support a thin density of domestic animals. As the grasses persist even through the drought period, it is possible to graze animals throughout the year. Agriculture is impossible without irrigation.

*Area covered by Forests:* The forests cover a total area of about 20 million

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(1) G.H.N.I.D. "Algeria" P.148
acres distributed as follows:  

<table>
<thead>
<tr>
<th>Country</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>Morocco</td>
<td>10 million</td>
</tr>
<tr>
<td>Algeria</td>
<td>7½ million</td>
</tr>
<tr>
<td>Tunisia</td>
<td>2½ million</td>
</tr>
</tbody>
</table>

In Morocco they occupy 16% of the non-desertic area. The lowest percentage of forest area is in Tunisia being 8% of the total and a much larger percentage is desirable as forests are essentially complementary to agriculture in terms of their influence on soil and water conservation. In Morocco too it has been advocated that the best advantage of the climate and hydrology of the country can be taken only if forests occupy up to 45 million acres\(^1\) (more than four and a half times their present area).

The Destruction of Forests:

The vegetational cover of Barbary has been profoundly modified by man and extensive areas have been deforested with the passage of time. Viewing the signs of destruction and reading about past luxuriance of vegetation, French writers have often expanded on what they call "the Arab's hate of trees" and attributed the present bare landscape to the "atavism" of the Arab invaders and nomads. Present opinion is, however, becoming modified towards the conclusion that the large scale clearance of forest cover through the ages was a natural development under the existing mode of life - which was predominantly pastoral. The nomad's herds of animals, his need for fuel and shelter naturally used up reserves of forests.

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\(^1\) J.P. Challot "L'Homme et La Forêt Marocaine" Revue des Eaux et Forêts. May 1946, p. 233
in a region where "vegetation does not regenerate easily"(i). Forest fires must have been frequent in a land where the long summer drought renders vegetation easily combustible.

If we pursue the history of the destruction of the forest cover, the Roman epoch must have been the first period of large-scale deforestation to construct ships, to meet exports of timber as well as the requirement of colonists and townsmen. The time of Arab invasions and the subsequent centuries saw a steady reduction of forested land through the needs of a nomadic population, extension of cultivation as well as to meet the increasing consumption by large towns. Finally, even during French rule the destruction of forests has continued at an accelerated pace. "No region of North Africa has seen its forests retreat and its natural vegetation degraded as much as the Tell Atlas in Oran where colonisation has been most successful"(ii). And indeed the figures of the extent of forests in Algeria(iii) through the ages as recently calculated leave no doubt that the recent generations should have known better than to blame their predecessors - there were about 13,600,000 acres of forests before Muslim times, 9,880,000 acres in 1830 as compared to 7,400,000 acres today.

WEST PUNJAB

Except for parts of its wetter northern fringe, West Punjab is without any extensive forests and indeed, in the plain, hardly any vestige of natural vegetation has survived.

(i) Despois Op.Cit. 86
(ii) E.C.M. "Algerie" P.368
(iii) Ibid, P.85
The vast expanses of scrub-forest which used to cover the "bar" uplands between the rivers have been cleared for irrigated cultivation. In the Potwar plateau, the destruction of natural vegetation through deforestation and over-grazing has brought on the evil of soil erosion in its severest form. In general, the low percentage of forested land has rendered it necessary for peasants to burn dung as fuel rather than to utilize it as the valuable manure that it is. Thus of vegetation destroys the soil in some regions, deprives it of much-needed organic fertilizers in others.

The following forest types may be distinguished in West Punjab in relation to rainfall and other natural conditions:—

1. Himalayan Moist Temperate Forest
2. Himalayan Sub-Tropical Pine Forest
3. Sub-Tropical Dry Evergreen Forest
4. The Tropical Dry Deciduous Forest
5. The Semi-Arid Thorn Forest

Of these the first four are confined to the comparatively rainier and hilly northern mountains and sub-montane zone, including the Potwar Plateau while the plain has a single type of vegetation conforming to the monotony of the environment. (1)

1. Himalayan Moist Temperate Forest
   and 2. Himalayan Sub-Tropical Pine Forest

These types occur in the limited segment of the

(1) This study of forest types is based largely on H.G. Champiön Op.Cit.
Himalayan Chain known as the Murree Hills. Their distribution is a matter of altitude and rainfall. The moist temperate forest occurs above 5000 feet in a zone where rainfall exceeds 50" and consists predominantly of a tall coniferous forest with a rich evergreen undergrowth, mostly oaks. The forest is practically impassable due to the growth of luxurious herbaceous vegetation during the summer which provides good grazing. Podzolic soils occur in this zone. Pines and deodars are the principal species.

The Sub-tropical Pine Forest is an almost pure association of pine (generally pinus longifolia) occurring between 3000 and 6000 feet in a zone receiving a rainfall in excess of 35". There is practically no underwood and shrubs too are few, except when moisture conditions are favourable. A grassy cover is usual and provides a fairly good pastureland.

From the agricultural point of view, rich crops of maize, wheat and even hill rice at lower slopes can be obtained with terracing. Temperate fruits flourish very well.

3. Sub-Tropical Dry Evergreen Forest

This is low forest of small-leaved evergreen trees and shrubs including thorny species, the latter becoming prevalent with drier conditions. This type of forest is usually associated with a rainfall of over 20" with some winter incidence of precipitation. During the monsoon there is a development of herbs and grass. This type of vegetation
occurs in the more elevated parts of the Potwar Plateau and on the Salt Range and bears a "fairly marked resemblance to the dry evergreen types of the Mediterranean". (1)

The principal species are olive and phulai (acacia modesta) This vegetation zone has been largely deforested with consequent denudation of the soil.

4. Northern Tropical Dry Deciduous Forest

This type does not occur anywhere in the West Punjab as a continuous canopy as it has largely been cleared for cultivation. It now occurs in patches as riverain "shosham" forests or scrub and consists of deciduous tress with a thin shrubby undergrowth including some evergreen xerophytic species. The region of its occurrence has a rainfall of 30" or more and the contrast between the bare, leafless trees in the dry summer and the luxurious growth during the monsoon is a striking feature. The principal botanic species are Acacia catechu and Shorea robusta. This zone provides some of the finest agricultural lands of the province.

5. The Semi-Arid Thorn Forest

Occurring in the zone receiving 10" to 30" of rain, this is an open low forest in which thorny hardwood predominate, acacia being particularly characteristic. There is a thorny bushy undergrowth while climbers are numerous, all displaying xerophytic adaptations. There is a thin grass growth which

(i) Ibid P.211
may be considerable in inundated tracts. The forest covers the larger part of the West Punjab plain and the lower hills of the Salt range.

The type prevalent in the arid tract in the south-west and in the Thal may be called the desert thorn forest with a still more widely spaced tree cover. The principal tree-types found in those two thorn-forest zones are Jand (Prosopis spiligera), Wan (Salvadore Oleoides), Okan (Tamarix Articulata) and Karai (Capparis aphylla).

It is in these zones that irrigated forest plantations have been set up, the best known being those of Chhanga Manga and Chirchawatni. Their object is to satisfy the fuel requirements of the population.

Extent of Forests:

Nominally, the area classified as forests covers over 1,150,000 acres in West Punjab but the majority of the "forest reserves" in the plains are nothing more than wasteland covered with stunted trees and bushes or merely coarse grasses. The best-preserved forests occur in the north-western hilly tracts and in the government plantations. The destruction of the West Punjab forests is a sad story inscribed in the countless bleak gullies and ravines in the Potwar region as well as elsewhere and will be treated in detail on the chapter on Erosion.
Chapter 6

THE CORRELATION OF PHYSICAL FACTORS

The several physical factors considered so far may now be integrated and some conclusions may be drawn in relation to cultivation. The most fundamental relationship is the one between aridity on one hand and natural vegetation and agriculture on the other. The aridity line of 5 in both regions approximates to the limit of desert vegetation - desert shrub in Barbary and desert thorn forest in West Punjab. Making an allowance for areas with high coastal humidity, the distribution of dwarf palm - temperate grass in Barbary agrees with the limits of the indices of 10 and 20. Wherever the index of aridity exceeds 20, temperate brush predominates. The productive capacity of these various zones of vegetation was indicated earlier. In West Punjab too, the distribution of vegetation zones approximates closely to the various indices of aridity. Thus Himalayan coniferous forests occur where the index exceeds 30, while the dry deciduous forest is confined to the sub-montane tract where the index of aridity is more than 20. The Potwar Plateau has its own Mediterranean type of vegetation. The gradations in the vegetation zones of the two regions thus agree closely with the degree of aridity. The relationship between the soil, vegetation and climate was pointed out before.

Index of Aridity and Variability of Rainfall:- In both Barbary and West Punjab, the average variability of rainfall increases with aridity. Thus in Algeria, the percentage variability is below 15 wherever the index of aridity exceeds 30. In the west, over the Shelif valley, where the index is below 15, variability increases to over 25%. The intermediate figures and the figures
The Natural Zones of Barbary

Limits of Crops in Barbary

(Afro乾隆 d'AFRIQUE du Nord, 1844)
for the drier parts show the same relationship as a comparison of the Maps of Index of Aridity and Variability of Rainfall show. Except for Rawalpindi district, variability in West Punjab increases towards the south-west exceeding 40% where the index of aridity is round about 5.

**Critical Limits**

With its comparative uniformity of physical conditions, West Punjab does not have many critical limits to the extent of cultivation. The most serious limitation, that of moisture has been largely offset by the development of irrigation. The only uncultivable parts of the province now are:

(a) Regions beyond the reach of irrigation - parts of the Thal and Derajat tracts, the Salt Range.
(b) Eroded, water-logged or saline lands whose distribution is dependent on human factors as much as on natural ones.

**Barbary** on the other hand presents a greater variety of conditions and critical limits based essentially on climate may be applied.

(i) Despois has demonstrated how topographic, climatic, vegetal and even hydrographic features in the region change at the frontier between the Tell zone and the Steppes, a factor reflected in the distribution of cereals and the limits of olives and the date-palm, the last marking the passage to the Sahara. The choice of these old-established crops is significant because they conform much more to the habitat than other crops developed by European colonists. The following generalisations may be made on the basis of these limits:

1. The isohyet of 16" marks the passage from the Tell to the

(i) Op. Cit. p.97 - 110
steppes and also coincides in Algeria and Tunisia to the Northern limit of inland drainage and of alfalfa grass. It also forms the limit of the profitable cultivation of cereals in these territories. The only exceptions to the latter rule are the lower plains of western Algeria and the plateau of Sebesou. Here cereals do not give good yields without irrigation or dry farming. The lower precipitation of the southern part of the Atlantic plains in Morocco is offset by high humidity as already explained under Climate and the zone of profitable cereal cultivation is extended to the isohyet of 12".

2. The isohyet of 8" follows very closely the southern edge of the Saharan Atlas and also agrees with the northern limit of the date-palm as well as the southern limit of the olive in Tunisia.

3. The principal areas irrigated in the traditional manner lie in the semi-arid zone receiving a rainfall between 8" and 16". A map of land available for cultivation in Barbary has been drawn, based largely on physical factors.

(1) The date-palm plantation around Marrakesh is an exception but it was created artificially with the help of khettaras. The quality of the dates is indifferent.
To understand the present it is necessary to make a historical survey of foreign cultural influences. Since prehistoric times the human element in our two regions has been greatly modified by successive migrations and occupation from outside so that the present-day rural life reflects the extent to which these invaders modified the existing civilization.

The primary objective of this account is to trace the origins of current agricultural practices and systems of farming. Allied to that and, indeed, inseparable from all practical aspects of life is the mental make-up of the people or their cultural outlook and ideals as determined by the same influences. This is essentially a geographical concept - to trace back the influence of other environments as transported by the conquering peoples.

**BARBARY**

Belonging to the Mediterranean Basin in which developed some of the earliest and greatest civilizations of the world, Barbary itself has made no outstanding contribution to the progress of culture. It has always depended upon foreign stimuli to keep pace with world developments and even these foreign colonists and empire builders have in the course of time succumbed to the "vast inertia" of the region and fallen back to its own primitive ways. Great cultures - Phoenician,

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Greek, Roman - have lighted their torch in its dark and dreary wilderness, shone resplendently for a time and then flickered out leaving very often nothing more than a few imposing ruins. Only the Arab, or strictly speaking the Islamic influence, penetrated the thick hide of Barbary's passivity and continues to this day as the leading light of the region.

It is difficult to explain this local genius in terms of geographical determinism. Greece or Rome, which rose to such heights of culture, had the same rugged relief and difficulty of communications even though their climate was not so arid. Perhaps the proximity of the Sahara close behind the well-watered coastal lands had something to do with this fact but again Arabia with a similar environment produced a dynamic culture which has left a lasting imprint on mankind. We can only regard Barbary's barrenness in human achievement as one of those numerous facts of history which remain at present unexplained.

The pre-historic epoch can be briefly passed over. The most significant period was the Neolithic when a white people, probably a branch of the Mediterranean race occupied the region at the expense of its black negroid inhabitants. (1) This period was marked by the domestication of animals and the cultivation of cereals on a small scale.

The Phoenician occupation of Barbary was the first historical event of which a record exists and lasted approximately from 1200 B.C. to the 2nd century before Christ. The city of

Carthage near the present site of Tunis was the most famous settlement of this epoch. A large part of north-eastern Tunisia was cultivated and irrigation by canals practised. But the Phoenicians, being essentially maritime traders, did not penetrate deeply into the country. The planting of vines and olives grew considerably and some vassal and allied chiefs developed the cultivation of cereals in the interior. The High Plains of Constantine, for example, became a cereal growing region of great importance.

The Romans who followed the Phoenicians after the Punic Wars did not reach their greatest expansion till the first century A.D. and remained in occupation up till the Vandal incursion in early 5th century. It was under them that Barbary acquired its reputation as an agricultural region of importance and came to be known as the granary of Rome. Effective occupation by the Romans was limited to the Tell Atlas although in the eastern section the two provinces of Africa Proconsular and Numidia extended right up to the Sahara. In these latter regions, impressive remains of large and well-planned cities are encountered. Ruins of oil presses and irrigation works occur in regions which are now barren steppes. We make as an example the numerous ancient reservoirs around Tebessa some of which have been cleared of the debris accumulated in centuries and brought into active use again. Sbeitla in southern Tunisia is yet another instance where occur ingenious constructions of stone walls which served the
dual purpose of conserving soil and water. These signs of ancient prosperity led to the widespread assumption that the arid southern steppes of Tunisia and Algeria once had a better climate. This idea has been refuted by most climatologists, however, and the only conclusion we can draw is that irrigation and dry farming reached a high state of perfection during Roman times. These great works of irrigation as well as the advanced agricultural practices did not survive the Vandal onslaughts and Barbary sank back into its primitive ways.

The Arab conquest during the 7th and 8th centuries opened up another epoch of great cultural advance, for these invaders brought with them not only a new faith but also a host of new ideas collected from their rapidly increasing empire. Irrigation practices prevalent in Persia (khettaras - see chapter on Irrigation), Egypt and Mesopotamia were introduced. New crops brought from the East included rice, sugar cane, cotton, oranges, apricot, indigo, henna, saffron, most of them grown with irrigation. Oasis-cultivation and date palm plantations were extended. This was also the epoch when many large cities were founded, later to become the main bulwarks of culture and also to wield a considerable influence on the nature of cultivation and land-utilisation through the

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(ii) Notably Fes, Tlemcen, Kairwan
great demand for garden and vegetable crops. The later invasion by large nomadic Arab tribes, notably the Beni Hilal and Beni Solaym provided a set-back to agriculture and a large part of the Algerian High Plains became a land devoted to pastoral nomadism. The harmful effects of these invasions on agriculture have been over-emphasised for many of the descendants of the Beni Hilal later took to sedentary cultivation notably in Morocco. The Islamic influence penetrated deep into the life of the local inhabitants and Arabic became the leading language. The Arab invaders were different from previous ones in that they were not merely concerned with conquering and exploiting new lands, but came with a missionary spirit, offering equality and brotherhood to all. Hence their culture became the culture of most of the inhabitants of Barbary.

The introduction of Islamic property laws was a significant development, one which has had a far-reaching influence on agriculture up till today. Particularly to be mentioned are the habous lands, dedicated to a religious purpose. The Islamic property regime is discussed in the following chapter.

Later developments during the Islamic epoch included the arrival of a large number of Muslims from Spain where their domination was coming to an end. As they had perfected the art of irrigated cultivation of fruit crops in Spain, they had a significant contribution to make to the make up of the
rural population. They brought with them many of the crops grown in the New World, chief among them being maize, tobacco, tomatoes, pumpkins and many types of beans. Their descendants known as the "Andalous", are considered to be the best market-gardeners and cultivators in Barbary.

At the beginning of the 16th century, a large part of Barbary became incorporated in the Turkish Empire. The epoch is not a memorable one except for the harshness of taxation on the land, rendered far worse by the practice of "farming" the revenue through extortionist agents. Lack of security over a major part of the country resulted in the extension of nomadism. The struggles between neighbouring chiefs and tribes always had the effect of impoverishing the countryside, the more mobile nomadic groups establishing their overlordship over the sedentary cultivators.

This was the state of affairs when the French conquered Algeria in 1830. The most notable development during their domination has been the development of European colonisation. A large part of the fertile regions of Barbary has gradually been acquired through official or private enterprise. Marshes have been cleared notably those in the Mitija and Bone regions and cultivation extended over formerly untilled land, but the major part of the lands now owned by Europeans were formerly occupied by the Muslim peasants (fellahs). The state has backed and financed the colonists with all its resources so that today
mechanised cultivation has reached as high a standard as anywhere else in the world. Modern scientific research has improved crop varieties. Production has gone up on the whole but its distribution among the population is most unequal, the colonists sharing most of the newly developed prosperity. Cultivation of cash crops like vine, citrus fruits and early vegetables has been greatly extended to meet the requirements of France and other world markets. Among the livestock, pigs have begun to figure. There has been a great development of irrigation works and transport services.

The modern techniques used by the colonists have not been copies except by a limited number of large Muslim landlords. The French Government followed a policy of building up the prestige and power of local notables to support their policies. This has further reduced the independent status of the petty fellah. The effects of French colonisation will be further considered in the following chapter as also their modification of Property laws.

The development of transport and commerce has brought about the linking up of Barbary with the world's agricultural economy so that it is no longer a self-contained subsistence unit but adjusts its production to world trends. The French administration has thus introduced into Barbary most of the technological developments of the western world. But their culture has failed to penetrate deeply into the life of a thoroughly Islamised people. Indeed as a French writer has
observed "For all the influence of Europe to which Algeria and Tunisia have been exposed, it would be wrong to imagine that the powers of Islam have considerably weakened in French North Africa"(1)

Our insistence on the lasting influence of Islam would not be relevant unless it had a direct bearing on the agriculture of the region. Islam engenders among its followers an attitude to life that has puzzled Europeans who look upon it as fatalism, hindering, in their opinion, all enterprise or progress. But the attitude of the Muslim is not based on fatalism, rather on fortitude in the face of a capricious climate. That he is not averse to progress will be noticed in a later chapter. The main results of the peasant's being steeped in religion are:

(a) He refuses to cultivate certain crops that are forbidden. Vines were not grown except on a very small scale for eating purposes because wine-drinking is not allowed. Thus the present strides in vine-cultivation would not have been possible but for the Europeans. He would also have nothing to do with keeping pigs.

(b) His attitude to advanced techniques continues to be that of suspicion and even hostility as they have been brought by a conquering race. The Barbary Muslim is proud of his traditions and much of his conservatism is caused by his antipathy to the superior attitude of French administrators and colonists.

Summing up, we may quote the opinion of an enlightened Muslim landowner of Morocco on the nature of foreign cultural influences "It is necessary to enquire as to why all traces of Latin culture disappeared entirely in these regions while the Arab culture has survived and even prospered. The answer to this question is very simple - Rome interested herself in North Africa itself, in its plains, its fertility and its richness without concerning itself with the inhabitants, whereas Mecca appealed directly to the man and his heart" (1) The dynamic spirit of Islam has not survived the centuries though its cultural influence is a basic human factor to be considered with relation to all social and economic activity. This persistence of the Islamic manner of life (though, unhappily, not its spirit of enterprise) prove that unless a foreign power applies its energies to the betterment of the peoples its influence cannot endure for the land soon returns to its natural state once they quit and men continue as before. The present effects of French domination are closely comparable to those of Roman occupation. Land has been colonised, irrigation works developed and transport and communications developed, but, on the social plane, the only opportunity offered to the Muslim inhabitants is to quit their own culture and laws and become French citizens. This they will never do and so it would appear that unless there is a radical change in the French attitude, their influence on

the civilization of Barbary will not prove to be enduring.

WEST PUNJAB

The historical record of the province goes back beyond 2000 B.C. when the Indus Valley civilization flourished, and has left its remains at Harappa, near Montgomery. Since then its peculiar position at the very gateway of the fertile Indian sub-continent made it a battleground on which wave after wave of invaders contended for the riches of the vast land-mass. The remarkable fact is - and here lies the close parallel to Barbary - that although Islam did not appear on the scene till after 700 A.D., its influence alone has proved to be enduring and has ultimately prevailed. The region was introduced to western science and technology and brought into line with the rest of the world by a western power - in this case Great Britain.

The cultivation of cereals was carried on during the days of the Indus Valley civilization and possibly even earlier. The Aryans invaded the country sometimes between 1000 and 500 B.C. and this province was the first to be occupied. The Aryans established a patriarchal system and carried on sedentary cultivation with cereals as the principal crops. The later introduction of the caste-system with its consequent division of society into four classes - priestly, martial, agricultural and trading, and lastly menial - had an influence on the social and economic edifice that is still noticeable today. On one hand it resulted in the development of hereditary skill but on the other
it rendered society inelastic, hindered progress by erecting artificial barriers between men and restricting them to only one occupation. Later vitiation of the caste-system had its repercussions on rural life principally by relegating the actual tillers of the soil to a low social position and developing a large idle aristocracy. A salutary development was the growth of the village into a self-contained unit, governed by the elected group of elders or the panchayat.

We should remember, however, that the cradle of the Aryan civilization lay to the east in the Ganges valley wherein all the institutions associated with the Hindu civilization reached their greatest development. West Punjab lay on the outskirts of the sub-continent and bore the full brunt of a ceaseless stream of invaders— from the 5th century B.C. nomad races from central Asia descended on the province through the north-western passes and settled down in sufficient numbers to occupy large areas. Prominent among them were Scythians (from whom present day Gakhars are descended), Parthians, Kushans, Huns etc. These conquering groups retained their tribal organisation and were hardly affected by Brahmanical Hinduism. Later on, most of their descendants accepted Islam and became its hard core, finding its militant spirit and its simple ritual much to their liking. Most of the great West Punjab tribes of today are descended from these groups and so are the major agricultural classes. Those of these tribes who retained.

(1) H.K. Trevaskis "The Land of Five Rivers" P.76
their pastoral habits longest and, for a long time, continued to graze their cattle in the jungle prairies of the inter-riverain lands acquired or retained the name of Gujars. But the great mass of the tribes who took more readily to agriculture were called Jats (1) The latter became par excellence the peasant of the Punjab and have continued to be the finest cultivators of the province till today.

The first Islamic invasion of the region followed the Arab conquest of Sind early in the 8th century A.D. and an Arab state flourished in Multan for several generations. At the beginning of the 11th century began the Muslim invasions from the north-west which soon resulted in the establishment of Islamic dominion over the province. West Punjab was thus the first region on the Indian sub-continent to be Islamised. There were contacts between the new invaders and the Hindus but never any fusion. Islam was too individualistic, too militant, too well-defined a creed to be absorbed in a philosophy that had hitherto succeeded in incorporating most conquerers into its fold. Subsistance cultivation continued at the same level during the rule of succeeding Muslim dynasties. Cotton was widely grown. Irrigation must have developed early in West Punjab though no records are available. It was a Mughal governor who constructed the Hasli canal from the Ravi River to irrigate the Shalimar Gardens near Lahore - the canal which was the origin of the Upper Bari Doab Canal. A significant irrigation development was the introduction of the Persian

(1) Ibid
wheel. The legacy of Islam cannot be defined in terms of countable items alone. The whole outlook and life of the people was transformed by this creed to such an extent that recently Punjab became the nerve-centre of the Pakistan movement which has resulted in the establishment of a separate Islamic state. Even agriculturally, because of the extensive trade relations of the sub-continent under Muslim emperors, many new varieties of crops must have been imported of which no exact record is yet available. As for the human side of agriculture the village continued to function as a self-contained unit. Land was cultivated by small holders, large capital farmers being absent. The practice of "farming" the revenues which often prevailed discouraged agriculture. The administration of rural areas was in general confined to maintaining peace and collecting land revenue.

The decay of Islamic power during the 18th and 19th centuries resulted in a period of Sikh domination, quite unremarkable in its lasting effects on the agricultural and general life of the area. The British conquest of the province in 1856, however, set into motion those great developments in irrigation, transport and administration which have transformed the rural landscape. Although the introduction of these modern techniques was inevitable at some stage, their growth took place under specially favourable circumstances and was accomplished with remarkable speed and smoothness. The development of internal transport and external trade brought about the growth into importance of commercial crops like cotton, sugar-cane etc.
The total area under crops was extended greatly through irrigation. The organisation of agricultural research, the development of new varieties of crops had the effect of raising yields and total production.

On the human side the control of diseases and of famines both resulted in a great increase in population, further stimulated by the prosperity brought by the canals. Despite the great extension of cultivated area, this has ultimately had the effect of increasing pressure on the land. British policy which encouraged the growth of landlords "set into motion processes which were neither intended nor foreseen" (i)

It weakened the autonomous village unit. The landlords became mere rent receivers playing a small part in the agricultural partnership. Furthermore their tendency to move to the towns has resulted in the drain of rural wealth to urban areas.

The development of large-scale industries has had the effect of depriving the village communities of the income they received from cottage industries, thus increasing the pressure on the soil. The total effect of these tendencies has been that "the greater output has to be divided amongst greater numbers and has probably been accompanied by greater inequality of distribution" (ii)

Despite the growth of communications and trade and the development of landlordism "the village, placed in its ancient organic, social setting, is definitely holding its own" (iii)

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(i) L.S.S. O'Malley "Modern India and the West" London 1941 P.234
(ii) Ibid P.290
(iii) Radhakamal Mukerjee "Economic Problems of Modern India" Vol. 1 P.103
The strong tribal affiliations still prevalent in many parts of the province have maintained its status as a self-contained agricultural community. Even large scale settlement in the newly irrigated canal colonies had to be based on village or tribal groups unified by strong ancestral ties.

Since the coming of Independence in 1947 and the establishment of a government that is bound to be guided largely by Islamic ideals, great changes have taken place. The mass movement of population on partition has made the former Muslim majority of about 70% into an exclusive element there being only a few thousand Hindus left. This has reduced considerably the extent of the Hindu element in the present social and economic make-up. The arrival of millions of destitute refugees from East Punjab has necessitated the breaking up of many large estates formerly owned by Hindu and Sikh landlords into small allotments. The government has recently announced its intention of nationalising the land with the object of abolishing landlordism altogether though it is doubtful whether this shall be achieved very soon. A vast programme of rural uplift and development is taking shape which, if put into effect, should greatly improve the lot of the peasant. The exclusively Muslim population is increasing very fast however, and no rural planning can ultimately be effective unless this tendency is checked through educating the masses.

In conclusion it is noticeable how the population, its outlook and its ideals have been dominated by Islam. Most present-day planning, even if influenced by western or Soviet
practices, claims to be Islamic in inspiration and it is certainly true that no projects can succeed among a heterogeneous people consisting of so many tribal and racial elements unless they appeal to their strongest and deepest loyalty - the one to religion. The western influence has been mainly technological and administrative and has little disturbed the main currents of rural life or the methods of cultivation.
Chapter 8

THE REGIME OF LANDED PROPERTY, TENURES AND HOLDINGS

After the brief survey of historical influences which have determined the present day farming methods and crops, we may proceed to enquire into the regime of the ownership of land, the prevailing systems of tenures and the size and distribution of holdings. The importance of these aspects of man's relationship to land can hardly be over-emphasised because they integrate on one hand the physical social and historical factors behind the land and on the other exert a far-reaching influence on the amount of human initiative and energy expended on its cultivation.

That ownership of land and the tenancy systems respond to the environment will be noticed subsequently both in Barbary and West Punjab. They are related more directly, however, to the social judicial organisation of the rural population. In this the influence of Islam needs to be considered specially. The history of French modification of property laws in Barbary has been one of continuous conflict with a system which they found to their bewilderment and annoyance to be rooted in religion itself so that interference on their part struck at the very root of the entire social and economic organisation of the population, based as it was, essentially on the Koran. This history will be surveyed in brief at a later stage in this chapter. In West Punjab, the role of Islam as a factor in determining man's relation with land has been equally powerful though several
existing features date back to the pre-Islamic days. The influence of religion in governing the size of individual holdings is even more powerful and is at the root of one of the greatest problems of agriculture in both regions—the problem of the small-holding.

It is proposed in the following account to consider the regime of landownership, land-tenures and agricultural holdings of our two regions side by side, to draw comparisons and contrast between them in relation to the geographical environment and to consider the influence of these socio-economic factors on crop production. The history of French modification of the property regime in Barbary comes in for some discussion as under the influence of a number of conflicting colonial policies, this interference produced a dual regime—one traditional and Islamic, the other western and French. Such an historical survey of the land regime in West Punjab is hardly called for as the British administrators did not affect any considerable changes in the existing regime but only perfected and clarified it.

THE REGIME OF OWNERSHIP OF LAND

An element of collectivity dating back to the days when tribal organisation was still a dominating force persists in Barbary and West Punjab, much more in the former as the change to individual ownership is not complete. For this the importance of pastoral pursuits on the modes of life is
greatly responsible as will be noticed in a later chapter. Collectivity has survived in West Punjab chiefly in the shape of common pastures in villages known as shamilat. This is further indicative of the role of pastoralism in maintaining a collective property regime. Individual ownership is associated with sedentary cultivation, more especially with irrigation. The influence of Islam has been to emphasise the distinction between private ownership and the common (unproductive) lands. The one special institution introduced during the Islamic epoch was "habous" or "waqf" by which landed or other property could be willed to some charitable body in perpetuity. The area of such lands is much greater in Barbary than in West Punjab, less due to a greater devotion to charity than to an anxiety to safeguard property under conditions of greater insecurity and chronic internal chaos than subsisted in West Punjab. The latter land has by no means been peaceful and it is probable that historical or social factors unknown to the present writer have been responsible for the comparatively minor importance of habous or waqf lands in this region.

The last category in Barbary, for which West Punjab does not have an exact counterpart is state or Makhzen lands. The Crown Waste Lands of West Punjab correspond to the undeveloped and, at present, unproductive part of the Makhzen lands and have been used for irrigated settlement with the
extension of the Qanal system. They have also been utilised to reward military and civil service to the state of the yeoman grants in the Canal Colonies. The Makhzen lands of Barbary are however more than this. Parts of them constitute the private domains of the Sultan of Morocco and the Bey of Tunis and these figureheads are peculiar to Barbary.

Despite the differences in relative importance of the types of landed property, differences that are in the case of collective lands indicative of the greater degree of aridity and the predominance of mountainous relief in Barbary, the similarity in the fundamental features is striking. This is a parallel that is specially significant for this study as it brings out the thesis that in spite of their great distance from each other and contrasted relief, similarities in the degree of aridity and a comparable cultural background lead to similar features of land-use and give rise to agricultural problems that are basically identical.

BARBARY

We may now proceed to study the traditional modes of landownership as they exist today in their modified form, followed by an historical account of the modifications introduced by the French.

The following types of ownership go back to the

(1) See account of settlement of the Canal Colonies under Irrigation.
pre-French times:

1. **The "Melk" lands** are those that are owned individually under Islamic law or "Sharia" and are under the jurisdiction of Islamic courts. A peculiar feature about this type in Barbary is that whereas Islamic law upholds the division of property in equal shares among the offspring of a family, "melk" lands have remained indivisible, possibly under the influence of custom. The effect on agriculture is disastrous because on one hand the individual portions of the collective holding become progressively smaller and on the other there is no inducement to apply initiative and energy. The acquisition of additional land by a more efficient landholder is often out of the question as no sales are possible without the consent of the entire family. Cases are not rare where as many as ten families may be depending upon the holding which two generations earlier was supporting only one. A large proportion of lands in the fertile parts of Barbary is included under this category and they will perhaps continue to exist as Islamic law on which they are based is sacrosanct in the eyes of people. The French administration has recognised in essence the validity of this system but have introduced certain features to render it more precise. In Morocco for example, the individual property is confirmed after the proprietor has submitted a statement known
as "Istimrar-el-melk" setting out his title to the lands in question.

2. **Collective lands**, referred to in local parlance as "arsh" lands are those to which groups like tribes, clans or "dwars" (villages or hamlets) have a collective right. They may be cultivated lands or rough pastures and their boundaries are not demarcated as clearly as those of melk lands being very often small local streams or other natural features like crests etc. They are managed by the representatives (Jemaa) of the group which owns them and are supervised by the government. French colonisation has made deep inroads into this type of collective property because very often there was no written title, only a sort of "gentleman's agreement" between neighbouring tribes. Extensive acquisitions have been made and covered by adequate safeguards to render them secure which in most cases have taken the shape of their being registered under French law. Provision has also been made in Morocco for collective lands being rented out for periods of ten years or in perpetuity at the payment of an annual rent.

3. **Makhzen Lands**: They exist under this head mainly in Morocco and Tunisia and include all properties which were deemed to belong to the state before the establishment of the

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(i) J. Rey, "La Propriété Immobilière", "E.O.M. Maroc"  
(ii) Ibid, p.217
Protectorate. The state lands in Algeria (beyliks) were abolished immediately after the establishment of French suzerainty in 1830 along with the habous lands. These lands in the Protectorates include the "dead"(i) or waste lands, the lands acquired by the rulers, the properties falling to the state for the lack of heirs and finally lands confiscated from rebelling subjects or tribes. The rulers considered these lands to be his own personal property and made grants to those who deserved well of him. These grants were of two types in Morocco. One came to an end with the death of the incumbent ("Intifaa") while the other ("Iqta'a") could be transmitted to one's descendants. The latter was the origin of numerous large "melk" holdings to be found today in Morocco.

The Sultans of Morocco also used to allot "guich" lands to certain warlike tribes like the Wdaia, Sherarda etc. collectively in return for military service. These tribes then divided such lands equally among families. Jean Celerier has made a study of the changed régime of property-holding and the progress towards individual ownership due to colonisation in one of these tribes, the Sherarda(iii) which we shall study later on when we treat recent developments.

(i) French jurists point out that "dead" lands are those under Islamic law which are unproductive and they become the property of anyone who brings them under the plough.

The French administration has, since its foundation, regulated the affairs of these lands so that the private property of the State has been separated from the public property and the latter organised under the Public Works Department (Administration des Travaux Publics).

Extensive State lands that existed in Tunisia before the establishment of the Protectorate have been similarly divided into the private and public categories. Here as well as in Morocco the right of the enterprising cultivator to own the "dead" land he brings under the plough has been upheld.

4. Habous Lands: "Habous" or "wakf" is an act in Islamic law by which the owner of a property wills it in perpetuity either to a pious or charitable foundation ("habous khairi") or to a family or group of persons ("habous adi or ahili"). It is the perpetual and inalienable nature of this type of lands supported by a strong religious sentiment which is their special feature, a feature which tempted so many persons to put their lands into this category to save them from the unstable political régime as well as from the prodigality of their descendants.

The twofold division of the habous does not affect their judicial position or the validity of the bequest; the distinction is only in manner of their administration. (i)

(i) Mohammad Saadallah "Les Habous". E.C.M. "Tunisie" P.204.
There is only a slight difference in their management in Morocco and Tunisia, the two countries where they exist today. The public habous are looked after in Tunisia by a Director of the Administration of the Habous helped by a Council of Administration consisting of five Muslim notables. The various acts of this administration are subject to the control of the Supreme Council presided over by a Minister of the Bey. Individual habous are supervised by local bodies known as Jemâa. In Morocco the care of public habous is entrusted to Nadirs or failing that, they are managed by the local Qadi, both being ultimately under the administration of the Sultan. The extensive properties of the public habous which consist of olive orchards, cultivable lands etc. are let out to tenants under the prevailing systems of tenures as also some special ones we shall note later on.

The private habous are looked after in Tunisia by a makaddam named by the founder or otherwise by the Qadi. In Morocco they are managed by the beneficiaries themselves under the surveillance of the Qadi.

The exact area of the Habous lands cannot be calculated as statistics are imperfect and also take into account the buildings, shops etc. similarly dedicated. That their extent is considerable may be gauged by the large size of the habous administrations (over 450 officers and subordinates in Tunisia alone.) In Algeria, where the public habous
were abolished by the French immediately after their conquest, "half of the melk lands were habous" at that time. The private habous were later declared alienable and have been reduced to negligible proportions.

Various safeguards exist today in Tunisia and Morocco to protect these properties which cannot be sold or exchanged unless they are replaced by a property of equal or higher value. The habous lands serve a useful purpose in that they help to maintain many social services and charitable institutions, schools, orphanages etc. They are usually cultivated in the manner typical of the the districts in which they are situated, although some collective habous are largely under olives, i.e. in Northern Tunisia.

One great advantage of their legal position has not been exploited fully - the fact that they can be used for experimentation with new crops and techniques which would be more difficult to achieve with individual proprietors. There are sporadic instances of their being managed in conformity with modern agricultural trends. In Tunisia, for instance, over 1400 acres of habous lands were planted with citrous fruits in 1940 in the Cap Bon Region, an area in which fruit-growing is proving to be the most remunerative mode of cultivation.

(ii) Mohammad Saadallah, Op-Cit. P.206.
The history of French land policy in Barbary commences with the disastrous handling of the traditional regime in Algeria, first to be conquered. Experience that was gained here through trial and error and with consequences wholly tragic for the local population, later benefited the two neighbouring territories where the established system received a more sympathetic and imaginative handling. While the contradictions and changes of French colonial theory have much to do with the development of a land policy, it has been the drive for settling European colonists in Barbary which has always dominated its main trends. Algeria was conquered and colonized during a phase when the idea of establishing a new France overseas had become a governing principle.\(^{(i)}\) By the time Tunisia and Morocco were incorporated into the French Empire a colonial philosophy based on "colonies d'exploitation" rather than "colonies de peuplement" had emerged so that these territories which were made into Protectorates retained their traditional regime largely unchanged.

THE LAND POLICY IN ALGERIA

Right from 1830, the conflict between the interests of the settlers and the Arabo-Berber population presented the administration with its greatest problems in Algeria. The colonists wanted land with security of possession before they embarked on any work on its cultivation. On the other hand, the native population clung tenaciously to its land whose overweening importance among a primitive society was increased by the sacrosanct dictates of religion (1) which determined the regime of ownership. The root of the difficulty lay in the fact that most of the land was owned collectively by tribes. The administration sought to apply French ideas of individual ownership and legal transfers to the country and in doing so played havoc with the traditional system as well as all those whose lives depended upon it.

The Beginnings:— In 1830, on the eve of conquest, all habous and state lands (beyliks) were expropriated. Apart from this step which caused great resentment among the local population, the government did not feel the necessity of bringing about any modification in the property regime.

(1) Ibid p.196.
Inaction was confined to ensuring security of tenure for the colonists. Thus the Ordinance of 1844 confined itself to regulating the expropriation of land and validating the sale of habous land. The law of 1846 recognised the "anarchical state of rural property" and laid down that unless claims to ownership of land in areas earmarked for colonization were forthcoming within a certain period, all land would be deemed vacant and available for colonization. The law of 1851 guaranteed the right of property to all private owners whether Europeans or natives. It also warned off capitalists from lands not open for colonization. This was a recognition of the difficulties inherent in dealing with tribally held lands.

The policy of "Cantonnement" (restricting tribes to limited areas) 1851 - 1853: About this time the increasing influx of colonists led to new measures for acquiring land from the native population. There were three types of landed property then existing in the country:

1. **Makhzen** - state lands which had been granted to tribes by the Turkish rulers in return for military service.
2. **Arift** or tribal communal lands.
3. **Melk**.

The first category was expropriated on the ground

(1) V. Piquet "La Colonisation Francaise dans l'Afrique du Nord" P.150
that it had never ceased to be the domain of the state. The second one was encroached upon because "it was maintained that according to the Koran, such land in Muslim countries belongs entirely to the sovereign and the individual has only the right of occupancy." (i) The policy of restricting tribes to areas necessary for their sustenance and making the rest available for colonization was therefore instituted. This was essentially humane in its application and left the tribes with enough land to carry on their activity without undue difficulty. Thus between 1857 and 1863, the territory of 16 tribes covering 343,000 hectares was divided and of this they retained 282,000 hectares. They were stripped, however, of their best lands.

"The Arab Kingdom episode": With the accession to power of Emperor Napoleon III, a phase of marked liberalism set in. In a celebrated letter to the Governor General of Algeria in 1863 he declared that he wanted to convince the Arabs of the civilizing mission of Europeans by stopping all exploitation and by granting them the right of possession to the land they occupied. The collective lands were, however, to be delimited and partitioned into dwars or villages. Thus between 1863 and 1870 376 tribes had 7 million hectares of land divided into 676 dwars. (iii) This was envisaged to be a step prior to the introduction of the regime of individual

(i) Ibid p.162.
(ii) Ibid p.164.
property. The measure was later criticised because it was argued that the law thus wished to consolidate the very regime of collective property it set out to destroy.

The Policy of Assimilation: With the advent of the Third Republic, the notion of applying French institutions in the colonies became the governing policy and in 1873, a law was passed which abruptly stated that the French ideas of landownership had to apply in Algeria. Any man in a tribe could apply for his share of the tribal land and the property of the entire tribe would be divided up. Communal land-ownership was thus attacked root and branch. The measure had consequences that might have been foreseen. "The majority of the Arabs affected could not understand the intricate legal process, nor perceive why they should have to pay large costs when they (ii) received no obvious advantages." Whether it was the negligence of legal forms or inability to bear the cost of the process, the result of both was expropriation. The speculators made immense gains for it was extremely easy to bribe any tribal renegade to claim his share in order to start a process which culminated in the forced sale of the entire tribal land to meet the heavy cost. The native population lost a large proportion of their lands in this fashion.

The folly of this precipitate individualization was recognised in 1887 but then the government went to the other

extreme and all transfer and alienation were forbidden. A trend towards individualization had set in under however inauspicious circumstances and it was by no means politic to stem it abruptly. The law of 1897 finally established the pattern of the Algerian land policy, the principle being that any individual who wished to have his land separately could get it delimited without upsetting the whole tribe. This law has worked well and is still in operation after some minor modifications. But the legislation till that date has had lasting consequences because by its errors and contradictions, it has engendered enduring and "disillusioned hostility" among the local population which remains opposed to all reform.

According to Pierre Berthault, 4,100,000 hectares are at present registered according to French law (2,300,000 belonging to Europeans, the rest to Muslims) while 7,400,000 hectares are still governed by Islamic law.

TUNISIA AND MOROCCO These countries have benefitted from the experience gained in Algeria. A new system known as "Immatriculation" has been introduced in Tunisia since 1885 and in Morocco since 1913. Based on a type developed in Australia, it aims at consolidating private property by establishing undisputed possession to a clearly defined holding or estate which is then entered into a register. Although instances of

(1) Ibid, p.203
(ii) E.C.M. "Algerie", Vol.1, p.240 The figures are presumably for 1942.
exploitation of illiterate peasants by unscrupulous persons did occur, registration of property in this manner has steadily gained ground. Above all, it has consolidated the colonists' position. At present the area under this regime is as follows:

Tunisia 1,770,000 hectares.
Morocco 4,000,000 hectares.

REGIME OF LANDED PROPERTY IN WEST PUNJAB

The systems of landownership in West Punjab vary from region to region but on the whole one basic distinction is between those of the old-settled districts and the newly-developed canal colonies.

LAND-OWNERSHIP or OWNERS' TENURES: (1) Old Settled Districts

The main feature of the regime of land-ownership is the predominance of land-lord or joint types, both based upon tribal or family relationships. Land is held in full proprietary right by a group but an individual or a family claims superior status by virtue of ancestral rights. The proprietary body may consist of twenty or fifty or even more co-sharers, usually of common descent and they attach great importance to their landlord's right over the whole area of the village, arable or waste alike.

The joint or landlord-villages have been subdivided into Zemindari, Pattidari and Bhaiachara. (ii)

The term zemindari is applied to cases where a single

(ii) Baden-Powell: Land Systems of British India.
landlord had obtained the governing proprietary right. Through the multiplication of the number of claimants after several generations, a numerous group would enjoy the right, and the term, Mushtarka (joint or communal) is applied. Quarrels are bound to occur at some stage among the joint-owners and the land is then divided according to the law and custom of inheritance. The village is then said to be on the Pattidari tenure. If a village is divided on some principles other than those of the ancestral family holding, it is known as Bhaiachara and true custom has been to divide the village artificially with equal lots. The whole area is divided into grades of various quality and each type is then sub-divided among the incumbents of the property.

Owners are sometimes found in West Punjab village communities who do not belong to the brotherhood and are not sharers in the joint lands (shamilat) and other collective rights. The title is limited and is known as "Milkiyat Kabza".

Instances are not uncommon where the proprietary right is divided. The owner with the greater rights is known as ala Malik or zemindar and the inferior ones with the title as adna Malik, the latter may or may not have title to the joint land. The joint nature of these older systems leads to villages paying their land revenue to the state collectively and in fact acting as a body in all matters between them and the administrative authorities.

The Great Landlords Although, strictly speaking, there is no counterpart in West Punjab of great landlords of the
Bengali zemindar type, the insecurity and arid conditions of the pre-irrigation epoch have handed down a legacy of large holdings and of tribal chiefs. The latter were not in possession of such vast properties as they do now as the members of each tribe had a tradition of independence and equality. During the British rule, however, privileged interests were developed as has already been described under the historical survey of agriculture. Their special role in the agriculture of the province will be discussed later.

(2) The Newly Settled Districts Land is held directly by each holder in the colonies and each holder is bound to pay land revenue by his separate agreement. This system is a comparative innovation and although large grants were made to certain persons for their services to the government, and there were large purchases by capitalists, the large majority of peasant grantees were allotted uniform parcels on which they were required to take up residence. Conditions imposed included permanent residence on the land and direct cultivation of the lands granted. Other conditions like keeping brood-mares for horse-breeding, breeding of camels, introduction of scientific methods of cultivation and of improved crop varieties were sometimes additionally enforced. The exact nature of these tenures will stand out when they are described with colonisation in the newly irrigated areas under IRIGATION.
LAND TENURES

The traditional systems of tenancy in both West Punjab and Barbary are of a rudimentary nature based on the sharing of actual produce. The khamessat and associated tenures in Barbary and the batai (equal sharing) system in Punjab have both remained dominant despite recent developments of irrigation and transport that have opened up the agricultural produce of these areas for international commerce. This is partly due to the local agricultural economy having remained essentially a subsistence one although other factors such as the desirability of having permanent tenants, the general lack of accumulated capital among local landowners may also have played their part. Historically, insecurity in both regions must have made money a scarce commodity as well as a risky one so that kind was preferred to cash. In addition, under the essentially simple socio-economic organization based on autonomous villages and tribes, people did most of their transactions in kind until recently, and village menials in West Punjab are still paid in kind on the occasion of the harvest. It may be added that with the extension of European colonization, a capitalistic system of agriculture has become established over large parts of Barbary with the
employment of paid labour, while in West Punjab, even the big landlords continue to cultivate their lands on a system of prolonged tenancy based as often on sharing of produce as on the payment of rent in cash.

LAND TENURES IN BARBARY

The most common tenancy contrast in Barbary is known as "khammessat" under which the tenant only provides labour and the plough, the animals, seed etc. are the responsibility of the owner. In return for his work the tenant or "khammes" gets a fifth of the produce. The tenant is provided for by the owner till the harvest but if his share of the produce does not make up for the grain etc. advanced by the owner he is obliged to work with the same owner till he has cleared all his liabilities. Under the capricious climate of Barbary, tenants often find themselves indebted for life and bound to work with the same owner. This practice is native to Barbary and has been a subject of controversy among Muslim jurists on account of the very unstable basis of remuneration.

The basis of this and several other related systems of tenures is the traditional conception of five factors in
agricultural production

1. The seed.
2. The field.
3. Labour.
4. The animals.
5. The plough.

Thus work on the field constitutes one-fifth of the factors involved and earns a corresponding reward. Another contract is the direct opposite of khammessat under which the owner leases only his field and all the other requirements are supplied by the tenant. The owner is then entitled to a fifth of the harvest and this type of association is known as "bel khobza".

Other variations deriving from the above conception are "khammes wa ferrad" by which the tenant supplies a ploughing animal plus his work and is entitled to two-fifths of the total yield and lastly "Shirka bin Nosf" (association with equal sharing) by which the tenant provides his service, half the seed and the animals and can claim half of the produce. The conception of these various factors is known as "sehma".

Khammessat still remains the dominant system of tenure although the increase of work involved on the field in cultivating new crops like fruits etc. and increasing complications accompanying new methods (preparatory tillage, application of fertilizer) have led to modifications in an increasing degree. In the Gharb plain in Morocco, the practice of periodic payments in grain (simama) in anticipation of the harvest has come into vogue and is spreading to neighbouring regions. On the whole the tendency is to work up towards monthly payment

of wages making the khammes into a paid labourer. In this respect the influence of the European farms has been considerable. There are also cases where the share of the tenant under the khammessat contract has been increased to one-fourth (Rubaa).

Apart from these traditional systems native to the region, there are two tenancy practices which derive their basis from the Islamic conception of "dead" and living lands as already defined. Mukassara (breaking up) is a practice by which unproductive land becomes the property of the person who brings it under the plough. This is in line with the emphasis placed on increasing agricultural production by Islam for the Prophet Mohammed said "Whosoever plants or sows something and from the fruits of his trees soil would feed men, birds and beasts - all of this will be judged as charity".

The other tenancy contract based on Islamic tradition is "mgharsa" under which the tenant (mogharsi) clears a formerly uncultivated piece of land owned by someone, plants trees and digs wells. Until the trees come into production, the mogharsi may cultivate cereals between the young trees. The owner is entitled to a quarter of the harvest if he does not furnish the seed but he is entitled to one half if he gives all the seed, and one third if half the seed. After the trees come into production, the whole area is shared equally by the mogharsi and the proprietor. This system is especially prevalent in the Sahel region of Tunisia where it has been instrumental in achieving the great expansion of olive orchards.

After the land has been divided between the mogharsi

(i) J.A. Tournieroux "L'oleicultura en Tunisie", p.271
and the owner, the former may continue to take care of the whole orchard and give only a third of the produce to the owner. This is known as the contract of mousakat. The owner is also entitled to $\frac{1}{5}$th of any cereals produced on the land.

The systems enumerated above apply to all types of properties, but there is one system associated specially with the habous lands known as enzel. Land is rented by the governing authority on a perpetual lease at a fixed rent and the enzelist holds it like a proprietor and can pass it on to his descendants. This system has resulted in some extraordinary situations much to the benefit of the tenants many of whom are Europeans. There are large properties in Tunisia which were rented fifty years ago at 2 francs per hectare (2.47 acres) which at that time represented a substantial sum. Today the rent remains the same but the two francs represent less than a half-penny! The system of enzel leases also provides that if such lands lie across the different parcels of land of a neighbouring proprietor, he can purchase enzel lands though habous lands are, in theory at least, inalienable. The practice of enzel is widespread mainly in Tunisia.

The geographical distribution of different types of tenants cannot be demonstrated for the whole of Barbary for the lack of adequate data. The following figures for Algeria give an idea of the relative proportion of ordinary labourers, khammes tenants, owners etc. on native and European farms.
For 1929-30
(Source - First World Agricultural Census)

<table>
<thead>
<tr>
<th>Classification</th>
<th>Absolute data</th>
<th>Percentage of group</th>
<th>of total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Owners:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muslims</td>
<td>1,209,069</td>
<td>97.2</td>
<td>50.2</td>
</tr>
<tr>
<td>Europeans</td>
<td>34,061</td>
<td>2.8</td>
<td>1.4</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>1,243,130</td>
<td>100</td>
<td>51.6</td>
</tr>
<tr>
<td><strong>Share-tenants:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muslims</td>
<td>634,600</td>
<td>99.1</td>
<td>26.3</td>
</tr>
<tr>
<td>Europeans</td>
<td>5,678</td>
<td>0.9</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>640,278</td>
<td>100</td>
<td>26.6</td>
</tr>
<tr>
<td><strong>Other tenants:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muslims</td>
<td>50,771</td>
<td>86.2</td>
<td>2.1</td>
</tr>
<tr>
<td>Europeans</td>
<td>8,149</td>
<td>13.8</td>
<td>0.3</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>58,920</td>
<td>100</td>
<td>2.4</td>
</tr>
<tr>
<td><strong>Labourers:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Muslims</td>
<td>428,032</td>
<td>92.0</td>
<td>17.8</td>
</tr>
<tr>
<td>Europeans</td>
<td>37,082</td>
<td>8.0</td>
<td>1.6</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>465,114</td>
<td>100</td>
<td>19.4</td>
</tr>
</tbody>
</table>

Total agricultural population 2,407,442

**TENANCY IN WEST PUNJAB**

"Though the Punjab is 'par excellence' the province of cultivating proprietors, yet about half of the area is cultivated by tenants" (1) Three types of tenants are in existence:

1. Hereditary tenancy (under Punjab Tenancy Act) Locally known as "maurus"

2. Those held under court decree, lease or other special agreement.

3. Tenancy-at-will.

(1) K.S. Ahmad, Op.Cit. p.245
Direct cultivation by the proprietor is known as Khudkasht. Several systems of farming by tenants are at present in vogue:

1. "Batai" system - Land is leased on a sharing basis the usual share being half and half between the tenant and the landowner. The expenditure on land and water dues is shared though the cost of the seed has usually to be borne by the tenant. Ultimately the tenant's share is considerably less than that of the owner.

2. Siri System - This is a system of direct cultivation by the owner in which the labourers get a fixed proportion of the produce instead of cash. They also share a corresponding proportion of the land revenue. Their feeding is the landlord's responsibility.

3. Nakdi rents - Farming is done on cash rents irrespective of what crops are grown.

4. Zabti rents - In this case cash rents are fixed at different rates for different crops.

5. Chakota - This is farming on lump grain or cash rents consisting of a fixed amount of money in the autumn harvest and grain in the spring.

Most of the province is given to the batai system of farming. The system has some manifest disadvantages. Since the landlord ultimately secures the major part of the produce


(ii) Punjab Settlement Manual, 1915, p.159
there is no incentive for improvements or efficiency. On the other hand the system secures natural adjustment of rent to the produce and is thus independent of price fluctuations.

Kind rents have become prevalent during the last few decades. This may be accounted for by the fact that the spread of canal irrigation has given a greater security to crops so that the landlord stands to gain more by the larger yields of irrigated lands than by a fixed areal rent. It may be remarked that cash rents are still prevalent in the precarious barani (Rain-cultivated lands)

H. Calvert conducted an enquiry into the relative merits of kind and cash rents according to its effects on the efficiency of agriculture. His conclusion was that tenants worked harder when paying a fixed cash rent, thus hoping to make something over and above the normal produce. If working under the batai system, the tendency was to concentrate on more remunerative crops like sugar-cane. Batai tenants did not appear to be planting trees or ploughing carefully. These findings were later confirmed in the village surveys made by the Punjab Board of Economic Enquiry.

Regional Tenures: The types of tenures vary over the province. Central Punjab is marked by the prevalence of well-organised village communities in which groups are united by ancestral ties. The type of ownership here has already been described.

(i) "Wealth and Welfare of the Punjab" p.89-91, Lahore 1927
The Potwar Plateau has a strongly tribal organisation in which several villages may form a unit. Within these are found *Ala Malikan* or the big landlords, followed by hereditary owners (*Malikan*), *Adna Malikan*, the small proprietors and finally outsiders who have purchased land in these villages but do not enjoy a right to common lands (*Malikan Kabza*).

Tenures in South-west Punjab show the effect of aridity and pastoral pursuits that used to be the rule before canal irrigation. The unit of property is still the well over large areas and is known as *chah* or *patti*. Two distinct classes of owners are found, the old established landlords called *Malikan ala* and outside settlers, formerly called *riaya* (subjects) but known now as *malikan adna*.

The system of *adhlapi* prevalent in the trans-Indus district of Dera Ghazi Khan is similar to the system of *mgharsa* in Barbary. If a man sinks a well in barren land with the owner's consent, he becomes owner of half the commanded area. The share of a man who cleans an old well is 1/5th. (1)

**HOLDINGS**

The large majority of cultivators in Barbary and West Punjab are small-holders as will be proved by a study of available statistics. This in itself is a reflection of the pressure of population on the land as well as of the Islamic regime of property under which all members of the family are entitled to a share in the patrimony. Although the latter results in actual

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(1) Punjab District Gazetteers, D.G.Khan, page 79
partition of cultivated lands in West Punjab, in Barbary, the family holdings remain indivisible in theory. The fact remains however that the average areas of land cultivated by the individual peasants are very low and are being progressively reduced.

Side by side with the sub-division of holdings, there is the problem of fragmentation i.e. breaking up of individual scattered plots into smaller sections after each sub-division. The process, founded on the laudable object of providing exactly equal shares of various types of land, has been carried too far especially in West Punjab where it has been studied in detail. There are indications that the problem also exists in Barbary as the productive land forms a small proportion of the total area.

Relative position of Barbary and West Punjab  The only part of Barbary for which statistics are available is Algeria. The average size of holdings for whole countries while not conveying an exact picture, does present a basis for examining the general position in relation to other countries. The following table indicates average holdings in acres per cultivating worker in several countries (figures for 1921 for all countries except Algeria, 1929-30)

<table>
<thead>
<tr>
<th>Country</th>
<th>Average Holdings (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scotland</td>
<td>56.31</td>
</tr>
<tr>
<td>Wales</td>
<td>58.95</td>
</tr>
<tr>
<td>England</td>
<td>26.95</td>
</tr>
<tr>
<td>Germany</td>
<td>19.25</td>
</tr>
<tr>
<td>France</td>
<td>15.5</td>
</tr>
<tr>
<td>Algeria: European</td>
<td>223.4</td>
</tr>
<tr>
<td>Native</td>
<td>33.3</td>
</tr>
<tr>
<td>Punjab</td>
<td>9.2</td>
</tr>
</tbody>
</table>

Keeping in view the higher standards of cultivation in European countries the discrepancy is even more considerable than the figures indicate.

The figures for Algeria are relatively high but while the lands of the Europeans are undoubtedly fertile, the native holdings are usually located on steep hill sides so that in terms of productive capacity they approach nearer to the Punjab figure.

The cultivation of the small-holding presents several disadvantages:

(i) The small area of the holding gives insufficient scope for the working capacity of the peasant family. It also gives disproportionately low returns for the amount of effort and money expended on it. As Mukerjee noticed by a comparison of farm accounts in the Canal Colonies of West Punjab, "the costs of cultivation increase in relatively greater proportion with diminution of the area of the holding and that almost similar results are traceable so far as the net income per acre is concerned, which tends to decrease as the area of the holding decreases".

(ii) The small-holders suffer from a lack of capital on one hand and of technical ability on the other. Their poverty is responsible for both. Indebtedness in bad years is a common happening.

(iii) The small-holder lacks the knowledge and resources to run his farm commercially. Neither his choice of crops nor his

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knowledge of market conditions are designed towards meeting the current requirements. The small-holdings also have some advantages i.e. possibility of intensive cultivation of lucrative and giving close personal care to the farm. For a maximum advantage to be taken of the small-holding, credits, co-operation, vocational training and an adequate marketing organisation are essential. Most of these are inadequate in Barbary and West Punjab.

Details of Holdings in Algeria

While the size of holdings observed personally will be given under the account of Agricultural Regions, the following statistics for Algeria should give a representative picture.

PRIVATE AGRICULTURAL PROPERTIES in 1930 ACCORDING TO SIZE

<table>
<thead>
<tr>
<th>Classification</th>
<th>Number of owners</th>
<th>Total area of land</th>
<th>Absolute data acres</th>
<th>Percentage</th>
<th>Average for owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 25 acres</td>
<td>372,258</td>
<td>4,032,480</td>
<td>16.8</td>
<td>10.8</td>
<td></td>
</tr>
<tr>
<td>From 25 to 124 acres</td>
<td>146,040</td>
<td>6,989,144</td>
<td>29.1</td>
<td>47.9</td>
<td></td>
</tr>
<tr>
<td>From 124&quot; to 247 acres</td>
<td>41,535</td>
<td>4,816,530</td>
<td>20.1</td>
<td>116.0</td>
<td></td>
</tr>
<tr>
<td>Over 247 acres</td>
<td>13,370</td>
<td>8,154,763</td>
<td>34.0</td>
<td>669.9</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>573,203</td>
<td>28,992,917</td>
<td>100</td>
<td>41.9</td>
<td></td>
</tr>
</tbody>
</table>

It will be noticed that less than 10% of the owners in the last two categories own 54.1% of the total cultivable area and that almost two-thirds of the owners own only about 10 acres each on the average. The following figures for European and Muslim owners further bring out the differences that exist between one group of owners and the other:

(i) International Institute of Agriculture, The First World Agricultural Census, No. 21 Algeria, 1938
### EUROPEANS

<table>
<thead>
<tr>
<th>Classification</th>
<th>No. of owners area (acres)</th>
<th>Absolute Percentage of total owner</th>
<th>Average per owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 25 acres</td>
<td>8,643</td>
<td>102,721</td>
<td>1.8</td>
</tr>
<tr>
<td>From 25 to 124 acres</td>
<td>7,006</td>
<td>533,550</td>
<td>9.2</td>
</tr>
<tr>
<td>From 124 &quot; 247 &quot;</td>
<td>4,700</td>
<td>595,731</td>
<td>15.5</td>
</tr>
<tr>
<td>Over 247 acres</td>
<td>5,359</td>
<td>4,238,216</td>
<td>73.5</td>
</tr>
<tr>
<td></td>
<td>25,807</td>
<td>5,770,218</td>
<td>100</td>
</tr>
</tbody>
</table>

The number of large holdings is not inconsiderable, 40% of the holdings being over 124 acres. The small proprietors are either those who practice the intensive cultivation of truck crops or cultivate some land as an additional occupation apart from their main profession in business or administration.

The figures for Muslim owners are given as follows:

<table>
<thead>
<tr>
<th>Classification</th>
<th>No. of owners</th>
<th>Total area of land owned (acres)</th>
<th>Absolute Percentage of total owner</th>
<th>Average per owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 25 acres</td>
<td>363,615</td>
<td>3,929,757</td>
<td>21.6</td>
<td>10.8</td>
</tr>
<tr>
<td>25 acres to 124 &quot;</td>
<td>183,945</td>
<td>6,455,584</td>
<td>35.4</td>
<td>46.5</td>
</tr>
<tr>
<td>124 &quot; 247 &quot;</td>
<td>36,935</td>
<td>3,926,799</td>
<td>21.5</td>
<td>106.4</td>
</tr>
<tr>
<td>Over 247 acres</td>
<td>8,001</td>
<td>5,916,549</td>
<td>21.5</td>
<td>489.5</td>
</tr>
<tr>
<td></td>
<td>547,396</td>
<td>18,222,699</td>
<td>100</td>
<td>33.3</td>
</tr>
</tbody>
</table>

Less than 9% of the Muslim owners have holdings of over 124 acres and the greater mass - over 66% possess parcels of land that average only 10.3 acres. The Muslim small holdings, even though of an area comparable to the European small holdings do not compare in quality for even as Pierre Berthault has observed "As against the European small holdings located in the rich zones, the native small property exists over the high plateaux or over the zones where colonisation cannot be successful except with very large holdings." This discrepancy combined with the age-old methods of the local peasants produces those great contrasts in productivity we shall notice later on.

Size and Distribution of Holdings in West Punjab

The average size of holdings in the various districts of West Punjab for 1931 is indicated on Map 7. It will be noticed that they are smaller in the congested old-settled districts of Rawalpindi, Jhelum, Sialkot, Gujrat and Lahore as well as in the mainly well-irrigated districts in the south-west—below 7.5 acres. In the canal colonies, they range from 7.5 to 10 acres while they exceed 10 acres in the two districts that extend over most of the Thal desert—Mianwali and Shahpur.

H. Calvert made a study of the size and distribution of holdings in the Punjab in the 1920's and arrived at some interesting conclusions as regards the role of various factors in determining their size. He distinguishes between owners' holdings (areas belonging to individual proprietors) and cultivators' holdings (areas cultivated by individual holders whether owners or tenants). For the undivided province, the relative proportion of the owners of various sizes of holdings may be judged from the following table (for 1922-23).

<table>
<thead>
<tr>
<th>Percentage of owners</th>
<th>Percentage of lands held</th>
</tr>
</thead>
<tbody>
<tr>
<td>Less than 1 acre</td>
<td>17.9</td>
</tr>
<tr>
<td>1 to less than 5 acres</td>
<td>40.4</td>
</tr>
<tr>
<td>5 to less than 15 acres</td>
<td>26.2</td>
</tr>
<tr>
<td>15 to less than 50 acres</td>
<td>11.8</td>
</tr>
<tr>
<td>More than 50 acres</td>
<td>5.7</td>
</tr>
</tbody>
</table>

Thus while the majority of the peasants (84.5%) own holdings of less than 15 acres, a minority (15.5%) hold 61.3% of the land. The average figure of 7.8 acres per owner applies in reality to less than 18% of the owners. The holdings of below 1 acre belong in most cases to cultivators rather than allotment holders or labourers.

(1) The Size & Distribution of Agricultural Holdings in the Punjab, "Cultivators", 1928.
Calvert has established that on the whole, the size of owners' holdings increases as the rainfall decreases. Along the Indus only 33% of the holdings are above 10 acres in Attock with a rainfall of 20.15". At Muzaffargarh which receives 5.95", their percentage increases to 87.8%. The same distribution was noted along the Jhelum and the Sutlej.

Different conditions obtain however in the canal colonies and the following distribution was noticed:

<table>
<thead>
<tr>
<th>Percentage of owners</th>
<th>Percentage of land</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 1 acre</td>
<td>10.5</td>
</tr>
<tr>
<td>1 to under 5 acres</td>
<td>24.4</td>
</tr>
<tr>
<td>5 to 15 acres</td>
<td>32.3</td>
</tr>
<tr>
<td>15 to 50 acres</td>
<td>24.4</td>
</tr>
<tr>
<td>Over 50 acres</td>
<td>8.3</td>
</tr>
</tbody>
</table>

Thus a majority of the cultivators (56.7%) own two thirds of the cultivated land in holdings of 5 to 50 acres. This shows the influence of government supervised settlement and uniform allotments to peasant colonists.

Cultivators' Holdings

Calvert's survey revealed that most owners holding less than 15 acres tend to take extra land for cultivation as tenants. About 83% of the cultivators cultivate less than 15 acres so that this may be recognized as the normal size of the cultivators' holding. This also reveals that the Punjab peasant is essentially the man with only one plough. In the congested sub-Montane district of Sialkot 55.6% of the cultivators held less than 2½ acres, most of it well-irrigated.

No connection was noticed between the size of holdings and the type or intensity of cropping. In fact, there appeared to be a tendency among smaller holders to grow a larger proportion of cereals and pulses than the bigger cultivators.
South West Portion of How-Kalan Village Before Consolidation

South West Portion of How-Kalan Village After Consolidation
**Fragmentation of Holdings and Consolidation**

Various surveys in different parts of the province revealed that small-holders held land in numerous scattered plots. In a study of this problem, Calvert estimated that in the congested districts of Jallundar, Hoshiarpur and Guriaspur (a part of the latter is in West Punjab) average holdings of five acres were held in 25 plots. The evils of fragmentation are easily imagined - waste of land in boundaries, waste of time in travelling to and fro between plots, lack of adequate care etc. A legislative solution of the problem was found to be impossible. A system of co-operative consolidation was, however, worked out under which cultivators within the same village exchanged their scattered plots among themselves so as to obtain large compact fields. The work was supervised by the Co-operative Department and cost the government less than 2 rupees (3 shillings) per acre in the 1920's.

The system has since become widespread and its virtues are being realised. Two diagrams show a part of the lands of a village in West Punjab before and after consolidation.
Chapter 9

Colonisation
European Land-settlement in Barbary

The most significant development in the agriculture of Barbary in recent times has been European land-settlement. The land policy it inspired was outlined earlier; yet so closely interwoven is this development with all aspects of agriculture that it merits treatment in some detail. To the Europeans in Barbary, the establishment of a large number of their compatriots in these territories represents their greatest achievement. They point to their modern farms and machinery, their commercialized and increasing production as well as the modernising effect they have had on native agriculture. On the other hand the native population considers it to be the greatest iniquity perpetrated by the conquerors and alleges that a great mass of formerly independent landholders is now living in misery and forced to plough the stony mountainsides or to work as labourers on what was once their own property.

Before any opinion may be formed about the merits of rural colonization by Europeans, it is necessary to examine the various factors involved in the process and to survey the history of its growth. Algeria must occupy the forefront again in this account as it was here that colonization first began immediately after the conquest in 1830 and passed through its more stormy phases. Algeria is also the most Europeanized of the three territories and almost two thirds of all colonised lands lie within its confines.
FACTORS INVOLVED

Algeria as a country for European rural colonization and the French as settlers possessed certain attributes which were peculiar to them during an age of rapid territorial expansion and overseas emigration. On one hand, unlike the new world or Australia, Algeria had a large compact population estimated at between 2 and 3 millions, with a well-defined culture and regime of landed property. Most of the cultivable land was occupied even, though indifferently, over large areas. On the other hand, France did not have a high birthrate and its population was attached to the soil. Indeed as G. Froment-Guizyesse has summed up after comparing France with Britain and Italy, "economic, social and political causes favourable for continuous emigration did not exist in France." (i)

The proximity of Algeria to France and the similarity of climatic and other conditions over large tracts are factors that have been favourable to emigration. Only some 450 miles across the Mediterranean, emigrants never felt really isolated from the mother country. The vine-growers of the Midi found the littoral plains like home while the peasants of High Languedoc found the high plains of Setif and Sidi bel Abbes quite to their liking. In spite of these advantages, the colonization of Algeria was carried out only through great effort and expense on the part of the government. A consistent

(i) E.C.M. "Algérie", p.228.
thread of anti-colonialism that ran through French politics rendered the job still more difficult. That so many people did settle in Algeria was consequent upon the liberal terms offered to colonists who, during most early stages of colonization, had only to volunteer to immigrate into the country to receive free of cost, land, a house all ready, cattle, implements and liberal credits and could after a minimum term of residence either become absentee landowners or sell their land at great profit. It is now proposed to examine the development of colonization in its various stages and to comment on its salient features.

History of Land Settlement in Algeria

From the beginning, the French policy of land-settlement was dominated by three conceptions, "a belief in grants as opposed to sale, official villages as opposed to desultory individual action and small settlement as against capitalistic effort". (1) There were several phases of the process during which many different modes were tried and it was not till 1878 that a consistent policy emerged. The present colonization policy was finally shaped by the laws of 1904 and 1926.

1830-1841: The period immediately after the conquest was one of hesitation. The new country was ineffectively subdued, only some coastal tracts being under actual control; there was uncertainty as to its future occupation and the local property regime presented great difficulties. The first settlers

to arrive were not Frenchmen but 400 German and Swiss emigrants destined for America who were persuaded to come to Algeria. (i) A few villages were established around Algiers but the most enterprising step of this period was the foundation of Bufarik in 1836 in a marshy and unhealthy tract. The village was planned officially, sites being allotted for 562 houses and 173 rural grants were made. With a year 110 hectares had been brought under cultivation. Most of this came to nought when the war against Abdul Kader started in 1839.

Marshal Bugeaud, 1841-1848: More important than hostilities within Algeria was the hostility of public opinion in France because, among other things, of the high mortality among colonists. Duvivier, himself an architect of the French conquest, wrote in 1841 "the plains, whether that of Bone, or of Mitija and many others are homes of disease and death. Improve them? No one shall ever succeed in that" (ii) Non-expansionists popularised the phrase that "Algeria is a rock without water, a place where only air is found and even that is bad" (iii) In this state of opposition in France and difficulties within, Bugeaud assumed charge in 1841 as the governor-general. From the start he declared his intention of doing something "enduringly useful" for France. He wanted

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to populate the land with soldier-colonists who would have on one hand the discipline of soldiers to ward off the incursions of the local population and on the other hand have the initiative of private settlers. The government "acquired" the lands more by force than by negotiation, the army cleared them and helped in the construction of villages and roads and when all was ready, families would be settled each with an allotment 4-12 hectares. By 1847, 61 such villages had been founded. (i) While the government provided a free passage to Algeria and free land and houses, the colonists were required to bring the land under cultivation within a certain period before being given the final title. By 1848, out of 150,000 hectares conceded, only 23,000 were owned under a final title and many colonists had returned to France. (ii)

Despite his policy of military colonization, Bugeaud did not favour the current idea of the "refoulement" (driving back) of the native population and believed that the colonization of uncultivated land could be carried on side by side by both Europeans and Algerians. He gave a real start to rural settlements by Europeans and by the time of his departure in 1848, the number of colonists had gone up from 1500 to 15,000.

1848-1860: In 1848, there was an industrial crisis in Paris following the closing of the national workshops. It was decided to allot lands in Algeria to a large number of the unemployed workers and by 1849, 13,500 of them had arrived.

They were settled in 42 new officially created centres. The immigrants were complete strangers to agriculture and it is no wonder that large numbers of them sold their lands and went to the towns. Epidemics of cholera in 1849 also took their toll and precipitated a movement away from the centres of colonization. The opportunities of easier life in administration or commerce have always had the effect of attracting the town-loving settlers away from the countryside and despite all the assistance and encouragement given by the government, large numbers of the colonists settled at great expense have always migrated to the larger urban centres.

In 1851, the practice of making free grants was discontinued and as free sales of land in British colonies had given excellent results it was decided to give them a trial and sales of official allotments at token prices were instituted along with which complete possession was conceded. The aim of this step was two-fold. Firstly it was designed to remove the discouraging factor of free grants being conditional. Secondly it was expected to attract capitalists who could invest money in the land. While the practice of establishing planned villages of colonization was continued and 85 villages were thus established from 1851 to 1861 involving an allotment of 250,000 hectares to 11,000 grantees, "grande colonisation" or the exploitation of land by companies was also encouraged and in 1853, the "Compagnie genevoise" was granted 20,000 hectares.

(1) Ibid p.154
It had been stipulated that 10 villages of colonists were to be established but after 5 years, only 500 people had been installed. (i) The period from 1851 onwards increased the attraction for agricultural settlement as a law in that year removed restrictions on the export of Algerian produce to France. But the results of State organised settlement continued to be meagre.

1860-1870: Realising that several policies tried till then by the government had failed in spite of the provision of financial and other aid, Napoleon III decided in 1860 that this part of the State's activities was economically absurd. Open sales were therefore introduced in that year and three years later the Emperor wrote that official colonization had failed beyond the possibility of doubt. (ii) Henceforth, he held, small settlement by Europeans should cease and they should confine their role to that of being "seigneurs" (landed aristocracy) investing only their money into the land. A decree of 1864 absolutely forbade free grants. In other words all further extension of rural colonization was to be achieved by private enterprise. This period saw a decrease in the agricultural population of 1% and not a single new village was created from 1864 to 1870. (iii) The colonists in Algeria alleged "scandalous desertion" on the part of the mother country but

(i) Ibid. p.156.
they had to wait for the Third Republic to restore the complete backing of the state without which the settlement of Europeans could not succeed. This period was, however, marked by several large grants and in 1865 24,000 hectares were granted to Société de la Macta et de la Habra and 100,000 to Société Générale.

The Third Republic: 1871-1878: When the Third Republic was proclaimed in France in 1870, official colonization again sprang to popular favour. Even so the uneasiness caused by Napoleon’s policy and by the series of famines and diseases after 1866 continued to make its influence felt for a decade.

The defeat of France in 1870 and the German annexation of Alsace-Lorraine posed the problem of settling thousands of loyal Alsations. It was therefore decided to allot "100,000 hectares of the best state-held lands in Algeria" to those who would emigrate. The state-held lands at this date could not have satisfied this demand had the Kabylie revolt of 1871 not yielded a large reserve in the shape of an expropriated area of 450,000 hectares of land and a large sum of money realised as indemnity. The Alsation settlers however proved no better than the worker-immigrants of 1848, being, like them, new to agriculture. According to an enquiry made in 1899, out of 1188 families settled originally, only 387 retained their concessions while most of the rest drifted to the cities.

(i) Piquet p.179.
The regime of 1878: The decree of 1878 regulated settlement for the next twenty-six years and for the first time gave a definite shape to the official colonization policy. Under this decree land could be obtained free on condition that the grantee resided on the land for three years and improved it to the extent of 100 francs per hectare. The grantee could leave after one year provided he installed another French family in his place. The area of individual lots was increased to 20-50 Ha. for Settlers in a village and 50-100 for isolated farms.

This was a period when all factors favourable to colonization appeared to combine. Large areas confiscated from the rebels were lying unutilized. A hardy and reliable class of settlers was at hand due to the depredations of the phylloxera in the Midi. The administration's policy was favourable for land-settlement and the development of railways was opening up the country-side. Thus it was that the period from 1870 to 1890 saw a great increase in the total area colonised (see graph). When the lands acquired from rebels had been exhausted, expropriation was resorted to although the French government refused a loan of 50 million francs to carry this measure out on a large scale. This was also the period when the infamous land regime of 1873 was in operation by which any one tribesman could get the tribal lands split up into individual lots. The combination of expropriation and forced sales had consequences altogether tragic for the native

GRAPH SHOWING THE AREA COLONISED BY EUROPEANS IN ALGERIA

(A BY DECADES TILL 1900, THEREAFTER AT IRREGULAR INTERVALS)
population who lost two-fifths of their lands between 1873 and 1889. (1) This period marked the extension of colonization beyond the Tell Zone into the interior. In all 643,456 hectares were settled by Europeans from 1871-1895. Of the original grantees numbering 13,301 only 5,184 remained on the land. (ii) The other 8,117 did not all leave Algeria but sold their lands to other colonists and gravitated to the cities. Ultimately the gainers were Algerian Frenchmen. This led to the criticism that official colonization was designed to transfer lands from the native population without adding considerably to the European rural population.

The results of official colonization during this period have been disputed. In a celebrated enquiry, de Peyerimhoff (iii) defended the high cost of this policy and the waste of effort involved by pointing to the increase of French population and the successful installation of hundreds of centres of colonization to act as nuclei for the spread of French influence. The economic development of the country had thus been precipitated and the conquest of the country rendered definite and lasting.

Roberts has pointed out the weaknesses of some of these arguments: de Peyerimhoff, in attributing all economic progress in this period to official colonization, neglects the

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(iii) Enquête sur les résultats de la colonisation officielle de 1871 a 1895. Abstracted by Roberts, Piquet, Bernard etc.
"spontaneous or natural development as may have been going on at the same time and independently of the official policy".

The Burdeau Report of 1892 criticised the system of free grants and advocated free sales on the model of the system of 1860. This had already commenced in 1884 on a limited scale but following the growing criticism of the policy of official colonization, the principle was finally adopted in 1904.

The Law of 1904: The decree passed in 1904 changed the whole character of Algerian land-settlement. Sales became the rule but residence was encouraged by giving rebates to those settlers who personally lived on the land. To prevent the previous monopolization by Algerian residents, two-thirds of all land was reserved for immigrants. Sale of land to the native population was forbidden. Free grants could still be made under special circumstances and the maximum size of allotments was increased from 40 to 200 Hectares.

In theory, the new policy was designed to replace artificial colonization by spontaneous settlement. In practice, however, the Algerian Government continued to establish official villages even in lands acquired by free sale. Free grants also continued to be made in large numbers and according to Piquet, 2820 grants were made between 1901 and 1910 while only 431 lots of land were sold openly between 1900 and 1907.

\[\text{(i) From Land Policy, p.227-228.}\]
AGRICULTURAL COLONIZATION IN TUNISIA.

(Source Geographical Handbook, n.d.)
The total amount of land acquired by Europeans between 1900 and 1920 was about 200,000 hectares. The latter part of this period saw colonization reduced, and according to A. Bernard, "during the War and up to 1920, the natives had repurchased from the Europeans more land than they had sold them" (i) Since then, large areas have been added to the domains of European colonization. The law of 1924 forbade all free grants except to French immigrants. (ii)

Recently, the government has again taken the initiative in an attempt to acquire more lands for colonization from the native population. The Martin Law in Algeria, passed in 1942, requires that in all areas already benefitting from the government's irrigation schemes, proprietors must cede 15% of their lands to the state without compensation. For regions about to be irrigated, the percentage is to be raised to 30 while it shall be 50 for all future projects. (iii)

Agricultural Colonization in Tunisia and Morocco

Land-settlements by Europeans in these countries have largely been achieved by private enterprise. Tunisia came under French suzerainty in 1882 and at first the government was reluctant to launch any official scheme of settlement. Vast domains were however bought by enterprising persons and

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"out of the 1,094,700 acres owned by French persons in 1892, 1,027,900 belong to sixteen individuals" (i) Among the earlier domains to be established was the Enfida Domain of 96,000 hectares, the largest in all Africa, and official colonization did not start till 1901 and then only to counter the increasing Italian population by attracting Frenchmen to the land. Between 1900 and 1914, the government granted 125,000 hectares in lots of 100 hectares or more. Following the war there was a period of recession from the French point of view for over 80,000 hectares of land passed to Italians and the native population. In fact, French settlement in Tunisia has been very slow and until the Second World War, the numerous Italian and Maltese landowners were the leading political headache of the government. (ii)

A notable feature of land-settlement in Tunisia has been the settlement of the native population in the centre and south which has been largely responsible for the extension of olives. By 1912, 6,000 natives had been settled in the Sahel region and occupied along with 150 Europeans an area of 144,000 hectares. Most of the land in the Sahel was obtained by the expropriation of the extensive Siala domain (iii) (shown as Sialine lands on the map of Agricultural colonization in Tunisia).

(ii) Roberts (Op.Cit.) gives the total number of French landholders in 1928 as 1708 as against 1565 Italian and 102 Maltese, p.274.
(iii) Ibid, 276.
Rural colonization by Europeans in Morocco has been along the same lines as in Tunisia with private enterprise playing a leading role. Official colonization was carried out only between 1924 and 1928 when large scale expropriations took place. The changed political temper made its influence felt recently. When an attempt was made to colonise the Beni Amir plain before 1939, public opinion and the revolt of the tribe had the effect of defeating it.

On the whole, the settlement of Europeans has not caused the same upheavals in Tunisia and Morocco as in Algeria largely because the colonization policy was not aggressive or aimed at establishing a considerable European population. The alienation of land was simplified by the system of Registration of Property. The changed manner of land-settlement in these countries is reflected in the larger size of average holdings.

Present distribution of colonised land:

The total area owned by Europeans in Barbary is given below along with the number of holders: (1)

<table>
<thead>
<tr>
<th>Area in hectares</th>
<th>Number of holders</th>
<th>Average holding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Algeria</td>
<td>2,700,000</td>
<td>26,000</td>
</tr>
<tr>
<td>Tunisia</td>
<td>770,500</td>
<td>6,000</td>
</tr>
<tr>
<td>Morocco</td>
<td>850,000</td>
<td>4,000</td>
</tr>
<tr>
<td>TOTAL</td>
<td>4,320,500</td>
<td>36,000</td>
</tr>
</tbody>
</table>

Despois has divided these holdings into three principal categories:

(i) Those in cereal-growing regions, mostly non-irrigating, averaging 100 to 400 hectares and more. The larger ones are found in drier tracts where half the area is left fallow every year under dry-farming, e.g. the plateau of Sersou. Lately citrus plantations have been expanding in the irrigated parts at the expense of cereals.

(ii) Those that are devoted to vines are in general smaller affairs, 60-70% of these being below 10, and forming parts of larger estates, 17-25% have an area of 10 to 50 hectares while a number of very large vine-growing estates exist principally in the plains of Mitija and Bone.

(iii) Holdings under early vegetables, requiring intensive cultivation and yielding a high income from small areas support a high density of population so that holdings of as little as 4 hectares are not uncommon.

THE EFFECTS OF EUROPEAN COLONIZATION ON THE NATIVE AGRICULTURAL POPULATION:

The motives behind European colonization have become clear from the account of its development as also from the history of French land policy outlined earlier. One was to ensure the permanent occupation of the conquered lands by settling French cultivators in the belief that the "soil belongs to those who cultivate it". Later on when large numbers of immigrants from the overpopulated lands of Spain,
Italy and Malta threatened to outnumber the French colonists, official colonization was intensified to maintain French superiority in numbers. These motives, however honourable and glorious in their time cannot obscure the fact that the settlement of Europeans was achieved at the cost of "refoulement" (driving back) of the native population. The colonization policy which in the earlier stages had been tempered with humanity ended up in depriving the Arabo-Berber population of its best agricultural lands in Algeria and to a lesser extent in Tunisia and Morocco. The maps of colonised lands in Algeria and Tunisia show the location of these lands and when taken in relation to the physical background, there can be no doubt that these tracts are agriculturally among the richest in these countries.

One might be asked that granting the dispossession of the native population achieved through official colonization in Algeria, how is the forcible expulsion of the local cultivators to be proved in Tunisia and Morocco where lands were acquired mostly through direct purchases by capitalists. The answer, though it cannot be documented adequately on the basis of existing literature, may be given along the following lines. Firstly, a large proportion of the lands even in these territories was firstly acquired by the government through a system of "cantonnement" such as the description of a Moroccan tribe will later illustrate. Thus the government

(1) A. Bernard, Afrique Septentrionale et Occidentale, p.113.
took a proportion of their land from each tribe and sold it to the colonists instead of giving it away. In this sense official colonization continued to replace the local population with settlers. Furthermore, the effect of the influx of capital on a land subject to the extremely variable climatic regime needs to be studied. In years of drought when the small-holders find themselves hard-pressed, it is not unnatural that they should sell their land-capital to those who offer them the hope of subsistence by buying up their lands. The most obvious and willing purchasers of their lands have been the European settlers although some native landlords have also been accumulating lands in this manner.\(^{(i)}\) This exploitation of calamity in an age of growing humanitarianism is a blot on the record of the administration which fails to provide adequate relief and has, therefore, been accused locally of deliberately countenancing the expansion of the settlers' domains in this manner.

Even in 1912 Piquet had reflected on the misery of the rapidly increasing native population "detached from the soil, forcibly impoverished and powerless to transform itself overnight into a working population" and had wondered if "French colonization had not perhaps been a little precipitate" \(^{(ii)}\) He had made these remarks in the belief that "the land has been occupied by the colonists everywhere it has been possible" and drew his conclusions about what he

\(^{(i)}\) J. Nouvel "La crise agricole de 1945-46 au Maroc et ses conséquences économiques et sociales, La Revue de Géographie Humaine et d’Ethnologie" Vol. 1, 1948
had considered to be "an accomplished task". Yet the process of uprooting the native population has continued and the curve of the area acquired by colonists has mounted after Piquet's times as the graph illustrating the progress of colonization in Algeria shows. The graph, however, does not go beyond 1934. A comparison of the proportion of land held by Europeans in 1930 and 1946 will show the development of colonization in recent years:

PROPORTION OF EUROPEAN LANDS IN ALGERIA 1930 and 1946

<table>
<thead>
<tr>
<th>Year</th>
<th>European lands</th>
<th>Total agricultural lands</th>
<th>European percentage of total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1930</td>
<td>2,340</td>
<td>9,716</td>
<td>24</td>
</tr>
<tr>
<td>1946</td>
<td>3,079</td>
<td>11,390</td>
<td>27</td>
</tr>
</tbody>
</table>

The actual increase in the area owned by Europeans during this period has been over 31%. The total cultivated area also increased during this period but this expansion was achieved mainly on the poor marginal lands. In the opinion of this writer the colonization of Barbary in general and of Algeria in particular has been achieved at the cost of the impoverishment and even destitution of the local population. In 1946, an official estimate put the number of agricultural families with insufficient or no land in Algeria at 600,000 or 60% of the total.

(iii) From Renseignement Statistiques et Agricoles, 1946.
(iv) Documents Algeriens, "Paysanat Musulman", 1st June 1946.
Thus whatever the achievements of the colonists in the realm of the modernization of agriculture, this development cannot be divorced from the human context of misery and poverty it has created and the enduring hostility it has generated against progress as brought by the European civilization.

**EUROPEAN COLONIZATION AND THE AGRICULTURE OF BARBARY**

Whatever views may be held as to the debit side of colonization it has also got a credit side to it. The higher agricultural standards established by the colonists and their considerable influence in improving varieties and production cannot be doubted. A comparison of the new and traditional methods will be made in later chapters and their yields contrasted. The colonists have also been instrumental in bringing extensive areas, formerly ineffectively exploited, under intensive cultivation. They have also cleared marshy tracts of which the Mitija plain stands out. In doing all this, it should be recalled, they received every assistance from the government. Furthermore it is also true that, in most cases, all that the colonists have invested in the land has been their supervision for most of the farm-work has always been done by cheap native labour.

With the passage of years, some distinct tendencies have emerged. The fact that despite the prodigious efforts by the government over a century to populate the countryside with Europeans the number of landholders has come down in Algeria to
26,000 illustrates one of them. This is the concentration of land in the hands of a few and the creation of "what amounts to actual latifundia". Another trend has been towards the mechanization of agriculture. While it shall be discussed further in a later chapter, it has emphasised the problem of the landless natives by reducing the number of workers required on the land. It has also been largely responsible for the first trend by facilitating the cultivation of large farms and even conferring advantages on it. Lastly, the cultivation of commercial crops is becoming intensified and there has been a marked extension of citrus and fruit orchards, early vegetables, flax, sun-flower etc. In this respect the colonists are giving a lead to the rest of the cultivators in the diversification of agricultural production.

The Influence of Colonization on the Regime of Landed Property among a Moroccan Tribe (ii)

The change in the regime of landed property among the Sherarda is being described in detail because it represents in miniature many of those far-reaching developments in the man-land relationship that have been taking place all over Barbary. The study also illustrates how the system of landownership and tenancy is an economic and social expression of the interaction between a human group and the environment and undergoes a change when this environment is modified.

(1) A. Bernard, Pioneer Settlement, p. 231.
(ii) Based on Jean Celerier, Op. Cit.
The Natural Setting of the Sherarda:

The tribe formerly occupied the eastern extremity of the Gharb plain along with the bordering hills. Their territory lay to the south of the Sebu from its confluence with Wadi Mikkes up to that of the Wargha. The geographic limits on the other sides are not so well-defined but could be placed approximately at Wadi Segotta on the east, Wadi Krumane on the south and Wadi El Hamma on the west. In 1912 (before the Protectorate) the total area occupied by their lands was over 154,000 acres and consisted of two natural regions.

1. The Low Plains are parts of the alluvial plain of the Sebu and its tributaries. They lie below 300 feet and are divided into two parts by an anticlinal fold. The western part is drained by the Sebu, Rdom, Tihili, Hamma and Beht while the smaller eastern plain of which only one section belonged to the Sherarda is drained by the smaller wadis of Mikkes, Segotta and Mellah.

2. The ravined uplands consisting of two anticlinal folds with a synclinal depression between them. They reach a maximum height of 2,680 feet. The western ridge has been cut through by the Rdom in a gorge (see photo opposite). The crests of the folds are bare and rocky but between them lie several smaller valleys.
Climatically, the region is well-watered, the rainfall varying from 16" to 20" in the plains and exceeding 24" in the folded zone. Except for the crests, the soils are fertile and deep and the region is well-drained. The predominance of impermeable strata does not favour the development of subterranean reserves of water so that the area is subject to the vagaries of the rains for its harvest.

Summing up the natural conditions, the territory that formerly belonged to the Sherarda "is one of the best agricultural regions of Morocco". It yielded good crops of cereals and leguminous crops. The abundance of watering points made it especially suitable for rearing cattle and sheep. That the area has greater potentialities was proved by the extension of citrus plantations after colonization.

The Sherarda and their Established Regime of Land

The Sherarda are descended from the Maqil tribe which immigrated into Barbary from Arabia during the 11th century. They are a warlike people who played a significant role in the rise and fall of dynasties in Morocco. Originally settled in the Sous region, they migrated to the Marrakesh plain where they continued their turbulent career. After an unsuccessful revolt in 1830, they were deported by the existing Sultan to their present habitat in the Sebu Basīq. They consist of four tribal groups whose respective strength at the time of the 1936 Census

(i) Ibid, p.11
They were collectively allotted the area they occupied on the condition of providing military service to the Sultan. Thus the tribal assembly or Jemaa allotted a uniform parcel of land each year to every male member of the tribe capable of carrying arms. This consisted of about 20 acres and was called mokhzani - "held in the service of the administration". These warlike people, finding themselves settled in a fertile region soon became attached to the land although their land laws continued to be a simple unwritten state, administered by the Jemaa on the basis of orf (custom). They must have made poor soldiers because if the Sultan engaged in a prolonged campaign and the harvest drew near, the Sherardi braves would quit their swords for the scythe and desert in large numbers. Theoretically, the mokhzani were allotted every year before sowing time but in practice they became more or less permanent as tens of thousands of acres remained as collective property from which further allotments could be made to the younger generation.

**Colonization**

In pursuance of their policy of settling Europeans on the land, the French authorities made three successive requisitions of land as follows:

<table>
<thead>
<tr>
<th>Year</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>1919</td>
<td>17,400</td>
</tr>
<tr>
<td>1925</td>
<td>1,285</td>
</tr>
<tr>
<td>1929</td>
<td>8,715</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td><strong>27,400 acres</strong></td>
</tr>
</tbody>
</table>
This took away more than a sixth of their territory but what is more, the Sherarda lost all the western plain, the best and the most easily cultivated lands they possessed.

Results of Colonisation

(1) The Disruption of the Existing Regime

The different tribal groups were affected by this expropriation of land to different degrees. The Shebanat and Zirara who had their lands in the plains lost heavily whereas Ouled Delim were less affected, their lands being of a mediocre quality. The latter now occupied half of the remaining tribal lands and the dispossessed elements from the other groups found themselves in a sore plight. One of the first measures by the government to re-establish a balance was the allotment of 8,900 acres belonging to the Ouled Delim to the Zirara.

The great land-hunger produced by the loss of so much fertile land led to dissatisfaction and quarrels within the tribes and was accompanied by the growth of dishonest practices. The area of mokhzani allotments had been reduced to 17½ acres but even so the increasing numbers in the tribe made demands very heavy. Formerly the title to an allotment became established with marriage which was recognised as marking the attainment of adulthood. But whereas the impoverished tribal members could not afford to marry and thus claim a share, the well-to-do landowners would marry their numerous male progeny even before puberty and thus acquire several mokhzani allotments. Local civic
dignitaries - qaids, khalifas and sheikhs made use of their powers to accumulate large estates. Privileged persons like religious leaders and those holding special titles from the Sultan exploited the opportunity to their own advantage.

Certain established practices further complicated matters. Bernisha is an age-old institution based on a fact of soil chemistry. As leguminous crops grown in the spring enrich the soil for the following winter cereals, the occupier of the land can extend his leave on the ground that he is entitled to benefit from the soil he enriched during the previous year. This led to allotments and tenures becoming perpetual.

(2) Reduction in the number of Cattle came as an inevitable consequence to the reduction of collective lands on which they used to graze. The large collective enclosures containing the tents of a dwarf and the land reserved for the movement of animals (known as msaha) became progressively reduced and privileged persons like local chiefs extended their cultivated land on to them. This made movement and accommodation of cattle and sheep a serious problem. The following figures show the extent of the reduction in numbers:

<table>
<thead>
<tr>
<th></th>
<th>1925</th>
<th>1934</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle (grown up)</td>
<td>12,684</td>
<td>8,524</td>
</tr>
<tr>
<td>Sheep and goats</td>
<td>66,447</td>
<td>39,115</td>
</tr>
</tbody>
</table>

With their old-established regime in a chaotic state, the strong exploiting the weak, the cattle and sheep decimated, the
Sherarda made a plea for the intervention of the government to regulate the property laws and the system of allotments.

Re-organisation of the System

The task of reforming the regime in the light of the changed condition was accomplished smoothly with the co-operation of several departments of the governments as well as the Jemaa and the Caids. The unit of distribution was retained at the reduced area of $17\frac{1}{2}$ acres. Actual distribution presented a problem as the lands left in the hands of the tribe after colonisation were of mostly of an indifferent quality and everyone was keen to have the limited valley and plain tracts. The duration of the mokhzani was prolonged to the lifetime of a holder and the age at which a male adult became eligible was fixed. These latter modifications of the old regime represented an advance towards private ownership though property could not be inherited.

That the new allotments were well-defined and of long duration was certainly an advantage but the loss suffered by the tribe through the colonisation of its best lands could not be remedied. Of the 5,644 people who were allotted mokhzani in 1935, only half found it possible to subsist on the land, the rest leased their shares on nominal rents and migrated to the cities, seeking work on buildings, roads or worked as labourers in the fields. The area of communal lands was down to 1,100 acres after the reorganisation and the plight of the cattle and sheep was a great factor in the reduction in their numbers.
The standards of the cultivation among the tribe were never high. Now on reduced holdings and poorer lands, even subsistence was a problem.

Here we have an example of the influence of colonisation on the life and lands of a tribe, resulting in general impoverishment and migration. Celerier piously hopes in his study of the tribe that the intensification of agriculture will solve the difficulties of making a living and of providing a livelihood to the increasing population. That, if achieved at all, shall certainly take a long time because modernisation is the more difficult among impoverished peasants. In the meanwhile, large estates have been created in the rich plains for European colonists who practise mechanised agriculture and have established extensive citrus fruit orchards on their large holdings (the average in Morocco, to remind ourselves, is 520 acres). They are practising efficient modern methods and obtaining high yields but can their material prosperity be divorced from the poverty of the large native population they have uprooted?
Chapter 10

Modes of Life and Settlement

In Barbary both geographical and historical factors have combined to produce a great variety of modes of life. These range from the nomadism of the Saharan tribes involving extensive seasonal migrations to the sedentary orchard cultivation of the elevated Massifs with an adequate rainfall. Between these two extremes lie a series of transitions which can be distinguished by a study of the type of habitations, the materials used in their construction and the size and nature of their groupings. West Punjab also had a wide range of modes of life before the great irrigation schemes fixed the semi-nomadic population of the drier tracts to the soil, thus creating a fair degree of uniformity. Even so, the present day differences in the size and plan of villages are reminders of the former diversity and at the same time portray the existing variations in land use. Historical and social factors also figure prominently in determining the variations in agricultural settlements. On the whole, however, the interest of West Punjab from this point of view is less than that of Barbary so that a brief account of its agricultural settlements will suffice.

Travelling over Barbary, one is struck by the frequent and sudden changes in the types of habitation. Within the same physical regions there are contrasts between poorly built huts and large modern houses or between isolated tents and large agglomerations of rural habitations. The very location of
villages and hamlets shows remarkable variations for in one area settlements may hug the river banks while in another they avoid valleys and lie perched above precipitous escarpments in defensible positions. The progression from north to south has a definite zonal character i.e. from houses and huts associated with sedentary cultivation near the coast to the tents of the Saharan nomads. But such is the diversity in the types and grouping of habitations within these zones that no generalisations in terms of physical factors alone can suffice. The role of historical and cultural factors as well as the present day economic position of different groups is equally important in determining the nature of the rural cultural landscape.

Agricultural Significance:

The modes of life and settlement interact significantly with the type and intensity of land use. The type of agriculture practised by the semi-nomad who is able to visit his cultivated lands only twice each season - once at sowing time and once for the harvest differs greatly from the constant care given to the land by the cultivator living close to his field all the year round.
The settlements mirror a social organisation, i.e. the degree of tribal cohesion which is directly related to the regime of landed property. Wherever the tribal organisation is still strong and mutual social and economic ties unaffected to any considerable extent by individualistic tendencies generated by modern developments, the collective regime of property prevails. This is mainly in the domain of nomadic pastoralism and semi-nomadic cultivation combined with large-scale stock-rearing. In zones of old established cultivation or wherever the impact of European culture has disturbed tribal collectivism, the individual or "melk" property regime is dominant.

The following account treats mostly of the Muslim rural population of Barbary because as a result of prolonged residence in the region, its social organisation, methods of land use and the modes of settlement are adapted to the environment and show greater differentiation. European rural settlements are, comparatively speaking, insignificant in their number. Even if their considerable economic and social importance is realised, they are all creations of recent times and do not vary to any considerable extent in their design and layout. The indigenous tent, hut, or house, differs little from the landscape by its height or colour whereas the modern European farm stands out as a sight at once foreign and unusual with its orderly stables and barns, the houses with red-tiled roofs and the geometrical shapes of the field and farm alike.
Even though the survey of European farms and villages is not by itself as important as that of indigenous rural settlements, the impact of their installation as well as the technical developments associated with western rule have disturbed the age-old adaptations to the environment. Everywhere the entire social and economic structure of the native rural population is undergoing change. In the previous chapter, the influence of European colonisation was considered in many of its aspects. Other developments such as the establishment of political stability and individual security, the development of modern transport and communications, the introduction of a monetary economy and the growth of foreign commerce have all widened the local horizons, undermined collective social and economic organisation and indeed modified completely the relationship of man with the soil and with other men. As stated in the chapter on the Agricultural Heritage, the main currents of civilization have hardly been disturbed. But the aspect of the rural landscape is changing as irrigation developments bring former pastures under the plough. The installation of a strong administration has reduced the power, influence, as well as the movements of the great nomadic tribes who often had the sedentary population of the valleys and plains at their mercy.

Such a study is not only of intrinsic interest as a compelling human development but has great practical utility. The population of Barbary is predominantly rural and is rooted in the soil. Any planning envisaging their social and economic
advancement must establish the characteristics of different groups in relation to the environment and the cultural factors, past and present. Neither paper plans based exclusively on the theories of economists, which often treat the peasant as an abstraction, nor well-meaning administrators can achieve concrete and lasting results unless the peasant is placed in his natural setting and seen in the cultural perspective, bearing the weight of tradition on his shoulders. The geographer is perhaps the best equipped of all scientific investigators to work out an analysis of the system of forces that mould the peasant's way of life, his manner of cultivation and the nature of his settlement.

Factors Determining Modes of Life and Settlement in Barbary

Physical Factors: Although relief, climate, hydrography, soil and vegetation all influence the life and settlements of the population of Barbary, climate dominates the other natural elements not only by dint of its intrinsic importance but also because relief, running water, soil and natural vegetation are greatly influenced by climate. If man finds it impossible to maintain himself permanently at high altitudes it is more the occurrence of snow and the exceptionally low temperatures in winter rather than the actual elevation which force seasonal movements. The presence of water-supplies for domestic use and for irrigation is also as much a function of the climate as of the nature of geological strata although beyond certain limits, i.e. in arid regions, the rare downpours cease to be a
modifying influence in the life of the people and permanent settlements cluster round springs and artesian wells, as in the Sahara. In the domain of the semi-nomadic and the nomadic communities seasonal movements are directly related to the seasonal changes in temperatures and rainfall. Within climatic, and specially rainfall, zones, however, the finer aspects of distribution of settlements are governed by topographical features and the distribution of soil types as well as the nature of water supply.

This dominant role of climate is a feature of semi-arid regions as distinct from those temperate and tropical regions wherein the climatic conditions are generally favourable and the role of soil types and relief is more important. Furthermore whereas the soil can be improved by manuring or the use of fertilizer, and the steeper slopes can be terraced, there is no means of improving the climate by human effort. One can only remedy the deficiency of water by irrigation within the limits of available water supply. Beyond that the dominion of climate over modes of life is much more complete and lasting than that of the other natural elements.

The role of relief in the distribution of settlements is best summed up in the importance of plains and valleys by reason of their being better suited for cultivation, the ease of transport and exchange and the usually abundant supplies of water. Mountains and plateaux have difficult communications, cultivable land is rarer and the soils thinner. Water supply also presents problems so that even in mountains, it is the
valleys of streams that form the nuclei of settlements. Within plains, settlements lie above the periodically inundated flood-plains on terraces or other elevated features. Gentle slopes are best, for while the disadvantages of steep slopes are obvious, no slope at all leads to bad drainage and marshy conditions. This general description of the role of relief is elementary but has been given here because in Barbary it does not always hold and the reverse is often true, i.e. high Massifs with steep slopes have long been inhabited by dense sedentary populations whereas the low-lying valleys and plains have been the domain of the semi-nomad. For this climate and history are about equally responsible. Mention was made in summing up the chapters on the physical background how favourable relief features in Barbary and West Punjab/ not always combine with favourable climatic conditions. The relation of this fact to the modes of life and settlements will now be examined.

Except in the north of Barbary, where rainfall is sufficient, the low plains and valleys have their well-known advantages for rural settlement discounted by prevailing semi-aridity. On the other hand precipitation increases with altitude. Beyond a height of 3300 feet, however, temperature conditions become unfavourable. (1) The zone of high plains and lower mountains thus combines the advantages of suitable temperatures and adequate precipitation. Thus it is that the

(1) J. Celerier "Le Paysage Rural au Maroc" Hesperis 1943,
lower northern slopes of the Atlas ranges in Morocco, the Massifs of Kabylie, the dir (foothill) zone of the Moroccan Atlas ranges and the lower Pre-Rif and Rif mountains have been the zones of rich orchard cultivation with large fixed settlements. Higher up, weather conditions in winter become rigorous but even so cultivation of barley, the plantation of walnuts and along with them the settled hamlets exist up to heights of over 7,500 feet in the High Atlas of Morocco. Here, however, seasonal migration has to be practised as will be described later on in the chapter.

Reference may be made here to the map of settlements and cultural zones in the Tunisian Sahel adapted from Despois (No. 26) where settlements are seen to be concentrated north of the 12" isohyet. The concentration of a population deriving its livelihood mostly from olive orchards became impracticable further south as distance between individual trees would increase as would the distance between individual holdings. As isolated habitations could not withstand the periodic incursions of the Saharan nomads, and large agglomerations capable of doing so were out of the question as the orchards would stretch too far away from them, the olive plantations did not extend greatly west of Sfax till the establishment of a strong government under the French eliminated the fear of nomadic raids. Prior to that the 12" isohyet virtually formed the limit of sedentary villages.
The influence of water supplies is paramount in the actual location of settlements and the periodic resting places of nomads centre around watering-points. Some of the best-defined zones of settlement in Barbary are located along spring-lines at the foot of mountain-ranges i.e. at the foot the High Atlas in Morocco. The role of this factor will be pointed out later on when each zone or community is described in detail. Water-logged regions on the other hand are avoided. Before the French conquest, the marshy plains of Gharb, Mitija and Bone had permanent habitations.

The role of soils in the distribution of cultivated land as well as of settlements is an important one. Certain heavy soils (such as the "tirs" of Morocco) have a high moisture-retaining capacity and ensure cultivation in years of drought. Coastal sandy soils (remel) in Morocco are also well-appreciated by the peasants and yield good crops under the prevailing conditions of high humidity. Such zones have long been inhabited by fairly dense sedentary rural communities. Regions of waterlogged or saline soils on the other hand have resisted human settlement. The problems of these areas and their possible solutions will be discussed in a later chapter.

The role of vegetation is evident in the modes of life and settlement in two ways. Firstly, for the pastoral population, the type and abundance of the pasture is of paramount importance. The Land Classification Map of Barbary indicates very generally the capacity of different vegetation

(1) Reproduced from Shantz & Marbut "Vegetation & Soils of Africa"
types. Thus, the dwarf palm - temperate grass zone which covers a large part of the lowlands and high plains is shown to be a region of medium carrying capacity - about the best in Barbary from this point of view. These as the subsequent account will show have indeed been prominent in the pastoral economy of the region. The second function of vegetation is its role in providing the raw materials for the construction of houses and huts of various types. The variation in the construction and shape of huts is related to the vegetation from which their building material is derived.

CULTURAL AND HISTORICAL FACTORS

The rural landscape is essentially a handiwork of man for which the natural environment is only a setting. He moulds it or shapes his adaptation to it according to his needs, his knowledge and his power. The nature of man's activity with relation to the soil is determined not by the individual but rather the collective group whether it is tribal or racial. The activity of the human group is not changed suddenly with a change of environment and may go on according to its ingrained habits after a change of habitat. Celerier sums up this influence as follows "A human group when it is installed or goes on to instal itself in a region, carries with it, by reason of its being a collective organisation, a system of psychological values, an internal dynamic spirit which is the most constant basis of its activity"(1) This influence is

(1) Op.Cit. P.143
reflected in striking anomalies in the types of settlements in a region due to the existence of a tribal group which migrated not long ago from another habitat. Many of the great transhuming tribes in Morocco are of Saharan origin and their use of the tent must be traced to Saharan precedents. The Alt Ayyash, who came from the south, established a large tent colony in the region of Fez, and a single walled oasis type village (ksar) in the Middle Atlas. The Iguerrwan found inhabiting tents around Meknes still have their distant cousins in the southern valleys of the High Atlas.

The group spirit and its attitude towards the land is not absolutely rigid and always reacts to a new environment by new adaptations and inventions, yet older traits tend to persist. Thus the second wave of the Arab invasion in the shape of the nomadic Hilalian and Beni Solaym tribes has left a lasting imprint and although many of these groups settled down, large groups today which trace descent from them practise transhumance at the Saharan Fringe.

The internal history of Barbary was largely shaped by the movements of the southern nomadic tribes towards the fertile plains of the north. One tribal group would conquer a kingdom by reason of its greater mobility, its hardiness, spurred on perhaps by drought. It would settle down in the plains and lose those qualities it had acquired in an unfavourable environment only to be over-run by a new nomadic invasion. Ibn Khaldun (1332-1406), the greatest Muslim scholar and historian Barbary

(1) E. Laoust "L'habitation chez les transhumants du Maroc central" Hesperis 1934, P.183
has produced put the life of empires at three generations.

"The first generation", he observes "maintains its nomadic character, its rude and savage ways of life; inured to hardships, brave, fierce, and sharing renown with each other, the tribesmen preserve their solidarity in full vigour; their swords are kept sharp, their attack is feared and their neighbours vanquished. With the second generation comes a change. Possessing dominion and affluence, they turn from nomadic to settled life and from hardship to ease and plenty. The authority instead of being shared by all is appropriated by one while the rest, too spiritless to make an effort to regain it, abandon the glory of ambition to the shape of subjection.... They retain however much of what they have known and witnessed in the former generation - the feelings of fierceness and pride, the desire for honour and the resolution to defend themselves and repulse their foes.... In the third generation the wandering life and rough manners of the desert are forgotten, as though they had never been .... they (the men of the ruling tribe) require protection like women and young boys" (i)

Role of Insecurity: This continuous rise and fall of kingdoms and the repeated incursions of the Saharan nomads into the plains and valleys of the north gave rise to the greatest single factor determining the type and location of settlements - insecurity. As periods of strong centralised administration were limited, sedentary cultivators in the plains always lay exposed to attack and pillage. This more even than climatic

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aridity was responsible for the absence of sedentary settlements in most of the plains of Barbary. Only around large towns or in areas effectively governed for considerable periods such as the Atlantic coastal plains in Morocco protected by the Makhzen (administration) and the region of Tunis can permanent rural settlements trace a long history.

The prevalence of huts of various types (gourbis, nwalas etc.) made of straw and branches of trees can also be attributed to insecurity. If the population of a region found itself suddenly compelled to abandon the area there would be little loss in leaving behind such habitations which could be speedily reconstructed in another region. This enforced mobility of the population was also responsible for the premium placed on cattle and sheep as this was the wealth that could be easily transported during an invasion. The other reason for the importance of herds and flocks in the rural economy has been the uncertainty of harvests even in well-watered areas due to extreme variability of rainfall. Almost everywhere agriculture is associated with cattle or sheep rearing which occupy the peasants' families, particularly the younger members who get their initial training in husbandry by tending cattle.

Yet another consequence of insecurity is the concentration of sedentary population in the elevated Massifs. In the southern Massifs and mountains, i.e. Aures and the High Atlas, as not only many of the men, but the whole community sometimes follow the flocks and herds in their transhumance, fortified communal granaries (guelaa, agadir etc) were
constructed. These will be described in some detail later on in this account.

The influence of religion may be noted especially. Since the early Arab invasions, almost the entire population has been Islamised. The cult of marabouts \(^{(i)}\), i.e. belief in the holiness of certain persons and in their spiritual power has resulted in many places being venerated as sacred either because of the tomb of a marabout or the residence of a living one and usually both together as the descendants of the original saint continue to be revered. Such places are inviolate and a nomadic tribe even if it be starving from want would not raid them. Hence these have been the nuclei of large settlements in almost all regions of Barbary. They are usually marked by the absence of fortifications and the location of the domed tomb of the saint in a prominent position. Most places whose name commence with Sidi (meaning My Master) or Mawlay ("My Lord") — and they are fairly numerous — are of such origin.

The rôle of the Tribe: The influence of tribal migrations in transplanting types of habitations different from those locally in vogue was described briefly in an earlier paragraph. As tribal organisation exercises an important influence over the distribution of various types of settlements, some of its outstanding features may be described here. The behaviour of human groups over most of Barbary has been determined more

\(^{(i)}\) A marabout is a descendant of the prophet Mohammed.
by their tribal loyalties than by their attachment to any particular region. This was more true of the former times of insecurity when in a habitat poor in natural resources, the struggle for the possession of oases, better lands and pastures led to the functioning of the tribal unit as the basic human group. This loyalty to the tribe ("biological patriotism" as Gautier put it) rather than to the land was a natural outcome of conditions in which limited stretches of territory could not support large communities who roamed over the countryside looking for pastures, a countryside belonging in effect to no one group.

Where land was fertile and climate favourable, i.e. in the lowlands of the Tell and the coastal zone, invasion and conquest by other tribes made lasting attachment to the soil impossible. This tribal spirit has persisted even where sedentary cultivation and private ownership of land have removed the raison d'etre of the tribal organisation. Settlements usually consist of members of the same tribal faction or clan and many of the customs and methods that go back to the period of residence in another habitat are still followed.

Tribal involves obedience to the chief of the family. The patriarchal family is the basic social unit. A group of families form a sub-unit called karouba in Kabylie, ikhs (or ighs) in Morocco. These units usually inhabit a hamlet or a section of a larger village. The next higher unit is the village (taddert in Kabylie, Arrem or dshour in Morocco and Ksar in the south)
The tribe consists of a number of villages and is an assembly of clans whose representatives from the jemaa or the central council which settles disputes and supervises various forms of pastoral and agricultural activity. The tribe need not always be a homogeneous group related by blood and may often be a combination of several groups brought together by common interest.

The extension of sedentary cultivation, the growth of communications and the establishment of peace and order during the period of French domination has weakened the tribal organisation. Large-scale movement of rural families to the towns has tended to mix the different groups. As was pointed out in the case of the Sherarda, colonisation has given an impetus to this exodus to towns which is by itself a normal development. Tribal loyalties die hard, however, and groups from a tribe tend to congregate even away from their home. The group consciousness of tribesmen can survive the tribal organisation by many years. This is proved by the experience in West Punjab where the colonisation of newly-irrigated colonies succeeded only when the government adopted the practice of settling members from the same tribes and social groups in the old settled districts (i) although the original tribal character of these people had disappeared generations earlier.

In the study of the human geography of lands where the tribal grouping has been a potent force till recent times the factor

(i) Deva Singh "Colonisation of the Rechna Doab" Lahore 1929, p.18
of tribal loyalty needs always to be kept in mind.

**ECONOMIC FACTORS:** If a community can satisfy its requirements from the resources of its environs, migrations on a large or small scale are not necessary. The influence of the climate in enforcing seasonal movements translates itself into an economic factor, i.e. frozen lands at higher altitudes not providing subsistence for men and cattle in winter. In this respect the Land Classification Map of Barbary should be compared with the map showing the distribution of modes of life. The Land Classification Map is based on vegetation as an index of the climatic and other natural factors and on soil and it does not take into account the role of human endeavour to improve productivity. Thus large sections of the Middle Tensift and Um-er-Rbia valleys have been cultivated in the Tadla and Haouz regions under irrigation and these are areas which on account of their aridity are shown to be "unsuitable for cultivation". The map does, however, provide a useful basis for seeing how far the modes of life accord with the potential productivity of different regions. It will be noticed that the zone of "highly productive agricultural land" does in fact constitute the domain of sedentary fruit-growers in the humid elevated Massifs and of cereal-growing cultivators in the remaining lands except for forested areas. Most of the regions which appear as being unsuitable for agriculture but
are "grazing land of low carrying capacity" are inhabited by pastoral semi-nomadic communities. The zone of medium agricultural productivity is mostly under cereal cultivation by sedentary farmers. Thus, broadly speaking, the modes of life do correspond to the natural productivity of the different zones in Barbary.

Apart from this basic economic consideration, the types of habitations built by the rural population of a region reflect not only climatic or cultural influences but also the comparative prosperity of the peasants. The tent is made either of woven wool or of skins of animals, hence to erect it requires some wealth in the shape of camels, cattle or sheep. The prosperous sedentary cultivator lives in a mud or stone house whose size, height and materials vary with his wealth. The hut (gourbi or nwala) is on the other hand the habitation of the poor be they impoverished pastoralists or cultivators. The large modern farms with separate buildings for agricultural machinery and farm animals are always associated with the large landowners whether European colonists or Muslim notables. Herein the role of the size of holdings is paramount and if nwalas and gourbis dominate in Barbary, this is essentially because about two thirds of the peasants own holdings of a size that support them only according to the poorest standards of life and leave no surplus to enable the use of building materials necessary for houses.
PRINCIPAL TYPES OF HABITATIONS AND SETTLEMENT

In the course of the discussion of the main factors determining the modes of life and settlement, several types of habitations were referred to. Before their regional distribution and differentiation can be undertaken, their general features might be described here.

The Tent: (khaima) Tents are used over the larger part of Barbary, mainly in the semi-arid and arid parts by the pastoral population. Bernard has observed in the case of Algeria that tents do not occur where rainfall is more than 500 m.m. (about 20") (1) This may be accepted as applicable to the whole of Barbary. Mountains are another limiting factor as tents are not suitable for high altitudes. The tent was introduced into the region by the Arabs and consists of flilj or strips of material of varying width made from woven wool, fibre of dwarf palm and often of skins of camels, goats sown together. The strips are stretched over a framework of poles which varies in design over different parts of Barbary. The width of a flilj is usually 16-28" and length several yards. They are sown together according to the size of the tent which vary in width from 12 to 22 feet in the case of smaller tents to 40-50 feet in the case of larger ones. Each tent is divided by means of a woollen curtain into two parts, one for the men and the other for women and children.

Whereas it is true that all the nomads live under tents, all those who live in tents are not necessarily nomads.\(^{(1)}\) In the plains of Western Morocco, the tents form the roofs above thatched or mud walls and are used as permanent habitations by the sedentary population. The tent is also used during seasonal migrations by tribes living in houses, i.e. the Shawia of Aures.

In recent years, the tent has retreated with the extension of cultivation. According to the map drawn by A. Bernard and E. Doutte in 1917, tents extended to the coast of Oran. Observations by the present writer as well as by other authors\(^{(11)}\) writing after that show that the gourbi has replaced the tent as cultivation has advanced at the expense of grazing.

Tents are usually arranged in dwars. A dwar is a circle of tents in which the central space (msaha) is reserved for the animals. The location of dwars is so planned that they are not easily observed, i.e. behind some natural obstacles off the main routes. Thus it can happen that the traveller may traverse a densely populated area without being aware of it. Lately with the establishment of law and order, dwars have tended to diminish in size and even isolated tents are a common sight.

**Huts:** (gourbis, nwalas) Numerically, huts are probably the most numerous type of habitation in Barbary. They

\(^{(1)}\) Bernard, A, *L'Afrique Septentrionale et Occidentale* P. 89
\(^{(11)}\) Notably Despois *Op.Cit.*
A tent in the plain of Beni Amir in Morocco. It consists of several lengths ("flīj") of woven wool joined together covering a wooden framework.

This photograph illustrates the structure of a hut (gourbi). The walls are made of tufts of dist grass (Ampelodesma Mauritanica) tied to stakes dug in the ground. The framework of round stakes to be covered with a grassy thatch for a roof is also seen. On completion, the gourbi will resemble the one seen partly to the right.
A dwarf of nwalas in the plain of Beni Amir. Notice its circular arrangement with an enclosure in the middle to shelter the flocks of sheep at night. One such flock with its young shepherd is seen in the foreground. Unstacked hay visible near the nwalas nearest to the camera.

Modern European-styled farm-buildings under construction. These are being erected for skilled labour (mechanics and tractor-drivers) on a large citrus growing farm belonging to a Muslim landlord in the Gharb plain. Behind the building under construction, the corrugated iron roof of the large granary on this farm can be seen.
characterise the average cereal-growing cultivator although they are often associated with the semi-nomad in which case they are intermediate between the tent and the house i.e. in the middle Um-er-Rbia valley (plain of Beni Amir)

There are many types of huts of which the materials vary according to the vegetation. Straw, reeds or branches of various trees and bushes, are used on a wooden framework. The two main types are gourbi which is rectangular with a double slanting roof (Photograph No. 2 and the nwala, a conical hut like that found in Sudan which is typical of Morocco. The zeriba of southern Tunisia and Algeria is constructed with trunks of date palms. Gourbis and Nwalas are both grouped as dwars with a central open space for animals. Photograph shows a dwar outside the irrigated sector of Beni Amir(1) consisting of several nwalas.

The hut, the permanent habitation of the poor peasant, is not only expressive of his poverty but also of the fact that in the past cereal cultivation did not fix a semi-pastoral people to the soil. A hut provided shelter in the prevailing conditions of penury, insecurity and a mode of life in which grazing animals were usually at least as important as cultivation. The gourbi or nwala occurs at greater heights than the tent, covering most of the Tell in Algeria and Tunisia with the exception of the Kabylie Massif. At the same time it is associated with a higher density of population than the tent.

(1) Described later in the chapter on Irrigation.
Intermediate between the hut and the house is the meshta in Morocco, of which the walls of mud or sun-dried brick bear a low thatched roof and it is used by sedentary cultivators in the lowlands of Western Morocco. (1) The word meshta means a winter residence and is applied in other parts of Barbary, notably in the mountains to the winter-house which is the chief home of tribes transhuming in summer. This brings us to a confusion of nomenclature about which care needs to be taken by the field worker. Thus the word khaima meaning tent is often applied to any habitation and especially to huts in the Gharb plain and its borders. This probably originated in those groups, who having originally been tent-dwellers continued to call new types of habitation by the same name.

The House: (dar) The house is in principle the typical habitation of the fruit cultivator and characterises the population fixed to the soil over most of Barbary. It consists of stone or mud walls with a flat roof. Only the Kabylie region and some of the neighbouring Massifs have gabled roofs, tiled with slate apparently because the Kabylie region is among the wettest in Barbary, there is usually snow in the winter for which a flat roof would be unsuited.

The typical house or dar consists of one room without any windows but with some holes in the wall at the top. The fireplace is always in the centre of the room and consists of three stones put together. Very often the single large

(1) J. Celerin, "Le Maroc" p. 49
room is divided by means of a wall into two parts, one reserved for the cattle and the other for the family. Above the stable is usually a garret reserved for women and children.

Houses generally occur in closely packed villages with narrow lanes, and unless gabled, they present a flat-topped surface on the plain and a step-like appearance on a slope as the rows rise one above the other in hill country. The village is almost always located in a defensible position above steep slopes or precipices. Sometimes, a village may consist of hamlets inhabited by families and clans, each lying near its own lands and yet close enough to the other quarters of the village to group together against an intruder. This is true especially of northern Morocco.

Scattered houses characterise only those regions wherein the rural population has enjoyed a reasonable amount of security. The Cap Bon region of Tunisia has its garden-cultivators living close to their lands.

Houses of European-type using modern building materials such as steel girders, cement etc. have been adopted by the well-to-do Muslim farmers in regions where colonisation has been intense. These houses are most marked around agglomerations of European population in Algeria, i.e. Oran, Sidi bel Abbes, Mascara, Algiers (see map of types of habitations) in the department of Oran modern villages were planned in some cases for native peasants displaced by colonisation. (1)

(1) A. Bernard & E. Doutte - Op. Cit. P. 227
Fortified Store-Houses are found in sedentary villages in the elevated parts of Southern Barbary where limited seasonal transhumance is practised. The villagers store their grain and other valuables in these storehouses which occupy the safest positions in the village or the neighbourhood and there are separate cells or rooms for each householder. In the Aures Massif these buildings are several storeys high. They are called guelaa and are often located in such formidable positions that no guardians are considered necessary. (1)

In southern Tunisia where they are known as ghorfas they consist of round roofed cells in rows, often several storeys high. In Morocco they resemble the guelaa of Aures in certain parts i.e. the Anti Atlas and are called agadir or assume the appearance of four towered Mghremt (see photo 26) which also house families sometimes.

Fortified Rural Centres: While most old-established sedentary villages in Barbary are placed for defence against attack, true fortress-settlements have developed in certain zones. Above the foot-hill zones of the Atlas ranges in Morocco, large fortified strongholds were built in the valleys. Locally known as kasbahs these once housed turbulent feudal chieftains whose importance was recognised by

(1) G.H.T. Kimble "The Berbers of Eastern Algeria" C.J.1941 P.342
the Sultan. Among these are Warzazat and Kasbah Tadla. The chiefs have lost much of their political influence by the establishment of French suzerainty but their settlements have usually become regional administrative centres.

Absence of Market Towns: On account of ever present insecurity and the absence of a large surplus among tribes with predominantly subsistence economy, no rural market towns arose. Instead, the function of exchange was taken over by weekly open markets or fairs (suqs). Some market centres have developed since the French conquest awakened the region to the requirements of world trade and commerce and introduced modern transport.

The Urban Settlements and their Role: The cities that grew up during the Arab epoch were mostly new centres created at the behest of a reigning monarch. The older cities decayed. Among these new cities those in Morocco deserve particular attention because many of them served at one time or the other as royal capitals and exerted a considerable influence on the countryside by settling large numbers of people whose needs led to the destructions of forests and the extension of cultivation. Fez, Meknes, Marrakesh and Rabat have all been capitals of Morocco. They are said to owe their origin and growth to the fancy of the kings of the time. Fez was founded in 808 A.D. by Idris II, Marrakesh in 1062 by Yusuf ben Tafshin, the founder of the Almoravid dynasty. The shifting of capitals was not entirely due to whims of fastidious monarchs but followed the policy of the kings in accordance with the well-known
A village in the irrigated section of the Beni Amir Plain. Nwalas without courtyards mix with houses with courtyards to indicate not only the relative prosperity of different peasants but also their recent change from a largely pastoral way of life. There are no planned streets but the houses are jumbled together in an incoherent mass.

Village of Amizmiz at the foot of the High Atlas. This is a large settlement built on a dissected fan of a large perennial stream and consists of two-thousand houses. View taken across the wadi shows terraced olive groves in the foreground, the village rising in tiers on the slope opposite as well as the lower gentler slopes that are partially terraced for unirrigated cultivation.
26 Tighremt (fortified grain-store) south of Marrakesh. Some of these towered structures are also used as communal residences. In the foreground land is barren for the lack of irrigation.

27 European village of Enfidaville in Central Tunisia midway between Tunis and Sousse. It lies at the centre of the large estate of Sidi Tabet covering 247,000 acres. It houses the European managing staff and is a regional administrative centre. Building to the right is a mosque for Muslim workers. Field of barley in the foreground across a small stream.
geographic principle laid down by Vaughan Cornish. (i) Each of
the capitals has been located in a productive region ("Storehouse")
such as the Haouz plain around Marrakesh or the Fez-Meknes
region. Marrakesh lay on the vital route to the south from
which its founder originated, Fez and Meknes both lie on the
important route along the Taza Gap to Algeria. Rabat, the
present capital, was chosen with the Moroccan Sultans
concentrating their attention on European coastal invaders.

The cities have been a world removed from the rural
settlements and their old established inhabitants have always
considered themselves to be the real gentleman, hadria, distinct
from the peasant settlers of towns, the berrani. Only four
cities in Barbary are known as hadria, Fez, Rabat, Tlemcen and
Tunis. (ii)

The older cities of Barbary consist of three parts,
the citadel or kasba, the residence of the ruler or governor
and his advisers and servants, the ghetto or mellah, the quarter
reserved for Jews and the main body of the town, the medina
with its numerous suqs (bazaars) and markets. These towns have
always been centres of administration, culture, trade and
handicrafts. Their agricultural influence has not extended
beyond their immediate environs. Some of the larger absentee
landlords live there. Usually the inhabitants of the outskirts
are cultivators of vegetables and fruits. But on the whole

(i) "Great Capitals" London 1922, p vii to ix
(ii) A. Bernard Afrique Septentlonale et Occidentale P.87
The town of Mateur in northern Tunisia lying in the centre of the Mateur plain with the undulating Beja region in the distance. Notice the mixture of flat-roofed old type houses in the distance and the tiled and gabled roofs of modern houses in the foreground. Mateur is one of the few old towns that might be called a rural marketing centre.

Town suq (market) at Mateur devoted to the sale of cattle. This one is held weekly on Monday in this large courtyard around the domed tomb of a marabout (saint). Modern buildings around are banks.
the urban settlement in Barbary has always been out of harmony with the countryside by its appearance, activity and spirit.

The Open Market or Suq: As stated, there was a marked absence of market towns over the region before the advent of the French. The number of sedentary settlements was small over large areas and even these did not have any considerable commercial activity. Under conditions of a semi-nomadic life, difficult communications and insecurity, there came into being the institution of the weekly market at which the members of neighbouring tribes could exchange their surplus produce for other necessities. The suq has long since become established as a feature characteristic of the rural economy of Barbary and plays such a significant part in the social, economic and political life of the rural population that it continues to thrive despite the growth of numerous trading centres all over the region in recent years.

The suq is held once a week in an area which may be occupied by one tribe or a subdivision of a tribe and is named after the day of the week on which it is held (i.e. Suq el-Arba, the Wednesday market, Suq el-Khemis, the Thursday market etc.) Larger tribes may have one on every day of the week in their different sections. The suq is never held on the same site on two successive days but may sometimes take place near the same site on two different days if there is sufficient demand for its functioning in that neighbourhood.
The arrangement and activity of a large suq in Morocco may now be described. The reason for this choice is two-fold. Firstly the suq is found in its most characteristic form in Morocco where French rule came latest and consequently the new rural centres have not changed the aspect of the suq. Secondly the suq reaches its greatest development where exchanges take place between products of contrasted economies i.e. between the products of the mountain-dwelling pastoralists or arboriculturists and the produce of the cultivators and artisans of the plains and valleys. These contrasts are most developed in Morocco.

The map showing the distribution of suqs in Morocco shows some distinct alignments corresponding to the zones of contact between tribes having different resources and modes of life. The N.E. to S.W. trend north and north-east of Marrakesh and the east-west arrangement of suqs to its south mark the contact between plains with sedentary cultivation and mountainous zones within which pastoralism is dominant. East of Fez there is a similar east-west arrangement of suqs at the foot of the Middle Atlas where exchanges take place between pastoralists and grain-cultivators. Between Meknes and Port Lyauty a curved line of suqs occurs where the Mamora forest with its wood-gatherers and pastoralists comes into contact with the cultivated plain. East of the Atlantic plains between Rabat and Safi, a noticeable alignment is N.NE to S.S.W. at the edge of the central Massifs which are largely semi-nomadic. A concentration of suqs also marks the lines of contact between the
Plan of a Large Rural House (Dar) in Morocco.

[After Perry, R.G. Morocco, 1923]
Sous plain and the bordering ranges.

This emphasis on Morocco should not mean that the suq is disappearing in Algeria and Tunisia and is being displaced to any large extent by the new towns. The main currents of native life go on side by side with the development of internal and external commerce and though the wares sold at a suq may change from native woven cloth to machine-made textiles, the suq itself continues to function as a medium of exchange and as a social factor of great influence.

A large Moroccan suq as will be described now represents most of the features common to most suqs in other parts of Barbary. It has an important political function as this is where the tribe congregates and justice can therefore be conveniently administered. Hence the centre of the larger suq is usually occupied by a group of tents housing the tribal and government officials. They collect dues and taxes, administer justice, and while some are maintaining peace and order others known as adoul (lawyers and solicitors) give legal sanction to the larger transactions such as the selling and purchase of animals. (i)

Around the administrative nucleus stretch the tents of traders selling comparatively valuable goods. They are grouped into three main sectors which are regularly arranged in the same

(i) The account of the Moroccan suq is based largely on W. Fogg "The Suq: A Study in the Human Geography of Morocco" "Geography" 1932, 257-267. The writer however did visit a number of suqs in different parts of Barbary - see photographs.
Diagrammatic Plan of a Suq

(after Fogg, "Geography," 1885)
MODES OF LIFE AND SETTLEMENT IN THE TUNISIAN SÄHEL.

(Adapted from Deshöft, Ann. de Geog. 1909.)
positions so that clients do not experience difficulty in locating them. The Kaisarya quarter contains foreign manufactured cotton and silk cloth, embroidery and fancy goods. "Suq-el-Haik" houses sellers of woollen fabrics and native outer garments. Lastly the "Suq-el-Altarin" or general grocery quarter sells sugar, tea, candles and other grocery wares.

In the outer circle swarm the miscellaneous traders, usually grouped in a fashion resembling that in towns. The usual positions are indicated on the accompanying diagram reproduced from Fogg. The livestock section forms a very important part of every suq and considerable numbers of sheep and goats as well as cattle, camels and horses change hands. Near the slaughtering section, a group of traders roast pieces of meat on portable braziers providing the poorer tribesmen with their weekly treat of meat.

Indispensable for any suq are the entertainers - acrobats, snake-charmers and story tellers who provide amusement to the tribesmen.

The suq usually commences early in the morning and reaches the peak of its activity in the forenoon. By the afternoon only the people of the neighbouring dwars remain and before the sun sets, the place is so completely deserted that the stranger will find it hard to imagine the morning's activity. During the few hours of its weekly existence, the suq is "like a vigorously pulsating heart; the heart of the tribe"(1)

(i) Ibid p.260
It is not only the centre where all the larger commercial transactions and the weekly shopping for the households is carried out, it is also an occasion for meeting other members of the tribe coming from miles away. Gossip, rumours and news are exchanged and this is the only occasion when the tribe comes into contact with some representatives of the world beyond its limited confines.

The social significance of the suq is further enhanced by its usual association with a marabout. Many of the tribesmen though without any business to transact, turn up to partake of the *baraka* (blessing) of a living saint. In the past days of insecurity and tribal rivalries, the marabouts made the suqs possible by their great religious influence. To the peasant or tribesman inhabiting the wide open spaces of the countryside of Barbary, the day of the suq is a real holiday, the only event which diversifies his monotonous life. Here is business to be done, home needs to satisfy, amusements, justice and last but not least, the blessings of a revered person. The French government has realised the importance of these weekly markets and exercises considerable control and supervision over them. They are also used for giving publicity to government laws, schemes and campaigns.

The location of a suq is determined by custom and the general convenience of access. There are certain essential requirements for a site which have to be satisfied. First and most important of all, water-supply must be adequate for the
supply of thousands of men and animals. Hence suqs are always near excellent wells, springs or a river. Secondly, the ground conditions should be such that under the feet of such large numbers of animals and men, the ground does not become muddy in winter or dusty in summer. Hence stony sites are preferred on flat lands. A hill summit or a slope is chosen where convenient. Sometimes if ideal conditions are not available, the site may be shifted slightly from season to season.

Suqs vary in size according to the resources of the area, and the density of population on the one hand and the strength of appeal of the tomb or the marabout near the suq on the other. Many suqs are of purely local importance and attract only small numbers. Such are the suqs in the higher parts of mountains i.e. the High Atlas. (1) The larger suqs are regional in character and attract thousands of people from a large radius. Some of these have grown into large settlements in recent years e.g. Suq-el-Arba and Suq-el-Khamis, the two centres of the Mejerda valley in Tunisia and the Suq-el-Arba du Gharb in the Gharb plain of Morocco. The geographical advantages of their positions may be noted. Suq-el-Arba du Gharb lies where the main route from Tangier meets the one from Rabat and Kenitra on the one hand the Fez-Meknes on the other. It is also at the zone of junction between the Gharb plain and the Rif Mountains. The two Suqs of the Mejerda valley lie at the centre of the broader part of the plain between the High

(1) W. Fogg "Villages and Suqs in the High Atlas" S.G.M. 1935, 147
Tell to the south and the fertile Beja region to the north.

Suqs are also held in some of the older towns, i.e. in Mateur in Tunisia, two weekly suqs are held, one reserved specially for sale of animals and the other for general purposes. Very often such specialised functions distinguish the several weekly suqs within the territory of a tribe.

Because of its root in local diversity and the corresponding economic and social conditions the suq is bound to continue as a significant and picturesque feature of the rural landscape in Barbary. In a larger way annual fairs of a religious nature (moussems) are also important media of trade and social contact. They take place at the tombs of the more important saints. One of the largest in Barbary is the one that takes place in the Gharb plain at Moulay bu Selham.

MODES OF LIFE AND SETTLEMENT IN THEIR REGIONAL ASPECT

The prevalent modes of life in different parts of Barbary will now be described mainly in relation to agricultural land use and settlement. At the very outset in may be stated that agriculture figures in a greater or lesser degree among all the communities of Barbary and the distinction between nomads, semi-nomads and sedentary groups is based on the relative importance of cultivation and grazing. As Despois has observed "There is no region in Barbary which is purely pastoral"(1) Even the full nomads, i.e. those who have no fixed habitation and move about constantly have some small

garden-plots or a few date palms in some oasis, managed by the oasis dwellers (ksourians) in the capacity of share-tenants (khammes).

Similarly within a tribe some family groups are more sedentary and own cultivated land while others practise seasonal migrations with their animals, the main source of their livelihood.

This diversity of the mode of life within the same tribe is reflected in the types of habitations. A map of the types of habitations in Barbary has been drawn here from a variety of sources (i) including field observations. Its study illustrates this mixture of agricultural and pastoral activity for over considerable areas tents are used along with houses or with gourbis, or with both. The comparison of this map with the map showing modes of life also brings out the intimate relationship between the type of habitation and the mode of life. Permanent houses are associated with sedentary fruit farmers, huts of various types with cereal growers while the tent figures in different areas according to the importance of pastoral activity and the magnitude of seasonal movements, becoming the dominant type of habitation in the steppes and among the Saharan nomads.

(i) Among these are a map of types of habitations in Tunisia in E.C.M. "Tunisie", page 99, an old map in A.Bernard and E.Douttee, Op.Cit; in addition statistics of the types of houses in Morocco in Annuaire Statistique du Maroc 1945-46 have been used along with a map of the modes of life in E.C.M. "Maroc".
Regional Types: The following account of the modes of life and settlement in the regional aspect has been grouped under the three main types - nomadic, semi-nomadic and sedentary. These types broadly conform to the physical conditions, particularly to rainfall as was established earlier by comparing them with the Land Classification Map. The fully nomadic communities inhabit the arid part of Barbary and many of them spend only a part of the year outside the Sahara. Hence only a brief description of their movements in relation to the factors described earlier has been considered adequate for this study. The semi-nomadic population combines a greater amount of agricultural activity with grazing and inhabits most of the regions that are of special interest to this study, notably on the fringe of areas of sedentary cultivation where agriculture has been extending in recent years under irrigation (Shelif Valley, plain of Beni Amir in Morocco) or under dry farming (plateau of Sersou). This has been accompanied by changes in the mode of settlement. As the ultimate aim of this chapter is to provide a background for the study of settlements as well as agricultural land use, these areas have been dealt with in comparatively greater detail. The importance of sedentary agricultural communities is obvious but the detailed regional account of their settlements will be given in the chapters on Agricultural Regions. Agricultural land use in relation to crop-production will also be treated in a subsequent chapter.
THE NOMADS: In the arid Saharan fringe of Barbary the movement of tribes between the Sahara on one hand and the Saharan and the Tell Atlas on the other has not only been by their pastoral requirements but also encouraged by their commercial activity. These regions are the bled Seguia (areas of irrigated cultivation) of Moroccan parlance in which cultivation is possible only at water-points - wells, springs or rivers. The oases grow mainly dates and do not produce enough cereals to satisfy the local requirements. The nomadic tribes have long been the only link between the inhabitants of the oases and the cereal-growing lands further to the north. They transport the dates, carpets, etc. produced in the oases to the Tell zone in the north and bring back cereals and other products in return. Their commercial activity has declined considerably as roads and railways have linked up the important oases with the north. As the meagre natural vegetation of this zone practically dies out during the long summer drought, the pastoral movement to the north is a feature which is bound to continue as long as the desert communities depend mostly on grazing for their livelihood.

Two Saharan tribes inhabiting the regions around the oases of Laghwat and Warga - the Arbaa and Said Arba have been accustomed to moving from their winter encampment in the Sahara to the Tell in the spring and summer, spending these months in the plateau of Sersou and the High Plains of Constantine. Formerly they used to move in large picturesque
caravans in May, carrying their tents and merchandise on the camels. They would graze their flocks and sell the produce of the Saharan oases, mainly dates, in the local markets. In October they would begin the long trek back to collect the date harvest. In the past few decades, the development of European colonisation in their summer pastures as well as the general extension of cultivation due to the increase of local population has restricted the areas available to them. Their movements are now regulated by the French administration and they migrate in small groups of 10-15 families accompanied by their animals.

Movements of smaller magnitude take place among the tribes inhabiting the eastern High Atlas, the Saharan Atlas and the Saharan fringe at their foot. In autumn there is a movement from the snowy mountains in which grazing is impossible to the warmer valleys below. In summer, other groups move to the fertile pastures higher above. Cultivation is carried on along principal streams and around springs. Here is found the sedentary settlement typical of oases and the more favoured valleys, the ksar. Families live in houses made of puddled clay and sun-dried bricks with flat roofs. These are closely packed with narrow lanes in between them and unless an agglomeration is protected by the venerated tomb of a marabout, it has high ramparts all round. The ksourians are usually tributary to a nomadic tribe and cultivate very small plots of land or an orchard containing a few date-palms.
They also tend date-palms or fields for the nomadic tribes. Apart from dates, the main produce, small quantities of other fruits such as pomegranates, apricots etc. as well as cereals and vegetables are also grown. Land is owned individually but the necessities of common defence and protection in the past have imposed a large amount of communal co-operation. Water from the rivers or springs is shared according to strict customs and unwritten laws. In Morocco, such ksour occur principally along the main streams of the southern High Atlas - Guir, Ziz and Dades as indicated on the map of types of habitations. Underground water channels or foggaras irrigate the oases in some parts of southern Algeria and Morocco.

The migratory tribes live in tents made from a mixture of wool and camels' hair. The Beni Guil of eastern Morocco carry the domain of the pastoral nomad to the coastal chain in an area where there is a large break in the southern chains of the Atlas.

**THE SEMI-NOMADS:** The semi-nomads may be defined as those who have a fixed habitat which they occupy for a part of the year but which they abandon for some time to search for pastures. The zone permanently occupied is the one where cultivation is carried on but as agriculture alone cannot support them, the requirements of their flocks necessitate seasonal movements. The range of gradations in the importance of agriculture, in the season and nature of their transhumance is
very great under the complex combination of factors discussed earlier. We can simplify their description by taking them in several categories and elaborating on significant divergences from region to region within these. The present writer has adopted three such categories as shown on the map of Modes of Life.

1. The Semi-Nomads of the Steppes - inhabit the arid and semi-arid areas bordering the domain of nomadic communities. They are mostly semi-nomadic in the transitional sense i.e. they were formerly nomads but are beginning to settle down as cultivation is extended on account of the limitation of pastures and the increase of population. Permanent settlement on the land is not possible without irrigation.

2. The Semi-Nomads of the Mountains - who practise pastoral transhumance because the agricultural resources of the mountains are inadequate to support them and large numbers of tribal communities must follow the flocks and herds to the different seasonal pastures. Herein the communities are part-sedentary and part-nomadic.

3. The Semi-Nomads of the Moroccan Meseta who are intermediate between the above two. They have been pastoralists largely because of the semi-arid climate in which cultivation does not always give good harvests. They come closest to the cereal farmers of the lowlands as their habitat is essentially
fixed and their movements very limited (see diagram showing seasonal movement in the plain of Beni Amir). Despois (ii) following Celerier has included this region in the zone of semi-nomads and sedentary cultivators lying between the coast and the Middle Atlas. Although sedentary villages are common enough on the banks of perennial streams or near springs in the zone separated by the present-writer, pastoralism accompanied by limited movements is much more important than in the Atlantic plains and the number of tents used very much greater. The relatively greater dependence on pastoral pursuits away from the coast is a natural consequence of the decrease of rainfall, the thinner and often stony soils and the more rugged topography.

Semi-Nomads of the Steppes

Eastern Morocco, Algeria and Tunisia have a zone of elevated high plains and plateaux in which natural conditions show a fair degree of uniformity. The zone is not continuous because of the interpolation of the Beni Guil in eastern Morocco, but it is everywhere characterised by a low rainfall, a steppe-like vegetation and an absence of large and perennial irrigation supplies. There are slight differences between different groups according to their history and degree of evolution as well as local variations in the conditions of natural environment.

(i) The differentiation of the third category can probably be extended to other parts of Barbary, particularly to some of the lowland steppes of Tunisia. The writer's observations in that region were so limited, however, that they cannot be the basis of any departure from the general scheme of their present classification.


(iii) Op.Cit. p.745
The Semi-Nomads of Eastern Morocco:

(i) Celerier has calculated the population of Eastern Morocco as consisting of about 100,000 sedentary inhabitants and 76,000 nomads, yet three quarters of the area forms the domain of tent-dwelling nomads, the sedentary population being concentrated in the few places where water-supply is abundant, i.e. some areas along the Muluya and its tributaries. They are inhabited by house-dwelling cultivators living in large agglomerations similar to the Saharan ksour. In these a wide variety of fruit trees are grown, notably in the neighbourhood of the settlements, while further away extend fields of cereals. Apart from these "islands" of sedentary agriculture, life resembles that of the Saharan nomads except for the fact that large areas are annually sown with cereals, especially barley and may yield a good harvest once in several years. The various tribes also own parcels of fertile land and small orchards in the areas favourable for cultivation so that they are in some small measure fixed. The evolution towards sedentary cultivation has been rapid in certain areas on account of colonisation and increase of population. The plain of Angad south of Oujda is indicated in the Map showing Modes of Life as the zone of sedentary cereal and fruit cultivation. This was until recently the domain of semi-nomadic pastoralism. Between Oujda and Taza several tribes practise seasonal migration, leaving the region for the high plains in the south in February, returning in May to harvest their crops. They dwell mostly in tents.

(i) Celerier Op.Cit p.87 He includes in this zone the entire area described in the chapter on STRUCTURE AND RELIEF as Eastern Morocco.
The Semi-Nomads of the Algerian Steppes:

Parts of the Saharan Atlas, notably the Mountains of Ksour are inhabited by tribes owning extensive pastures so that large scale migration is unnecessary. Their seasonal movement consists of a descent to the southern depressions in winter and a summer movement to the sides of the mountains. The habitations of these tribes are chiefly gourbis made of stone and crude sun-dried bricks with thatched roofs. Houses have increased with the extension of cultivation recent years and the animals of many tribes now move accompanied only by the shepherds and graziers. As the population has increased with security, the seasonal migrations towards the north in search of work have increased. Certain tribes such as the Oulad Nail and Oulad Amer go as far north as the plateau of Sersou. (i)

The Tribes of the High Plateaux have had their former commercial activity between the cases to the south and the centres of the Tell region greatly reduced as a consequence of the development of communications, particularly the railway to Colomb-Bechar. The Hamian were a prosperous tribe, renowned for its cavaliers and traders. They lost heavily in their resistance to the French advance in 1900 (ii) and took to the tending of sheep and cattle with the indemnity they received for their severe losses. Some of them still journey as far north as Saida either to do some trade or work for the harvest. The collection of alfa grass in the steppes is yet another source of income.

(i) Despois, Op.Cit. p.236
(ii) Ibid p.238
Their animals, however, do not move with them to any considerable extent. They have remained tent dwellers for the most part.

Among the tribes living south of the Massif of Warsenis, gourbis and houses have increased at the expense of tents as the colonisation of the Sersou region has restricted their pastures and made cultivation necessary. The rearing of camels and horses, formerly their main activity has been everywhere in decline.

The tribes of the Hodna depression consist of a mixture of sedentary and nomadic groups. Several communities still travel in caravans to the north as far as Kabylie, selling salt from the Sebkha and dates from the southern oases. Most of the tribes are really semi-nomads who cultivate the alluvial soils bordering the Shott by means of irrigation from rustic dams.

They live for half the year in houses, gourbis. They leave in small dispersed groups in April and May for the High Plains of Constantine and tend their own cattle as well as those of the inhabitants of these areas. Their tents are found in dwars all over the region between Souk Ahras and the plain of Mejerna.

As the result of the extension of cultivation, the number of their animals has gone down to as low as two or three per family. As a result, "pastoral nomadism is diminishing but the nomadism of labourers is maintained or even increases."(1)

The Semi-Nomads of Tunisia:

In the high steppes, the large Hammama tribe may be chosen as a community typical of the region. They cultivate

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(1) Ibid p.241
the fertile alluvial soils where the wadis emerge from their upper courses, and the larger sedentary settlements are located at the convergence of wadis. At the same time the area of these rich tracts is so limited that large groups tend sheep, goats and even a few cattle. Their tents are scattered in the pastures for the greater part of the year but are found concentrated in the cultivated areas at harvest-time. The sedentary groups have their gourbis and houses agglomerated close to their fruit and olive orchards. The poorest among the tribe move continuously with their tents looking for work. On the whole, however, the Hammama, like many tribes of the high steppes do not practise extensive movements.

The tribes inhabiting the Tunisian Dorsal come down to the neighbouring plains each winter. In recent years as large parts of the plains have come under cultivation, these movements have become restricted and only shepherds and graziers descend with their animals.

The low steppes of Tunisia present some special types of nomadism. In a habitat where growing of cereals presents the same risks and advantages as in similar semi-arid parts of Barbary, the constantly high humidity enables the extension of olivets. While a semi-nomadic life is quite compatible with the growing of cereals, olive orchards require constant attention and so an increasing number of the population has become fixed. Most families retain their mobility, however, and even if they
have houses near the orchards, they set out in spring with tents to other regions to graze their flocks. With greater distance from the coast the usual features of semi-nomadic life in the steppes become apparent, the tribes living by pastoral pursuits but also cultivating cereals in some favourable spots - depressions, valleys etc. Cereals have been extending in recent years with the increase of population. Large numbers migrate seasonally to the Sahel for the olive harvest.

Recent Changes in types of Habitations

Although the principal changes in the economy of nomadic life have been described, namely the diminution of pastures and hence of flocks, the extension of cultivation following colonisation and increase of population, the accompanying changes in habitations call for comment.

As everywhere, modes of life are in evolution and the habitation has ceased to be an exact index of activity. Only among the nomads does the tent convey an idea of dependence upon grazing with the few sedentary communities living in ksour that differ so radically from the dwar of tents. The most notable change in the habitation of the nomadic communities has been a reduction in the size of dwars owing to greater security.

Among semi-nomadic groups, tents, gourbis and houses are all used. Many a tent-dwelling community has continued to live in the old fashion even after taking to settled cultivation. Gourbis and houses have multiplied in the neighbourhood of cultivated areas but their dwellers use tents for several months

(i) Ibid P.243
PART OF A VILLAGE IN THE MIDDLE
ATLAS
when they accompany their still numerous flocks. The gourbi as was described earlier is not always intermediate between the tent and the house for the change from pastoralism to agriculture in a prosperous community means a direct change to the house. (i) The gourbi is essentially the habitation of the poor.

**Semi-Nomads of Mountainous Regions**

In the Middle Atlas, eastern High Atlas and the Aures Massif as well as a part of the Rif range, pastoral life is always accompanied by partial dependence upon sedentary agriculture. The seasonal movements take the shape of a winter transhumance to the plains and a summer transhumance of the Alpine type to the higher slopes. Agriculture is not of the shifting type as in many parts of the steppes but consists of the intensive irrigated cultivation of terraced hill-sides with fruit cultivation playing an important part. The house has long been the normal habitation, tents being used only seasonally by those sections of the tribe (consisting of groups of families) that move up and down with the animals. We may now undertake a brief description of the two main regions having this mode of life - the mountains of Central Morocco and the Aures Massif.

**The Semi-Nomads of Central Morocco**

Apart from their advantages of greater precipitation for cultivation which is restricted by relief, soils and water supply to the gentler valley slopes, these areas have great reserves of pastures under conditions favouring quick vegetation growth.

(i) Ibid p.254
In this respect the plateau-like heights of the Middle Atlas have an advantage over the much dissected High Atlas and Rif ranges. Consequently pastoralism has always been more important here\(^{(1)}\) than in its neighbouring mountains. Natural vegetation is preserved here to a greater extent than in most other mountains in Barbary. That is why one of the larger tribes of the Middle Atlas, the Beni Mguild, have found it possible to subsist almost entirely by pastoral pursuits and have remained tent-dwellers. Their winter pastures in the Sebu basin having been closed to them for several years when they resisted the extension of French sovereignty during the 1920's, their once numerous flocks dwindled in numbers and they were forced to cultivate here and there. Among other tribes of the Middle Atlas, the larger section of whom formerly used to depend upon grazing, there has been a great extension of cultivation since French blockade during their resistance closed the routes to the plains where they could exchange animal products for cereals. Following the establishment of French sovereignty, although the obstacle to trade was removed, the growth of agriculture persisted.

Cultivation is restricted, however, to the valleys and the lower fringes where vegetables, olives, figs and almonds are grown under irrigation while wheat and barley flourish without it. The economy of the region has undergone a far-reaching change with the development of modern road transport and large numbers of tribesmen work in the farms in the plains or enlist in the army. The house has become the dominant habitation in all seasons.

\(^{(1)}\) Célerier "Le Maroc" p.70
tents being used only by shepherds and graziers. The eastern and southern slopes of the Middle Atlas have settlements resembling the Saharan ksour.

The Shawia of Aures

Among the Shawia, who are of predominantly Berber stock, agriculture plays a leading part and grazing is secondary as a basis of livelihood. The emphasis varies from the Tellian conditions of the northern heights, where forests of oaks and conifers occur, to the southern valleys penetrated by desert conditions. In the north, with the help of irrigation from the main streams, cereals, beans, figs, apricots, pomegranates, tomatoes, nuts and dates are grown. Unirrigated cultivation of cereals is also carried on but is a gamble on the capricious rainfall. The two seasonal movements are northwards in summer to the richer and higher pastures and southwards in autumn to harvest dates in the oases around Biskra.

The Shawia are village dwellers and use two types of settlements. The meshta is a collection of houses or tents grouped over the cultivated lands of the valley or wherever the Shawia possess agricultural land. The deshra on the other hand is usually perched on heights overlooking the valleys, the houses rising tiers one above the other. (1) The latter is protected as much by difficulty of approach as by invisibility. Towards the south, the two types combine. During the period when the tribe is away in tents in the northern pastures, grain

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and valuables are protected in fortified store-houses called **guelaa** which are even more difficult of access than the village.

**The Semi-Nomads of Forested Mountains**

The mode of life of the inhabitants of forested mountains differs somewhat from that of the Middle Atlas or Aures. They depended in the past mostly on grazing in the forests for their livelihood but the effective state management of forests under the French administration has limited their rights to use them, excluding entirely the entry of goats and camels as they are so destructive of vegetation. Because of the consequent diminution of pastoral activity, there has been an increasing reliance on agriculture while collection of wood and work in the forests supports considerable numbers. The habitations range from tents to gourbis and houses, the last making their appearance only in sedentary settlements in the larger clearings.

Beginning from the west, the Zaer-Zayan Massif is inhabited by tent-dwelling semi-nomads grazing cattle in the still abundant forests. They also cultivate some land on the fringes of the plateau or in the valleys.

In western Algeria, the inhabitants of the southern most Tell range have become almost completely fixed over the last fifty years or so following the colonisation of their winter pastures in the Tell plains and they have begun to cultivate their lands. Although many have changed from tents to gourbis and houses arranged in small hamlets, the tent
is still used widely and even those groups who how live in fixed habitations have kept their tents to use when following their cattle in spring. Tribal cohesion has disappeared to a large extent. A similar mode of life subsists in the Massif of Wardenis though the region is much poorer.

The forested mountains south and east of the Kabylie Massif have a population that is fixed, lives in gourbis or houses agglomerated in hamlets located around springs or in clearings. It depends mostly on cereal-cultivation which, at the high altitudes suffer from winter frost and snow. Fruit cultivation is neglected but growing of tobacco is a speciality. Seasonal emigration in search of work in the neighbouring plains and valleys occurs on a large scale. Cattle and sheep are also kept, though in restricted numbers.

The Semi-Nomads of the Moroccan Meseta will be described in relation to their agricultural activity in the chapters on Agricultural Regions under "The Central Massifs" of which they occupy the part south of the Zaer-Zayan plateau. As distinguished from other semi-nomadic groups they also extend to the unirrigated parts of the Tadla plain.

The Sedentary Cultivators

The major part of the rural population of Barbary comes under this heading. It is their activity and their problems which constitute the subject of this thesis and come in for detailed and systematic treatment in subsequent chapters.

(i) Despois Op.Cit. p.276
A composite village (Beni Bahdel) above and just downstream from the dam of same name. It lies on the southern slope of the Mountains of Tlemcen and is typical of elevated fruit growing regions. The steep slopes with crags are fault-scarps while the valley of the Tafna river at the foot of the picture is a gorge. The village comprises three "quarters" or hamlets inhabited by different sections of the Beni Bahdel tribe. Two of these are seen in the photograph, one on the upper ledge near the top and one in the middle above the terraced fields. Trees are olives which constitute the cash crop. Cereals are cultivated on the terraces.
Farm settlement typical of intensively colonised region. It lies on the crest of a gentle undulation in the Baja region of Tunisia. The situation of the houses on top is due to its thin infertile soil. Large modern European farm with pitched roof and aeromotor to the right with huts of the workers lying in rows to the left. In the immediate foreground, the fertile lower slope is fallow ploughed. Just beyond, the farm building has a small garden attached to it marked by cypress trees (This aspect is fairly typical of colonists farms in Barbary)
Here it is proposed to outline only the essentials of their mode of life and lay down certain principles that determine the types of habitations used as well as the nature of agglomerations. A detailed account of their settlements will be given under the various agricultural regions.

Over most of the low-lying plains and valleys, sedentary cultivation has extended in recent years following the establishment of security. The traditional centres of sedentary cultivators have been the elevated and well-watered Massifs of the High Atlas, Rif and Kabyliq for reasons that were discussed in the first part of this chapter. Although animals are kept, they form only a secondary source of livelihood. Along with these Massifs, other notable zones of sedentary village-dwellers have been the Cap Bon and Sahel regions of Tunisia. It is to be remarked that these as well as the elevated regions are devoted essentially to the cultivation of fruit trees. This preference for arboriculture is directly related to the climatic regime. Fruit trees that are adapted to the Mediterranean climate find water at greater depths than other crops and are thus not adversely affected by the variability of rainfall. Another reason for their dominance in the over-populated Massifs is that they support a higher density of population. But while they offer these advantages for a dense settled population, they also require constant care and attention which is possible only under conditions of security and peace. The olive has often been referred to as the tree of peace, but other fruit
cultivation requires security. In this respect again, the above-mentioned regions presented manifest advantages, the Massifs because of their natural difficulty of access and the northern Tunisian lowlands because of the settlement of the Moors from Spain.

Some of the groups inhabiting the regions that will not be treated at length later on may be described briefly here.

The Shleuh inhabit the southernmost chains of the Atlas system (the High Atlas and the Anti-Atlas) and the Sous plain between them. They depend mainly on the cultivation of fruit—almonds, figs, olives and apricots—while some cereals and vegetables are grown wherever possible. Rainfall being higher in the High Atlas, irrigated cultivation extends to heights of 6,600 feet and walnuts figure increasingly at high altitudes. Life is centred in large villages most of which are dominated by large collective granaries (agadir or igherm). These villages centre around springs or permanent streams. They usually consist of several hamlets each inhabited by an ikhs (kin group brotherhood). Grazing is carried on as a secondary source of livelihood and small numbers of shepherds and graziers move to the higher pastures (known as tichka in the High Atlas) in summer. They use special summer houses of stone or thatch and the use of the tent is limited. Fortified granaries are less important in the High Atlas.

The Jebala and the Rifans who inhabit the Rif mountains also depend upon fruit cultivation. They live in houses of
a type peculiar to the region being constructed of mud walls in two stories, the upper storey with a thatched roof serving as a grain store. This is reached by means of a ladder. These houses are locally known as nwalas and should not be confused with the nwalas of the lowlands. The population is concentrated in large agglomerated villages.

The Kabylie Massif in Algeria and especially the Kabylie of Jurjura is inhabited by village-dwelling arboriculturists. The olive is the principal source of food and wealth though other Mediterranean fruits are also grown. Trees benefit from manures and from irrigation. There is little land to spare for pastures and relatively few animals are grazed. Bullocks used for ploughing land are often jointly owned by several peasants, such is the scarcity of draught animals. Cereals (especially barley) are grown on terraces.

A special house-type is associated with the Kabylie Massifs consisting of a single storied house with gabled roofs. Although the popular conception of the picturesque Kabylie village perched on a crest is not wrong, such villages are not as common as they are supposed to be. More common are the villages scattered in several small quarters (kharouba) which together form the village (taddart)

Most of these Massifs are greatly over-populated. Despite the rare ingenuity and care shown by the vigorous and active populations to extract the maximum from a poor and stony
soil, large numbers have to migrate to the plains in search of work. The Kabyles in particular work in large numbers on European farms in Algeria, or live in towns doing trade and commerce. Since the First World War they have emigrated in large numbers to work in factories in France.

The Sedentary Population of the Plains and low Hills

For reasons of insecurity and lack of irrigation, the low-lying valleys and plains were not inhabited by sedentary cultivators on a large scale and grazing of cattle formed an important source of livelihood. Tents and huts arranged in dwars were the dominant type of settlement, sedentary villages clustering around the sacred tombs of marabouts. By establishing peace and security the French administration removed the fear of rival tribes or nomadic intruders. But this factor by itself would not have sufficed to fix the population who would have followed the traditional mode of existence by geographical inertia. It was the acquisition of large areas by European settlers which limited the pastures and rendered cultivation necessary. The example of the colonists and the increase of population were other factors which stimulated this development.

The evolution from semi-nomadism to sedentary life is by no means rapid because traditional ways die hard among a people attached to their way of life. J. Despois (1) has summarised

(i) Ibid p.305-307
the process of growth towards sedentary life among a tribe of the High Plains of Eastern Algeria. Before 1830 the tribes Oulad Abd-en-Noor and Eulma lived in tents and moved regularly between the Srawat, fertile and well-watered hills in the north and the Sebakh, vast alluvial depressions with the marshy sebkhas in their centre in the south. After sowing the Srawat area with wheat and barley, they would migrate with their cattle and sheep to the Sebakh, going as far south as the Hodna depression in severe winters. They would return in spring to harvest the crops and grazed the animals on the stubble. By 1864, first signs of fixation began to appear when meshtas (winter huts) were constructed and grouped in hamlets in the Srawat region. Most families still retained their tents but only a part of the tribe migrated southwards. As colonisation acquired more lands more and more hamlets sprang up, the number of tents decreased and fewer people migrated with the reduced flocks. Slowly as population increased even the lands in the Sebakh area were ploughed up and collective properties were divided. By now the fixation of the tribes is complete and they inhabit gourbis made of sun-dried bricks with thatched roofs.

The nature of settlements in all the cultivated lowlands and plains need not be described here in detail. A distinction may however be made between the areas of intensive colonization where European type houses and settlements are
numerous. The two main effects of colonisation have been on one hand to stimulate those of the native cultivators with sufficient lands to adopt their type of cultivation, i.e. in the Mostaganem region 8000 fellahs cultivate 32,000 acres of vines. The other result of colonisation has been the creation of a large landless proletariat which produces a glut of labour. There is a continuous movement of labour from region to region so that the labourers do not construct permanent houses but live in gourbis.

In areas of less intensive colonisation, fixation of the rural population to the land has taken place mainly through the increase of population. Fields have come to have definite boundaries as the sense of private ownership has replaced periodic redistribution within tribes. Gourbis and houses have multiplied at the expense of tents.

As stated earlier, the detailed description of settlements in the cultivated plains will be given in the chapters on Agricultural Regions.

**MODES OF LIFE AND SETTLEMENT IN WEST PUNJAB**

Unlike Barbary, almost all the rural population in West Punjab is devoted to sedentary cultivation or related pursuits. Consequently no differentiation is modes of life is called for. It may be recalled, however, that in the not very distant past, extensive areas in the Bar uplands now comprising
the Canal Colonies were barren prairies in which a nomadic population grazed its cattle. Life was insecure and the sedentary villages were confined to the neighbourhood of rivers. Even these had to pay protection money to the raiding nomads. As the country became gradually settled following the establishment of an effective administration under the British, the cattle-lifting nomads had to make a living out of more honest pursuits and quasi-permanent settlements called "rahnas" were established. (i) The various groups, however, still depended largely on cattle and moved around looking for pastures and violence or thieving still persisted. It was only after the great canals were opened and these semi-nomads settled in villages that this mode of life disappeared. (ii) In other parts of the province traces of the ancient dependence on pastoral pursuits are found in the great value put on cattle wealth.

Attention may now be concentrated on the various factors that determine the nature of rural settlement. The basic unit of the rural landscape is the village. As in Barbary, the village is usually inhabited by a tribal or family group, the tribes, which are numerous, tracing their descent from various invaders of the country in the past or from some illustrious or legendary history figure within the country. Whatever their origin, they have a marked sense of unity and possess a patriarchal organisation. Certain leading families exercise

(ii) For dates of the opening up of different canals, see Chapter on Irrigation where an account of the colonization of irrigated lands is also given.
great influence and possess vast agricultural domains so that they have a far-reaching influence on the pattern of settlements as the following account will show.

A repetition of the various factors involved in agricultural settlement would be unnecessary. Those factors that apply specially to West Punjab or any other features peculiar in themselves may however be briefly indicated.

**Physical Factors:** As in Barbary, a combination of favourable climatic conditions and fertile land has taken place only in restricted regions which have long since been densely populated by a sedentary population. These are the sub-montane districts and the northern part of the Potwar Plateau. The fertile alluvial plains receiving less than 15" of rainfall were settled densely only on the basis of irrigation.

The rivers of West Punjab have figured prominently in determining the nature of the habitations and of settlement. Their liability to annual flooding made villages seek higher ground. At the same time as the lands moistened and enriched by floods are among the most fertile, temporary houses or huts have often been constructed in these tracts. Thus in the Mianwali District, huts predominate in the riverain lands on either side of the Indus. (1)

The influence of vegetation (or rather the lack of it) is discernible in the use of mud even in temporary structures because vegetation in the semi-arid plains has never been over-abundant since the Bar regions were brought under cultivation.

(1) Punjab District Gazetters, "Mianwali", 1915, p.44
Cultural Factors:

Mention has been made above of the role of tribal loyalties in agricultural settlements. This is a powerful factor indeed because the colonization of the newly irrigated areas did not succeed till the system of sending village and clan groups was established. In a population of small-holders, co-operation between the cultivators is necessary in the execution of various agricultural operations, the loan of implements or of cattle and the provision of help against difficulties. In this family ties play a leading role.

The influence of religion was most marked in the foundation of villages when several religious communities - Muslims, Hindus and Sikhs - lived side by side. Thus each community would tend to live in villages of its own or within larger villages, in quarters special to its members. Within communities, smaller religious groups of various orders and classes had the same tendency and among Hindus, the caste system used to play an important role. With the substitution of this multi-religious society by an almost purely Muslim population this factor is bound to recede into the background.

Security is again a factor that has operated powerfully in the past, resulting in the foundation of large, compact and fortified settlements but has today been replaced by the opposite tendency - that of dispersion under peaceful conditions. Many of the older villages in the Salt Range and the Totwar Plateau stand out as having been founded as strongholds.
Economic factors especially the relative prosperity of villagers play an important role in determining the size and structure of the habitations. In most villages, the larger landowners live in double-storied brick houses while the smaller owners and the tenants inhabit the typical Punjabi rural house—mud walls enclosing a courtyard with one or two rooms at a side and an open veranda in the medium sized houses. It is customary to keep the cattle in the courtyard. The roof is always flat and built of wooden rafters covered with reeds over which mud is then spread thickly.

The Influence of Irrigation: In those parts of the province where agriculture is largely dependent upon irrigation rural settlements have been influenced greatly by the sources of irrigation water. While it is possible to have compact villages under canal irrigation, well-irrigation encourages and even necessitates dispersion particularly if wells are located at considerable distances apart. Residence near the well offers obvious advantages of closer supervision of cultivation and irrigation and saves all the time or energy wasted in journeys to and from fields.

Towns: in West Punjab have largely developed as regional markets for agricultural produce or as administrative centres. There are some ancient cities like Lahore, Multan and Sialkot whose influence on the surrounding countryside is comparable to the older capitals of Barbary. New towns have also grown up and progressed in the Canal Colonies and
Lyallpur which was an insignificant village before 1890 had a population of 70,000 according to the 1941 census. Unlike Barbary permanent marketing centres have always existed in West Punjab.

Regional Types of Villages:

The influence of various physical, cultural and economic factors is reflected in a variety of village types found in the province. These can be grouped as follows:

The mountain villages of the Murree Hills: In these steeply sloping hills, cultivable land is scattered in small parcels on gently sloping spurs or on narrow terraces on the mountain-side. Hence the dispersion of villages reaches some of its extreme forms as each family finds it advantageous to build its house, cattle-shed etc. close to its own lands. Villages therefore merge into one another and consist of widely scattered houses grouped either by tribal or family ties or merely for the convenience of revenue collectors. More compact settlements occur on larger spurs or on "galis" - places where parallel ridges are joined by a col.

The Potwar Plateau and Salt Range are characterised by villages divided into several sizeable hamlets with one large central abadi (group of houses). The reason for this dispersion is primarily the quality of the land. As much of the land is eroded by gullies and ravines and traversed by the wide pebbly beds of torrents, cultivable land is restricted to small areas where it needs careful embankment and manuring.
Hence the rural population scatters itself into "dhoks" or hamlets of varying size. The territory of individual villages may cover vast areas, 50 to 100 square miles being not rare for the larger ones and may include a large number of dhoks. The Jhelum District Gazetteer gives another reason for the occurrence of scattered hamlets, this being that the warlike ruling tribes scattered their tenants close to the land to exploit them better and afforded them protection from their strongholds. Some old villages in the Salt Range are located on high ridges and bear out the function of insecurity. In the more fertile areas of the Potwar Plateau the Chachh tract of Attock, large compact villages are the rule.

(3) The Old Settled Districts: These include the submontane tract and the central Punjab districts of Gujranwala, Sheikhpura and Lahore. Rainfall in these districts can support unirrigated crops though somewhat precariously in the last two districts where irrigation has long been developed. Cultivable lands are compact and have been densely settled since ancient times. With these districts is associated the typical Punjab village - an agglomeration of mud houses with narrow crooked lanes, the larger houses (occasionally brick ones) being in the centre while the poorer and smaller houses of tenants and menials stretch on the outskirts. A mosque or a temple usually lies in a prominent position. Most villages have a pond of stagnant water created by the removal of earth for building houses. This is used for watering the cattle.

Occasionally a few scattered houses may occur near wells but the type settlement is a compact one within which the community is a well-knit entity.

(4) The Canal Colonies: The old established villages in these tracts consisted of numerous small hamlets scattered around wells although with greater dependence on canal irrigation, larger and concentrated settlements were also encountered. Settlements established since the commencement of perennial irrigation have been planned by the state and while the houses are still constructed from mud, they are roomier, are aligned along regular streets and there is also provision for a central open space in these villages.

(5) The Western Districts: Here, cultivation still depends upon a precarious inundation canal irrigation with wells providing the only secure source of water-supply. Hence there is a dispersion of villages into small groups of dwellings around the wells. In the western part of the Shahpur District at the foot of the Salt Range, villages occur in dhoks with the central dhok at the edge of the plain while smaller groups of habitations lie on the hill slopes or out in the plain. (i)

Settlements in the Thal desert consists of large, sedentary villages even though the people are still largely pastoral and wander over considerable distances. Wherever wells are used for irrigation, however, a centrifugal tendency sets in. (i) Punjab District Gazetteers: Shahpur, 1917, p.51
In Mianwali district, villages consisting of scattered houses, are found in the mountainous tract. These resemble those in the Murree Hills. Along the Indus, settlements tend to cluster on higher banks due to the danger of floods.

Some individual examples of villages will be provided under Agricultural Regions.
IRRIGATION

The practice of irrigation is a fact of human geography subject to the control not only of natural environment but also of men. Just as natural vegetation represents the sum and total of environment, the systematic application of water to land to grow crops is an integration of both the physical and human conditions.

In semi-arid areas such as the major parts of the regions under review, irrigation is the cardinal factor in agriculture and in the rural landscape. The contrast between unirrigated and irrigated areas is striking and is reflected in the life of the people and their standard of living. The unirrigated tracts are usually barren wastes with a sparse vegetation on which subsist the animals of a semi-nomadic population that knows no comforts, little security and lives close to starvation. If the rains come in time and in some quantity, the few fields sown carelessly yield a harvest that maintains the wandering group for some time. If the season is one of drought as it is more often than not, famine and misery are the result. Such was and is the state of human life in those of the semi-arid parts of Barbary and West Punjab that depend upon the rains. Irrigation completely changes the aspect to one of smiling fields, well-planned villages and flourishing sedentary communities of prosperous peasants who produce more than their need and obtain all the amenities.
of life. In many an unproductive waste, the transformation has taken place recently through the construction of modern irrigation works, i.e. the Lower Chenab Colony in West Punjab or the Plain of Beni Amir in Morocco. The statistics of their evolution will be given later but it is obvious that irrigation provides the one answer to all the problems, economic and social that arise out of that crowning disability of environment - scarcity of water to grow crops.

**Factors in the Development of Irrigation**

Basically the formula for the development of irrigation is a simple one. The need for irrigation should be present, facilities for it should exist and there should be sufficient human ingenuity and social organisation to utilise the water-resources.

All these factors vary at different times and places. The need for irrigation may not be felt even in a semi-arid region if there is only a sparse population that can make its living comfortably out of pastoral pursuits. The facilities for irrigation may be perfectly or imperfectly known according to the stage of culture of the inhabitants. Finally the intelligence of the population may not rise above the obstacles to the utilisation of water resources, and technical ability or social cohesion or both may be lacking rendering large-scale irrigation impossible.

Taking up the two regions under consideration, we
may now establish the bases for the development of irrigation. The limit of unirrigated cultivation of staple crops, i.e., cereals, is 16" (i) in Barbary and 20" in West Punjab. (ii) Except for a limited northern fringe, the major part of both the regions is thus in a zone where agriculture becomes precarious without irrigation. Even in the humid sections, the seasonal distribution of rainfall reduces the agricultural utility of seemingly high amounts of precipitation and it has always been found useful to irrigate crops in order to ensure high yields. The variability of rainfall is yet another hazard which endangers the livelihood of the peasant even in the most favourable parts. Finally the increasing commercialisation of agriculture has introduced crops like citrus fruits in both the regions, cotton in West Punjab and some parts of Morocco, and many others which cannot flourish without irrigation. From the climatological viewpoint, then, irrigation is a necessity almost everywhere in these regions.

The social and economic need for irrigation has been increasingly felt as the population has continued to grow at a very high rate indeed. The population of West Punjab grows about the fastest in the Indian sub-continent which itself is a region of phenomenal increase. From 1901 to 1941,

(i) This figure was quoted to the writer by almost all the farmers and agricultural officers he met. Also mentioned by several authorities on the region, notably Despois Op.Cit P.99-101; Bernard, Afrique Septentrionale et Occidentale, P.47

(ii) The amount of rainfall necessary for unirrigated cultivation is higher in West Punjab because rainfall occurs mostly in summer - the season of high evaporation
the overall increase in numbers amounted to 7 million.

Barbary too is a region of great population growth and Algeria for which alone figures are available for a long enough period, almost doubled its population in 50 years from 1886 to 1936 (i) from 3,200,000 to over 6,000,000. As the area ultimately suitable for cultivation is limited, the only means of supporting this fast increasing population is by bringing more areas under the plough and intensifying production in regions already exploited. Irrigation alone can enable that to be achieved. It can also help in raising the standards of living which are pitifully low at present.

Coming now to the facilities for irrigation, West Punjab is one of the most favoured regions in the world. The alluvial soils of the plains are everywhere rich in most elements of fertility. The alignment of the great rivers which spread out over the entire plain in such a fashion as to be able to water the dry wastes in between by gravity is by itself an advantage of the premier importance. Their water régime as set out in the chapter on hydrography is such that the melting of snows brings down abundant supplies during the most precarious part of the year - the hot and dry early summer. The quantity of water available throughout the year has proved to be sufficient for all needs. Barbary by reason of its smaller rivers with an unfavourable régime of water supply has facilities for irrigation that can hardly compare with West Punjab. There is a superabundance of water during a season

(1) Georges Froment-Guieysse "Histoire de la Colonisation et Elements de Demographie" I.C.M. "Algerie et Sahara" P.238
when rainfall is sufficient and irrigation is unnecessary. In the absence of extensive snow-cover, the rivers run dry and tend almost to disappear during the summer when water is most needed. Large-scale harnessing of such streams have proved to be much more costly and difficult. As regards underground supplies they are again present almost everywhere in West Punjab at low depths (see map ) whereas their occurrence in Barbary is limited to comparatively small areas.

The factor of human ingenuity and of co-operative or state-organised enterprise has varied in history as we noted in a previous chapter. Many of the methods still practised in both our regions have come down through the ages without being greatly modified. The greatest development of irrigation works has, however, taken place during the past hundred years or so when modern scientific technique and a marked degree of political stability enabled the ruling western powers to put into operation irrigation works on a scale hitherto unknown in these regions.

Today the old and the new systems exist side by side and shall be considered separately in order to bring out their characteristics and the way they are adapted to the natural and social environment. After treating the growth, the merits and the future of these systems, their influence on agriculture shall be discussed, followed by an account of rural settlement in irrigated colonies and its effect upon the semi-nomadic
peoples of these areas. The benefits of irrigation having been fully appreciated, its problems will then be taken up in this and the subsequent chapter.

**BARBARY**

Before the French conquest of Barbary, several modes of irrigation were in existence dating back mainly to the early Islamic times. These were admirably adapted to the environment and to the needs of a simple society that knew not of capital or of state-enterprise. They were governed by complicated (1) customary laws of water rights. Since the advent of the French however, large modern irrigation works have been constructed primarily for benefit of European settlers. The older systems have persisted among the communities that have used them since long but the French administration has modified their management to some extent in order to make them conform to the irrigation policy of the State as well as to increase their efficiency. They are also being modernised. We may now study the traditional and modern systems separately.

**The Traditional Systems:**

These consist of various types of wells, earthen barrages and stone dams that impound water during one season and khettaras or underground channels connected by wells which

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(1) The writer is not aware of any study of these laws which would doubtless be of interest. Most French authors remark on their intricacy and pass on to other things.
Well in the Kairwan region of Tunisia. A mule pulls a leather bucket up by means of the pulley seen on the well. Peasants mud house in the background. The land is flat and covered with natural grassy growth immediately around the well which is of modern design, i.e. stone bricks have been set by means of cement.

A well with a "dalou" in the Cap Bon region of Tunisia. This ingenious water-lifting device consists of two bullocks who walk down an inclined surface thus pulling two leather baskets which empty themselves automatically into the water-channel. Cactus on either side; a ploughed field and fruit trees in the background. This device is of ancient design as rough and crooked branches have been used against stone masonry in the well described above.
Wadi Fodda Dam. Note its different structure from the Ghrib dam - a concrete wall instead of a massive pile of stones and masonry. Built across a stony gorge. Its catchment area has been planted with trees to prevent silting up. Notice the heights of the Warsenis seen faintly. The dam has been irrigating the Orleansville plain since 1937.

The large reservoir at Larjana which is going to further regulate supplies from the Ghrib Dam. Notice cultivated land in the background with gentle hills on the left. White patches are ripened barley. Threes seen are fruit trees on the left but a canopy of natural growth on the right.
are designed to bring sub-soil water over distances with a minimum of evaporation. The last-named system is limited, apart from the Sahara, to the Haouz or Marrakesh plain in Morocco. There are also the springs which are utilised through canals or "seguias".

The account of these systems must remain very general as statistics are not available of their total number and the areas they irrigate. The one exception is the khettaras on which a paper was recently read by M. Petit, Agricultural Engineer of the Division of Marrakesh. This is fortunate as this is one of the most interesting systems of irrigation to be found anywhere.

Taking up well-irrigation first, the exact delimitation of the area where it is practised is difficult. In most alluvial plains where sub-soil water is not too deep, it may be used to a lesser or greater extent. There are also artesian supplies most prominent in southern and central Tunisia. The writer noticed well-irrigation on a really large scale in two regions, both in Tunisia- the Hammamet-Nabeul region of Cap Bon and near Kairwan. Only these will be described in some detail.

Wells are, in many ways, the ideal means of irrigation. As each proprietor owns his well, he can obtain water whenever he likes and in whatever quantities desired according to the

(1) L'Irrigation par Rhettaras de la Palmeraie de Marrakech" 1949 Unpublished.
requirements of the crops. As water does not have to be carried over long distances, there are no great losses by percolation or evaporation. Finally not only are there no rents and duties to be paid but the system is also free from all official formalities that become the bane of the peasant's life in large-scale government schemes.

Irrigation by wells is practised almost to perfection in the Hammamet-Nabuel region of Cap Bon whose inhabitants have "an innate sense of irrigation and of gardening". The well laid-out fields, the correctly aligned water channels and the traditional clump of mulberry trees near the well to provide shade to animals and man bespeaks their inherited skill. Demands on labour are heavy in the cultivation of fruit trees, principal citrus fruits, as well as vegetables and entire families participate, even the children assisting. Very high yields are obtained and it is not rare to see a family of 8 persons subsisting on a garden of 2 1/2 acres. The multiplication of the number of wells has resulted in many wells beginning to dry up. This is a grave menace to the agriculture of a prosperous region. Official steps have been taken to conserve supplies by limiting the number of new wells and also to increase sub-soil reserves by building small dams in the zones of percolation.

(i) P. Penet "Les Irrigations" La Tunisie Agricole, Vol. 31, 1931, P. 52
(ii) "L'Hydraulique Agricole" E.C.M. "Tunisie" P. 403
The area in which well-irrigation is practised near Kairwan is known as Al Awarab. The water is of an excellent quality and is used to irrigate olive trees as well as cereals covering 750 acres. Several modes of lifting water from the wells are used with the help of animals. Principal among these are "dalou" or pairs of bullocks or mules pulling up a self-discharging leather bucket from the well by walking down an incline (see photo) and an ordinary pulley arrangement in which the pulling up of the water is done again by animals.

Rustic dams of mud and stone are constructed across most wadis to hold up the waters of floods and use them for irrigating the fields on both sides. This may more properly be referred to as inundation rather than irrigation as water often covers the fields in times of flood. This type of irrigation has several advantages under the existing conditions:

(a) It utilizes the waters of the average floods to advantage.

(b) Whenever a flood of unusual force occurs, the barrage gives way, thus saving the lands on either side from erosion or coarse deposits.

(c) A temporary dam of this type is very economical and is often constructed by communal effort without capital expenditure.

This mode of irrigation is used widely in Barbary, notably in Algeria and southern Tunisia where the writer
visited the site of several such dams in the region of Kairwan. Brunhes, commenting on the relative merits of the large barrage-reservoirs (which at that time were either being silted up or destroyed by violent floods) and of these temporary constructions, also remarked that the latter responded much better to the natural and economic conditions. (i) The only risk with these dams is that the rivers and wadis may change their courses so rapidly in the open plains that a region which once benefitted from them may become a barren waste. There are instances of this having occurred in the Kairwan region.

Irrigation from springs is practised pretty universally in Barbary wherever a sufficiently regular supply is available. The water is used effectively or otherwise according to the qualities and traditions of the users. P. Penet observed how in most of central Tunisia, the mountain nomads were practising irrigation from the abundant springs in an indifferent and wasteful manner, growing native fruits or cereals on fields that were not properly levelled and divided into beds. (ii) Recent administrative measures taken to group owners of water-rights into associations and to give them agricultural supervision has improved matters considerably. These measures shall be described later on but everywhere, the exploitation of these natural sources is being improved and modernised.

(i) Jean Brunhes "L'Irrigation dans la Peninsula Iberique et dans l'Affrique du Nord" Paris, 1902, P.182

(ii) Ibid, P.50
The khettaras of the Marrakech region in Morocco are a feature that never fails to impress the visitor. The countryside is dotted with rows of wells, some of them shallow, at the bottom of which water may be seen flowing through a channel, others so profound that the eye does not penetrate the sombre depths. These are underground channels which tap the sub-soil water abounding south of Marrakech and bring it by a slope more gradual than that of the surface to irrigate the lands around Marrakech. Tradition ascribes their construction to Youssef ben Tafshin who conquered the region in 1092 and wanted to remedy the scarcity of water. He also founded the date-palm plantation which today covers over 32,000 acres and is the only one of any size north of the Atlas. The khettaras are apparently of Persian origin and are still in existence in Iran and Baluchistan where they are known as "Karez".

The streams which emerge from the High Atlas to the south of Marrakech lose most of their surface water by percolation through their porous deposits. In a region in which rainfall is less than 12", cultivation is impossible without irrigation. Water cannot be brought by surface canals as it occurs at considerable depth. Hence this ideal solution of the problem was arrived at in the use of khettaras and they have continued to flourish till our times. Today there are 600 khettaras in the Haouz plain. Their length varies

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(i) Most of this account is based on M. Petit's paper.
from 160 feet to over 4 miles and the depth of the wells from 8 feet to 200 feet according to the depth of sub-soil water. They lie mostly to the east of Marrakech and their direction follows the general slope from the High Atlas towards the Tensift.

The khettaras had great advantages as means of irrigation before the advent of pumping. They brought water over long distances to the fields without much loss by evaporation. Once constructed, apart from periodic clearing, no attention was required. No animals were needed to work them as with wells. There is no doubt that they have played a great role in converting the environs of Marrakech into a veritable garden, for apart from the date palm, cereals, vegetables and fruit trees are also irrigated. Their merits were recognised even by the French administration which constructed several large khettaras to supply water to European settlers and to supplement the supplies of old ones.

In recent years, however, it has increasingly been demonstrated that tube-wells not only possess the merits of the khettaras but have several additional ones. Khettaras were dug at a time when labour was extremely cheap and indeed to see the length and depth of some of these makes one wonder how much painstaking toil must have gone into them. Today labour costs have gone up so much that a khettara costs more than five times the cost of erecting a tube-well giving
the same quantity of water. Furthermore whereas khettaras could not but tap the sub-soil water superficially, a tube-well with modern boring apparatus can be dug to a depth where its supplies would be constant and secure and not be endangered by a lowering of the water-table. The khettara covers a large area with its wells outside the lands of the proprietor. Nowadays, with increasing population pressure on the land, it is not possible to appropriate such considerable tracts. The flow from the khettara being constant, the sub-soil reserve is being used up even when water is not actually needed. Also the water being exposed at so many wells, does not possess the same purity as water from a tube-well. All these considerations prove conclusively that the tube-well is superior in all respects to this age-old system.

Gradually, the khettaras are being replaced by tube-wells. Even during the last few years, the heavy cost of having the khettaras cleared after the damage caused by torrential rains has prevented many owners from having them cleaned. As many as a hundred khettaras have fallen into disuse. M.Petit is of the opinion that as time passes, this picturesque feature of the landscape will perhaps disappear completely and feels that the gain to the economy of the region through the more systematic and effective means of tube-wells will be incomparably greater. There are instances, however, of a few disused khettaras being revived, repaired with cement
and the writer saw one on which an electric pumping engine had been installed. It is possible that to save the high cost of annual repairs, more and more owners will have their khettaras thus "modernised" but to imagine that they will ever be completely abandoned is difficult as the local population is greatly attached to the system that has served them for centuries. Moreover complete abandonment would be a loss by itself as so many thousands of wells, now in use, will be pure waste. The writer is of the opinion that both khettaras and tube-wells can flourish in the Marrakech region side by side.

The Modern Systems

However ingenious and well-adapted they are to the environment, the traditional systems of irrigation have depended upon the unco-ordinated enterprise of individuals and groups with very elementary technical means. While their exploitation of underground water renders irrigation possible all the year round, their use of wadis and rivers does not attempt anything more ambitious than to inundate their lands during floods. With the advent of the French, the control of water-resources was assumed directly by the state which then attempted to store up the super-abundant supplies of one season for use during the period of drought through the construction of large dams. Although the conception is simple enough, Barbary presented very special problems to the engineer and the development of the great dams has been a notable feat in the
face of these difficulties, a feat rendered possible only through the advanced technical means at the disposal of the government. The chief problems in their construction are as follows:

(1) It is difficult to find suitable dam-sites in areas with resistant and impermeable rocks. This problem is particularly serious in Algeria where about the best terrain available consists of resistant limestones that are deeply fissured. Hence the difficulties in the way of giving the dams a solid foundation have been enormous.

(2) The water regime of the wadis and rivers is extremely irregular (for details was chapter on Hydrography) and has often spelt catastrophe for works previously executed. The extreme intensity of floods defies scientific calculation so that provision has to be made to withstand the impact of the type of flood that may occur once in a century. This lesson has been learnt at a great cost as the dam of Wadi Fergoug in the province of Oran was destroyed in 1927 by a flood of proportions that had not even appeared to be credible to either the engineers or the cultivators. Hitherto, over a period of sixty years, the highest flood-period flow had been 11,100 cusecs whereas the flood which wrought this havoc attained to 185,000 cusecs.¹

Despite these difficulties and the enormous cost incurred to overcome them, the construction of large dams has been found the only really safe means of providing guaranteed

¹ Martin, M.R. "Les Grands Barrages et les Irrigations en Algerie", p.9
The Beni Bahdel Dam on the Taftna is a picturesque structure built in a faulted basin. Notice the scarped fault at the top of the picture and the white outcropping limestone strata. Picture shows the hydro-electric plant at the foot of the dam.

The Nfis Dam, in Morocco, lies at the foot of the High Atlas some of whose heights are visible over the top of the dam. To the extreme right a part of the hydro-electric power station is seen. On the right the slope has been terraced and engineers quarters constructed. At the bottom the road from the power station to the main Marrakesh-Amizmiz highway.
Drainage channel in the Affreville plain indicated in diagram. Vines on either side. The lower gentler and the higher steeper slopes of the Miliana Massif are noticed clearly. Some of the lower heights are wooded.

The main canal in the Beni Amir plain. The water is kept at a high level in the central section to maintain regulated supply to distributaries. On the right, flat surface of the plain can be seen with a nwala in the distance.
supplies of water. The seven older dams which existed in Algeria before the new scheme was adopted in 1920 have either been destroyed by floods (Fergoug), silted up (Meurad) or had to be modified and enlarged (Sig and Hamiz). This is because these dams were not only not capable of withstanding sudden floods but also their capacity was limited to storing up the supplies of one rainy season for use in the following summer. This introduced an element of uncertainty as rains failed frequently and the limited capacity of the reservoirs became reduced rapidly through silting up.

The existing system of reservoirs in Algeria and Morocco was planned in 1920 when the need for storing the water of several rainy seasons as well as of taking adequate precautions against floods was realised. Accordingly these irrigation works have been conceived on a large scale. The table below gives the facts and figures about the quantity of water stored, the areas that are being irrigated now as well as the ultimate total in prospect.

<table>
<thead>
<tr>
<th>Dam or Weir</th>
<th>River or Wadi</th>
<th>Capacity</th>
<th>Irrigable Area</th>
<th>Area irrigated in 1947 (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOROCCO</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>El Kansera</td>
<td>Beth</td>
<td>8,015</td>
<td>74,000</td>
<td>20,000</td>
</tr>
<tr>
<td>Tadla</td>
<td>Umer Rbia</td>
<td>-</td>
<td>98,800</td>
<td>37,000</td>
</tr>
<tr>
<td>Nfis</td>
<td>Nfis</td>
<td>1,836</td>
<td>74,000</td>
<td>12,500</td>
</tr>
<tr>
<td>Wadi Melah</td>
<td>Melah</td>
<td>706</td>
<td>2,900</td>
<td>1,800</td>
</tr>
</tbody>
</table>

(1) Figures of actual irrigation in Morocco approximate.
Photograph shows the Ghrib dam, the artificial lake formed behind it and the hydro-electricity plant at its foot. The bare slope to the left has been terraced at its foot to prevent silting up of the bed. Cypress trees on both banks of the river for similar purpose. On the right above the dam is the small colony of engineers and workers. Photograph taken late in May on a day of passing clouds.
The Batban Barrage on the Mejerda in Tunisia. Flow of water is controlled by means of iron gates operated by the levers seen in the photograph.
construction epitomizes all the natural problems that have to be overcome by the engineer. It is also the only dam constructed on the Shelif, perhaps the most capricious river in the country. Its site lies about 30 miles from Affreville in a region consisting of unconsolidated marls and friable sandstone. The construction of a rigid wall adopted earlier for Wadi Fodda could not be envisaged hence an enormous embankment was created, over 245 feet in height and the side on which water was to be stored made impermeable with the ingenious use of alternating layers of coal-tar and cement. About 8,000 tons of cement and other chemical products were injected into the basin to fill up the fissures and thus minimise loss by infiltration. A very clever device has been used to evacuate waters of great floods without damaging the foundations of the barrage, the water falling into successive cement basins before flowing downstream. After running a hydro-electric power station at the foot of the dam the water flows downstream and is then again taken out by a pumping station at Lavigerie. A large artificial reservoir is being created here to act as an additional store. The dam is designed to irrigate the plain of Affreville.

The Wadi Fodda Dam:- This has been constructed on very secure geological foundations of hard limestones in a deep gorge and is 290 feet high. The bed-rock of the basin was extensively fissured but the injection of over 6,700 tons of cement and other chemical products has overcome this handicap. The dam rises almost vertically on the side away from
the artificial lake it has created while it slopes gradually on the water-side. This was the earliest important undertaking of the 1920 programme to be completed - in 1932. After running a power-station the water is controlled for irrigation by means of a small weir with adjustable iron gates to regulate the flow. The water from the dam of Wadi Fodda irrigates the plain of Orleansville.

The Beni Bahdel Dam: - A very novel and elegant design has been used for this dam on the Tafna, completed only in 1948. The water is held back by multiple inclined arches constructed of reinforced concrete. Its height is 180 feet and the separate construction of these arches has enabled each of them to be given a secure foundation. The device used for evacuating floods is equally ingenious providing a large surface along which water may flow out once it exceeds the safety level by means of a series of projecting conduits at that level. The water released from the reservoir into the hydro-electric plant is canalised by means of a small weir several miles downstream. This dam will irrigate the plain of Marnia and also supply water to Oran.

Not all the dams in Barbary are designed to collect the water of several seasons in a large reservoir and then to release it for irrigation as required. Along streams which have a constant flow, it has been found possible to construct the less elaborate weirs which only raise the level of the water sufficiently high to be diverted into irrigation canals. The
principal work of this type is in Morocco below Kasba Tadla and irrigates the plain of Beni Amir. There are several small barrages of this type in Tunisia of which one on the Mejerdha is shown in the photograph opposite.

Mention may also be made of the use of oil engine pumps on wells as well as of tube-wells. The former are used extensively in Tunisia while the use of tube-wells is becoming specially important in the Marrakech plain where 250 tube-wells have been dug up till now. Pumping water directly from the rivers is also resorted to particularly in the Gharb plain in Morocco.

**Design of Irrigation Channels:** Water being so precious, so rare and so expensively stored, all canals and distributaries are being built in cement. In the latest projects like those of Ghrib and Beni Bahdel, pre-fabricated concrete pipes have been employed. These, although costly, transport water over long distances without loss by evaporation and percolation.

**Prospects of Expansion:** The water-resources of Barbary have by no means been exhausted by the existing systems of irrigation and large projects are yet in hand. The Irrigation Map of Barbary shows the areas that are to be irrigated in the near future.

The greatest scope for expansion is undoubtedly in Morocco with its larger rivers and catchments. Basing his
calculations on the flow at present utilised and the ultimate total that could be used for irrigation, V. Bautzel has calculated that the area irrigated in Morocco can be raised to well over 3 million acres. (i) The principal schemes planned are as follows:–

(a) The irrigation of the plains of Abda and Doukkala by means of a weir on the Um-er-Rbia at Im Fout. Beginning with 125,000 acres, the irrigated area will ultimately be raised to 500,000 acres.

(b) The irrigation of the plain of Triffa (lower Muluya) by means of a weir on the river Muluya and the installation of a large number of tube-wells. The area irrigated will be 74,000 acres. (ii) Weirs are also being planned for the Sebu and its tributary the Wargha to bring the whole of the Gharb plain under irrigation.

In Algeria, a new programme of further irrigation works has been prepared in 1946 and it is planned to raise the area irrigated by modern works to 500,000 acres. A possibility of sensational magnitude was recently hinted at by M. Gautier, the chief of the geological department through utilising the underground water resources of Shott-es-Sharqui. This interior basin of about 16,000 square miles receives a rainfall of 12" and

(i) L’Hydraulique Agricole au Maroc, Rabat 1947
(ii) Dutard, J. "Contribution a l’etude de la mise en valeur des Triffa", Rabat 1949
allowing for the maximum possible losses by evaporation, it has been estimated that every year 21,000 million cubic feet of water percolates into the sub-soil. This keeps the Shott impregnated with water throughout the year, even after the prolonged summer drought. The plan for the utilisation of this vast store of precious water envisages its transportation by means of underground works (tunnels etc.) to the Tell basins that border the High Plateau. It is estimated that 500,000 acres could be irrigated from the supplies available. A research centre has been opened to investigate the possibility which may lead to similar utilisation from the sub-soil reserves of other closed basins. (i)

Apart from these large-scale projects, there is great scope for expansion in the development of small local sources of irrigation like wells, barrages etc. The organisation of the country into water-resource groups in Tunisia since 1933 is a very useful innovation. Each region with similar problems and with joint or related sources of water supply is administered collectively and communal irrigation works are undertaken. Individual proprietors are provided with boring apparatus or technical advice and loans and subventions are also provided. Hitherto administered primarily to the benefit of colonists, the system has also helped native cultivators. Large schemes like the development of the Kasserine region in southern

(i) G. Drouhin "L'Equipment Hydraulique de l'Algerie" T and E - No.2, 1948, P.16-18
Tunisia have also been undertaken under a plan for rural uplift (Plan d'Amenagement Rural). (i)

THE AGRICULTURAL DEVELOPMENT OF IRRIGATED AREA AND SOME OF THEIR PROBLEMS.

The coming of irrigation in a region certainly brings great advantages with it but also entails responsibility and co-operative effort as well as a rational utilisation of the water to the best advantage. Among the benefits of irrigation are security from the vagaries of the weather, higher and regular yields, better balanced food, greater employment of man-power and ultimately a higher standard of living. Commercial crops that cannot be grown without the security provided by irrigation are introduced and indeed in the case of Barbary, the great expansion in citrus plantations is the most important single agricultural development in recent years.

We shall now proceed to study the agricultural trends in the irrigated areas as seen through the production figures over several years. A number of areas that have benefitted from irrigation for a number of years have been chosen, named after the barrage that irrigates them and the acreage of various crops given in the following table:- (ii)

P.T.O.

(i) E.C.M. Tunisie, 396 - 412
(ii) Based on Service de la Colonisation et de l'Hydraulique Compt. Rendu 1947.
The following generalisations may be made from these figures:

1. There has been a general recession in the area under cereals and other winter crops i.e. leguminous crops like peas, beans etc.

2. Lucerne has tended to diminish. This, from the point of view of crop-planning, is unfortunate. This tendency appears to signify the neglect of stock-rearing which can have a

(i) In 1939, the quantities of water available being limited, cereals were not irrigated but other crops were.

(ii) Other than citrus.
beneficial influence on the food balance and the supply of manure.

3. Vine has decreased in area. Since this is a commercial crop, and now other commercial crops such as citrus and other fruits, are available and provide better and more assured returns this appears to be natural.

4. The most noticeable single feature has been the great expansion in the acreage of fruit trees, olives and truck crops.

These developments will be pursued in greater detail in a later chapter. It may be added here that the acreage under cotton, now insignificant, increased noticeably during the war years 1941-1944.

The table below indicates percentages under different crops in several irrigated sectors. These are significant in themselves but it is not possible to judge as to what shall be the ultimate proportion of different crops in the long run because as Rebour has estimated, the time taken to achieve the complete utilization of an irrigated area is 20 to 25 years.\(^1\)

<table>
<thead>
<tr>
<th>Crops</th>
<th>Wadi Fodda</th>
<th>Lower Shelif</th>
<th>Bakhadda</th>
<th>Habra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fallow &amp; ploughed</td>
<td>46.76</td>
<td>9.81</td>
<td>15.1</td>
<td>10.37</td>
</tr>
<tr>
<td>Natural pastures</td>
<td>2.21</td>
<td>1.25</td>
<td>24</td>
<td>9.43</td>
</tr>
<tr>
<td>Cereals</td>
<td>20.32</td>
<td>38.70</td>
<td>23</td>
<td>18.86</td>
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<table>
<thead>
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<th>Lower Shelif</th>
<th>Bakhadda</th>
<th>Habra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanent Forage crops</td>
<td>2.20</td>
<td>4.60</td>
<td>0.6</td>
<td>0.43</td>
</tr>
<tr>
<td>Olives</td>
<td>0.40</td>
<td>13.51</td>
<td>4.93</td>
<td>2.32</td>
</tr>
<tr>
<td>Vine</td>
<td>2.74</td>
<td>0.10</td>
<td>0.4</td>
<td>0.83</td>
</tr>
<tr>
<td>Citrus</td>
<td>7.43</td>
<td>2.85</td>
<td>10.3</td>
<td>27.45</td>
</tr>
<tr>
<td>Other fruit trees</td>
<td>4.76</td>
<td>1.10</td>
<td>3.9</td>
<td>2.55</td>
</tr>
<tr>
<td>Vegetable crops</td>
<td>10.31</td>
<td>19.46</td>
<td>16.8</td>
<td>23.15</td>
</tr>
</tbody>
</table>

It may be added that the percentage of crops in various irrigated sectors cannot be compared with each other as they are related to the natural conditions that prevail in them. These regional variations will be taken up in a subsequent chapter.

The development of newly irrigated areas has presented certain problems related mainly to the utilization of water, the crops grown and methods practised. The best use could not be made of irrigation water unless all the potentialities of a region had been explored previously through experiments and the nature of the soil determined. Once that had been accomplished, the choice of crops after water became available was comparatively easy. Rebour, however, points out the following lessons learnt from errors of cultivators using irrigation\(^{(1)}\) for the first time:

1. Unexperienced labour - The workers or tenants ploughing the land had to be trained in the practice of using irrigation.

\(^{(1)}\) Ibid P.70-80
2. Growing of commercial crops like citrus and other fruits at the initial stages of irrigation is a hazardous step. Less remunerative but more secure crops like cereals or forage crops are safer starting points.

3. Over-irrigation: There has been a tendency in areas irrigated for the first time to use too much water. The cultivators irrigating their fields from the Wadi Fodda Dam for the first time in 1940 used twice as much water as their counterparts in the region of Perregaux who had a long experience of irrigation. Five years later their consumption showed a noticeable fall. Excessive irrigation wastes fertilizers and tends to interrupt soil aeration.

4. The distribution of water from a dam has to be carried out among hundreds, even thousands of cultivators, hence a communal spirit of co-operation is necessary. The design of fields should facilitate quick distribution.

As the extent of irrigable areas was limited the Algerian Government has enforced the utilization of irrigation facilities under threat of expropriation. This step must be considered along with the Martin Law\(^1\) requiring voluntary handing over of a part of the holding benefiting from irrigation. Thus local proprietors unwilling to part with a portion of lands if irrigated stand to lose all of them. Both ways, the administration amasses further reserves of land for further European colonisation. Similar steps are proposed for Morocco.\(^{ii}\)

\(^{i}\) See Chapter on Land Tenures and Holdings
\(^{ii}\) V. Bauzil Op.Cit.
The practice of irrigation in Barbary has led to a great increase in prosperity and total production but is carried on under the shadow of the great reservoirs ceasing to function after some time. The period of usefulness of a dam has been estimated at 70-30 years. (1) The cause of this is the silting up of the reservoirs, the greatest single peril facing irrigation. The catchment area of the Wadi Fodda Dam is 25-30% wooded and yet it has been silting up at an increasing rate as the following figures will show.

Deposits from 1932 to 1937 21 million cubic feet per year

```
<table>
<thead>
<tr>
<th>Year</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>1932</td>
<td></td>
</tr>
<tr>
<td>1937</td>
<td>42</td>
</tr>
<tr>
<td>1941</td>
<td>130</td>
</tr>
</tbody>
</table>
```

In other words, out of a total capacity of just over 7,900 million cubic feet, 812 million cubic feet have been silted up in 12 years. The problem is of immense proportions and its solution will be discussed under Soil Erosion. Waterlogged lands and salinity of soil and water are other problems that are sometimes associated with irrigation in Barbary. We shall treat them in the following chapter.

The Transformation of the Plain of Beni Amir:-

This is the only large irrigation project completed in Barbary which has benefited the local population almost exclusively and brought about a complete change in exploitation of the land. We shall study this experiment of introducing a semi-pastoral

people to modern methods under irrigation in detail.

The Plain of Beni Amir lies on the right bank of the Um-er-Rbia below Kasba Tadla in Morocco. It is a flat alluvial plain occupying a height of 12-1500' and slopes very gradually towards the river. The river, as we noticed under Hydrography, is the largest one in Barbary from the point of view of water-supply which never dries up even during the summer drought and can therefore be used for irrigation by the simple means of a weir. The annual rainfall of the plain does not exceed 10" and as is typical of Barbary, is extremely variable. On this plain lives the tribe of Beni Amir which before the coming of irrigation reared large numbers of goats and sheep on the meagre grassland vegetation and also planted the soil with barley which would yield a good crop only once in five years when the quantity and distribution of the rainfall proved to be favourable. Their habitations were mostly concentrated along the river and along with the tribe of Beni Moussa to the south, they practised a limited transhumance within the plain itself (See Sketch 30).

Before irrigation of the plain was undertaken, an experimental farm was created at Dar Oulad Zidouh to apply the slightly saline water of the Um-er-Rbia to various crops that could possibly be grown under irrigation. Regular trials were begun in 1931 (i) and the water was found generally suitable.

(i) E. Miege "La question des eaux sales au Maroc"
A weir was constructed across the river by the same year and a
canal was completed taking water from this weir to the northern
part of the plain so that irrigation could be affected by gravity.

The beginnings of irrigation in 1936 were followed by
widespread unrest among the tribe which broke out into open revolt
at one stage. This development has been variously explained.
The official explanation ascribes this to the fact that the Beni
Amir were incited by the well-to-do of the neighbouring cities
who used to acquire lands and make profits whenever crops failed;
yet another explanation given is that the tribe hated to undertake
the labours required by irrigation. The local intelligentsia
give an explanation that is more plausible — that it was planned
to install European colonists in the plain as had been done in
other irrigated regions and the tribe rebelled. The situation
became calm, however, when the intention of making this scheme
into an experiment in improving the tribe's lands and cultivation
methods was announced through the Sultan and a special office
created in 1941 at Fqih-bin-Salah. This office has played a
vital rôle in the development of irrigation because it
co-ordinates the work of several independent departments such as
those of Public Works, Agriculture, Rural Equipment etc.

Since 1941, the area under irrigation has steadily
increased as more canals and distributaries are completed. In

(1) Tallec "L'évolution du milieu rural aux Beni Amir, Beni
Moussa, Bulletin d'Information du Maroc, Special number,
1946. P.264-
1948-49, about 50,000 acres were irrigated. The ultimate objective is to have the following proportion between different types of crops:

50% of the area devoted to plantations of olives, fruit trees etc.
20% " " " stock raising
15% " " " commercial crops like cotton, sesame etc.
15% " " " subsistence crops.

But during the initial stages, it is difficult to establish these percentages as the tribe is accustomed to growing barley and must be taught slowly. By 1948-49, 12,400 acres had been planted with fruit and other trees, olives taking pride of place (400,000 trees) following by apricots, figs, almonds (100,000 trees). Other crops grown and the areas covered by them were as follows:

- Barley 12,400 acres
- Wheat 5,000 acres
- Leguminous crops 5,000 acres
- Cotton 2,470 acres
- Lucerne 2,500 acres
- Vegetables 1,250 acres

Some 13,000 acres were in fallow.

The object of the proportion of crops planned is to produce only enough food to satisfy the needs of the cultivators and at the same time to produce commercial crops of the type that bring in high returns, thus to raise the standard of living.
Diagrammatic sketch showing the seasonal movement of cattle in the Beni Moussa plan.
Diagrammatic sketch showing the present arrangement of irrigated fields in the Beni Amir Plain.

Projected arrangement of irrigated fields in the Beni Amir Plain.
The irrigated area is divided into a number of sectors each with an area of 2,000 to 3,000 acres. Each sector is under the supervision of a European monitor who distributes improved seeds, fertilizer and supervises the crops.

**Holdings and Methods of Cultivation:**

Before this scheme was undertaken, most of the plain was held collectively by the tribe although there were areas held as melk. The office at Fqih bin Salah redistributed the land among the tribe before actual irrigation.

Although the size of holdings varies from $2\frac{1}{2}$ acres to over 600 acres, the average holding consists of $7\frac{1}{2}$ acres which is sown as follows:

- $2\frac{1}{2}$ acres - cereal (Barley or wheat)
- $2\frac{1}{2}$ acres - Leguminous crop (peas, beans) or cotton
- $2\frac{1}{2}$ acres - Fallow

Under irrigation and with the application of the super phosphate fertilizers provided by the Office, it is possible to obtain two harvests a year. These usually consist of a cereal and Sesame or a leguminous crop and cotton. The office maintains 50 tractors and 7 harvester-combines which can be rented by the small peasants at fixed rates. Although these are being utilised increasingly, the primitive plough is still used by a large number of the peasants.

The Office cultivates about 5,000 acres directly while there are two European colonists one with 150 acres, the other with 1,240 acres.
The rapidity with which the pastoralist tribesmen have acquired the modern methods of cultivation, crop rotations and all the care that goes with intensive cultivation has surprised the authorities. It had been planned to tutor the Beni Amir for a period of up to 12 years by having a large staff of European experts. These experts are all there, but the tribe has soon learnt how to take care of its new plantations and fields.

The Results of Irrigation:

The inevitable consequence of the introduction of intensive cultivation was a reduction in the number of animals that were formerly grazed on these praries. There were over 2000 horses before the scheme, now there are none. The diminution in the number of sheep has not been so great because a large part of the plain is still unirrigated and the flocks of the cultivators are looked after by their kinsmen further west under a sharing arrangement.

Very high yields have been obtained with the intensive methods used (see later chapter on crop-production) and the population has increased rapidly. The following figures of population change of the Beni Amir along with the changes during the same period among neighbouring tribes brings this out. (1)

<table>
<thead>
<tr>
<th>Tribe</th>
<th>1936</th>
<th>1947</th>
<th>% change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beni Amir</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Eastern Beni Amir</td>
<td>24,101</td>
<td>41,162</td>
<td>+ 70</td>
</tr>
<tr>
<td>Western Beni Amir</td>
<td>17,153</td>
<td>27,948</td>
<td>+ 62</td>
</tr>
<tr>
<td>Beni Moussa</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ouled Bon Moussa</td>
<td>12,181</td>
<td>9,766</td>
<td>- 19</td>
</tr>
<tr>
<td>Beni Wijlane</td>
<td>22,296</td>
<td>17,727</td>
<td>- 20</td>
</tr>
<tr>
<td>Ouled Arif</td>
<td>12,576</td>
<td>18,530</td>
<td>+ 47</td>
</tr>
</tbody>
</table>

(1) Atlas Monographique des Beni Amir-Beni Moussa, 1947
The change taking place in the habitation of the Beni Amir is very interesting. The normal house-type among them was the nwala, a cone shaped hut, and mud houses were built only by the notables. As one goes from the areas newly irrigated, to those that were among the first to benefit, there is a progressive diminution in the number of nwalas while the cubic-shaped diyar tend to increase.

Cattle did not figure prominently in the pastoral economy of the pre-irrigation days. Now well-known Moroccan breeds are being introduced and reared on lucerne and berseem both of which have succeeded very well in this area.

Some Criticisms:-

The use of tractors and fertilizers as well as of other technical facilities provided is sometimes officially enforced and the peasant presented with a bill at the end of the harvest. This has sometimes been known to exceed the total income of the smaller peasants who are thus obliged to borrow. This imposes a severe strain and cases have already been reported of a small holder selling his land to clear his debts. This overzealous propagation of mechanised cultivation and expensive appliances must be kept within limits otherwise misery will result instead of prosperity. The classic French practice of sending in a large official personnel is similarly a heavy drain and appears to justify local criticism that the object of the scheme is to give employment to Europeans rather than to improve the lot of the peasant.
Future Prospects:

It is proposed to increase the area irrigated to over 250,000 acres in the plain of Beni Amir and its southern counter-part, the plain of Beni Moussa. A dam is being constructed at Bin if el-Widane on the El Abid and its water will be transmitted to the plain through a tunnel. The irrigation and settlement of the areas to be irrigated in future is being improved and the lessons of the experience gained so far are to be employed.

Among the features of the new irrigated colonies will be model villages of 150 families and 2,000 acres. (i) One great inconvenience in the area irrigated at present is that the land is parcelled into small scattered plots on which ploughing and harvesting is difficult and the number of canal distributaries has to be excessive. In the new colonies, fields will be aligned in squares along canals and crops arranged in strips to facilitate mechanised ploughing (See sketch).

Conclusions:

This is the first instance of the French administration undertaking to transform not only the land through irrigation but also its people. In an amazingly short period, the Beni Amir have begun to practise modern methods of intensive cultivation with an efficiency that would be hard to beat.

(i) This approximates fairly closely to the typical canal colony village in West Punjab.
Their transformation is a proof that if the state provides all the facilities and means of improvement, the indigenous population of Barbary can bridge the gap of centuries between their use of land and the modern scientific technique in a very short time. This experiment is an encouraging success and the practice could be extended into other tracts planned for irrigation so that there may be a lasting cultural benefit from the contact of the local population and the west.

WEST PUNJAB

It would be no exaggeration to say that few regions of same size and population in the world depend as much on irrigation as West Punjab. Of its total cultivated area of 18,474,237 acres, 12,511,450 acres or 68% are irrigated.

We have already studied, in brief, the factors that led to this development. Map shows the proportion of area irrigated by various means in the different districts. The districts getting less than 10" of rainfall are the most heavily dependent on irrigation. It will also be noticed that government canals occupy a dominating position among the irrigation systems of the province.

Irrigation in West Punjab dates back to times immemorial and many ancient ways of watering the lands have persisted as in Barbary. Like Barbary again, their role in the agriculture of the province is only of a minor importance as

(i) Figures from Season and Crops Report, 1945.
compared to the great modern canals. We shall, however, take the traditional methods of irrigation first and study their relation to the environment, physical and human. Happily, statistics are more plentiful for West Punjab than in the case of Barbary.

The Traditional Systems:

In the case of West Punjab, they are chiefly wells and inundation canals.

Wells: Well-irrigation is probably the oldest means of irrigation in the province and still occupies an important position accounting for 13.3% of the total area irrigated. There are 197,159 wells, 137,629 of them masonry and the rest non-masonry. Their distribution by districts is shown on Map 77. Their greatest concentration occurs in Sialkot and the three south-western districts of Multan, Muzaffargarh and Dera Ghazi Khan. They are mostly confined to the khadir areas where water-level is high. In the Potwar region, they are almost the only means of irrigation as the topography is unsuitable for the development of canals.

Wells are the ideal means of irrigation in West Punjab because of a number of factors. Among an independent-minded people like those of West Punjab, they provide self-sufficient source of water for which no co-operative effort is required. They have also developed among a peasantry that is innocent of all use of capital and lacked the skill to attempt more ambitious
projects. Finally during recent times, wells have proved to be admirably suited to the small and scattered holdings that continue to be the rule in the province.

As a rule well irrigation is not practised wherever the depth of the water is greater than 35 feet as beyond that depth the cost of lifting water is excessively high as compared to the value of crops grown. (1)

Several means of lifting the water from the wells are applied. Those used extensively are as follows:

(1) **Persian Wheel (Rahat)** is by far the most common device applied. It consists of a large drum over which passes an endless rope or iron ladder with buckets attached to it at uniform spacing. The lower part of this ladder reaches below the water surface. The drum revolves when a pair of bullocks give motion to a toothed disc (or chakla) which is linked with the drum by means of a cog-wheel. The water pours continuously into a water channel. The persian wheel is a flexible device in which the size of the buckets or of the rotating drum can be altered according to varying water depths. The older types are wooden but iron persian wheels are becoming popular as they have proved to be more efficient. In some cases only the buckets and iron ladder are introduced on to a wooden drum instead of the old-fashioned earthenware pitchers and ropes. Worked usually by draft animals, a few persian wheels here and there have been worked by oil engines or electricity.

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(2) **Charsa:**—This method is not very common in West Punjab now having largely been replaced by the Persian wheel. It resembles the *dalou* of Barbary and is worked by a pair of oxen going down an incline.

(3) **Dhenkli or counterpoise lift:—** This is the poor man's device for lifting water from a well. It consists of a bucket made of leather or iron, suspended by a rope from the end of a pole which has a counterweight at the other end and is balanced, see-saw fashion, on a stout upright support. The lift is worked by manual labour and the counterpoise is of such a weight that no great exertion is required to depress the lift when empty or raise it when full. It is usually employed where the water in a well is not deeper than 6 feet or so.

(4) **Jhatta or Swing basket:**—This consists of a basket or a shovel-like scoop and is swung by two men, one standing on either side holding the ropes. It is suitable only for shallow water.

Wells have been modernised in numerous cases with the help of centrifugal pumps or electric motors which materially increase the amount of water available and also reduce the cost of lifting water.

It may be added in conclusion that wells allow of intensive cultivation much more than canals as water is available in required quantities whenever desired. Thus even in canal colonies, wells have been dug to supplement the irrigation from
canals that may or may not be available exactly when required.

Inundation Canals

These are among the oldest canals of the province, most of them having been in existence at the time of the British annexation in 1856. Many are as much as 200 years old. In some cases they were in a serviceable condition while in others they had been allowed to deteriorate into choked and useless channels. Most of them have been improved and extended during recent years.

These canals are taken off from the rivers without any dam or weir and flow with water only during the high water season, i.e. from the end of April to the middle of October. The depth of the water during inundation is usually 5 - 8 feet but may be as much as 10 or 12 feet. Waterings are irregular and infrequent. During the early period of supply, lift irrigation is practised but when water has risen sufficiently, summer (kharif) crops are irrigated by flow. Considerable areas are flooded with the double object of manuring the land by silt deposit and of saturating it with moisture for the following winter (Rabi) season. The following figures give the area of seasonal crops in acres for 1935-36.

<table>
<thead>
<tr>
<th>System of Canals</th>
<th>Kharif</th>
<th>Rabi</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indus Inundation Canals</td>
<td>134,934</td>
<td>109,232</td>
<td>244,216</td>
</tr>
<tr>
<td>Shahpur</td>
<td>47,531</td>
<td>23,909</td>
<td>71,440</td>
</tr>
<tr>
<td>Muzaffargarh</td>
<td>161,633</td>
<td>246,670</td>
<td>408,308</td>
</tr>
<tr>
<td>Chenab</td>
<td>113,516</td>
<td>80,533</td>
<td>194,049</td>
</tr>
</tbody>
</table>

Everywhere, the Kharif crop was more important except in the case of Muzaffargarh canals which were supplemented by numerous wells for the Rabi crop. Water from wells is provided for important crops like wheat and sugar-cane as supplies from canals are not enough. The early and late supplies of water from the canals are of great value as the early supplies determine the area of the sowings while the later supplies are valuable for maturing the crops and also determine Rabi sowings.

Inundation canals are used to irrigate lands on either side of the river and hence reach their greatest development where the rivers begin to converge near Penjnad and the Khadir widens out at the expense of the Bhangar.

Since the completion of the Haveli Project in 1839, some 550,000 acres formerly irrigated by inundation canals have been brought under perennial irrigation (1) so that the last two groups - the Muzaffargarh and Chenab Inundation Canals have largely been replaced. At present the two main areas irrigated by inundation are the khadir of the lower Indus and the riverain tract of the Jhelum below the Salt Range.

MODERN WORKS

These consist mainly of perennial canals deriving their water from rivers across which weirs are constructed to ensure a permanent and well-regulated supply. Some of the later systems such as the Sutlej Valley Canals provide only a seasonal supply according to the supplies available from the river.

(1) Sir Bernard Darley "The Development of Irrigation in India" Journal of the Royal Society of Arts, Vol.XC 1940-41, P.49
We may, at this stage, pursue the development of the modern canal systems in the light of the physical as well as the social and economic conditions of the province.

**Historical Survey:** The only perennial canal in existence before the advent of the British administration was the Hasli canal which brought water from the Ravi to Madhopur to the royal gardens near Lahore and also irrigated some cultivated land. It had been constructed by Ali Mardan Khan in 1633 during the rule of the Mughal Emperor Shah Jahan.

The British administrators noticed the irrigation possibilities of the province soon after its conquest and remarked on the existing irrigation works that were being utilised with marked harmony and co-operation. What led to the development of irrigation was, however, the recurrence of famines over a number of years. Erratic monsoons caused widespread distress in 1851-2, 1860, 1868-69 and 1877-78. The three main causes of the famines were:

1. Pressure of population on the land
2. Periodic failures of rainfall
3. Lack of transport facilities and means of communication

Famines thus tended to create a balance between population and food supply.

The government, by launching upon an extensive development of irrigation, endeavoured to remove this extreme

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(i) P.W. Paustian "Canal Irrigation in the Punjab" New York 1930 p. 25
Khanki Weir on the Chenab. This shows the sluices controlling flow to the Lower Chenab Canal seen to the left.

The Ferozepur Weir, one of the Sutlej Valley dams. Photograph shows the two canals that take off to the east and are now included in East Punjab. The weir also supplies water to the large Dipalpur Canal irrigating Montgomery District. Notice the wide expanse of the river below the weir.
Lining the bed of a canal of the Thal Project with bricks to prevent seepage which brings about a double loss - the loss of valuable irrigation water on one hand and of the surrounding lands through water-logging on the other.
reliance upon a capricious rainfall.

The first undertaking, commenced in 1850-51 sought to enlarge and extend the existing Hasli Canal so as to irrigate the Bari Doab up to Multan. Irrigation actually began in 1861 and the project proved to be a success. This has since come to be known as the **Upper Bari Doab canal** whose commanded area is now shared by territories belonging to Pakistan and India.

The severe famine of 1877-78 led to the Government planning new protective works and three projects were prepared, the **Sidhnai canal**, the Lower Sohag and the Para canals, both to irrigate the lower Bari Doab and the Ramnagar Canal which developed subsequently into the Lower Chenab Canal. The Sidhnai was begun in 1882 and completed by 1886, its head being situated on the Ravi River above Multan. The Lower Chenab Canal was commenced in 1884 as a minor project on an inundation basis but got soon silted up so that a new project was undertaken in 1390 and completed in 1392. The colonisation of the Rechna Doab by this canal, one of the most extensive and successful irrigation systems anywhere, will be studied in detail along with the general survey of colonisation, as it epitomises most of the features of human and economic transformation following irrigation in the province.

The **Lower Jhelum Canal** was the next to be undertaken and although opened in 1901, was not completed till 1917 on account of disputes with owners of the private canals in the
area commanded. It takes off from the Jhelum at Rasul and irrigates the western portion of the Jech Doab.

The Triple Canal Project is one of the most ambitious and original irrigation schemes to be completed in the province. For a long time the bare tracts of the Montgomery and Multan districts had presented attractive possibilities for irrigation only if water was available. The Ravi hardly had enough water to feed the two canals already taken off it, the irrigable tracts were far from the Sutlej while the Chenab itself was being used pretty exhaustively by the Lower Chenab Canal. The Jhelum alone had vast surplus supplies. Three canals were planned (whence its name) by which the waters of the Jhelum, the Chenab and the Ravi were to be integrated. The Upper Jhelum Canal taking off at Mangla carries the waters of the Jhelum to the southwest, irrigating the land through which it passes and empties its unused supplies into the Chenab river at Khanki. This water is utilised by the Lower Chenab Canal taking off at the opposite bank so that the supplies of the Chenab are freed for other irrigation purposes. These are tapped at Merala where the Upper Chenab takes off and after similarly irrigating thirsty lands on both its sides, discharges its contents into the Ravi at Balloki where the Lower Bari Doab canal takes off to irrigate the problem area. The project has surpassed all expectations of its success by irrigating much more area than
planned. Commenced in 1905, the entire project was completed in 1913.

The Sutlej Valley Project was undertaken in 1922 and envisaged the utilisation of the seasonal supplies of the river by means of four weirs at Ferozepur, Salaimanké, Islam and Panjnad. It was completed in 1932 and is another of the systems that have been imperilled by Partition. It irrigates the southern parts of the districts of Montgomery and Multan.

The Haveli Project has been completed in 1939 and takes off water at the junction of the Chenab and Jhelum rivers to irrigate areas formerly commanded by inundation canals and also to supplement the supplies of the Sidhnai Canal.

The Thal Canal is the last irrigation project, held up by the second World War but now being completed. It takes off at Kalabagh where the Indus emerges from its upper course and is designed to irrigate the desert spaces of the Sind Sagar Doab.

The following tables give the details of areas commanded and irrigated by the systems whose development has been traced above:

\[\text{Original area designed to be irrigated } 1,871,235 \text{ acres} \]
\[\text{Actual irrigation attained (1943-44) } 2,623,309 \text{ acres} \]

Table of Particulars about West Punjab Canals, 1935-36

<table>
<thead>
<tr>
<th>Name of Canal</th>
<th>Length of canals and distributaries (miles)</th>
<th>Area commanded (acres)</th>
<th>Area to be irrigated (acres)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Upper Bari Doab</td>
<td>1835</td>
<td>1,563,046</td>
<td>1,083,750</td>
</tr>
<tr>
<td>Lower Bari Doab</td>
<td>1467</td>
<td>1,801,107</td>
<td>877,908</td>
</tr>
<tr>
<td>Upper Chenab</td>
<td>1421</td>
<td>1,535,077</td>
<td>567,048</td>
</tr>
<tr>
<td>Lower Chenab</td>
<td>2890</td>
<td>3,611,819</td>
<td>1,884,989</td>
</tr>
<tr>
<td>Upper Jhelum</td>
<td>711</td>
<td>558,624</td>
<td>302,037</td>
</tr>
<tr>
<td>Lower Jhelum</td>
<td>1191</td>
<td>1,340,645</td>
<td>756,390</td>
</tr>
<tr>
<td>Sidhnai</td>
<td>318</td>
<td>418,444</td>
<td>243,623</td>
</tr>
<tr>
<td>Haveli Project</td>
<td>-</td>
<td>1,161,164</td>
<td>714,256</td>
</tr>
<tr>
<td>Sutlej Valley Project:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pakpattau</td>
<td>-</td>
<td>1,367,817</td>
<td>745,835</td>
</tr>
<tr>
<td>Dipalpur</td>
<td>-</td>
<td>1,082,570</td>
<td>584,280</td>
</tr>
<tr>
<td>Mailsi</td>
<td>-</td>
<td>733,374</td>
<td>393,373</td>
</tr>
<tr>
<td>Thal Canal</td>
<td>-</td>
<td>4,599,739</td>
<td>2,170,000</td>
</tr>
</tbody>
</table>

(Source K.S. Ahmad, Op.Cit. Punjab Irrigation Reports)

The Effects of Irrigation:

In West Punjab it would be true to say that the desert has bloomed in the canal colonies and the precious water constitutes the very life-blood of the rural population which has been attracted to those lands from congested districts.

The settlement of a well-knit and hard-working peasantry in well-planned villages was achieved by a colonization
process which will be considered later. Two developments that lend themselves to quantitative analysis may be considered:

(1) The growth of population: The increase of the total population of West Punjab from 1901 to 1941 was 82%. But the rate of increase varied from district to district as Map 7 shows. The highest increase was recorded in the canal colony districts of Lyallpur, Shahpur, Montgomery and Multan where it was over 100% and exceeded 200% for Montgomery. The increase in unirrigated districts, i.e. Jhelum, Rawalpindi and Attock was less than 50% as indeed it was in the south-western districts getting non-perennial irrigation.

The growth of population in the irrigated areas was not all due to natural increase, for a large proportion of it resulted from immigration from the congested districts.

(2) Increase in Cultivated Area and Unit Yields: Census estimates give the increase in cultivated area for the province as it was before Partition and it is not possible to make district-wise calculations over long periods because district boundaries were changed on a number of occasions. The provincial figures do give a general idea of the growth of cultivated area. When it is realised that most of the increases took place in the districts now comprising West Punjab, the real extent of expansion for this section can be recognised. In 1868, per capita cultivated area amounted to 1.25 acres of which only .06 was irrigated by canals. (i) By 1881, for a population increase of 6.3% over that of 1868, the cultivated area increased by 16% so that the cultivated area per head of population

(i) Calculations made from Census of India, 1941, Vol.VI, Punjab.
(ii) These figures are abstracted from P.W.Paustian, Op.Cit. Chapter V.
increased. The Census Reports of 1891, 1901 and 1911 indicate a higher rate of increase of cultivated area than the increase of population so that the cultivated area had risen to 1.41 acres per capita by 1921. As against only 6.3% of it that was irrigated in 1868, 36% of it was irrigated in 1921. Most of the increase in cultivated area took place in West Punjab districts. The total increase in cultivated area in the undivided province from 1868 to 1921 amounted to 8,828,000 acres while the total increase in canal-irrigated area was about 9,901,000 acres which clearly shows that canal irrigation played the dominant part in the increase of cultivated area. This trend has continued and by 1944-45 cultivated area had increased by 4 million over the 1921 figure to over 33 million acres while canal-irrigated area had also shown an increase of 2,210,000 acres again showing the contribution of large-scale irrigation to the increase in cultivated area. By 1941, however, the increase in the population had so far outstripped the increase in cultivated area that cultivated area per capita was down to just over 1.1 acre as compared to 1.41 in 1921.

Unit yields from irrigated land are everywhere considerably higher than those obtained without irrigation. This fact has been demonstrated by a comparison of the yields of several crops from the two types of land in a later chapter.

The Colonization Process with special reference to the Lower Chenab Colony

The success of irrigation projects in West Punjab has depended largely upon the organisation of the settlement of immigrating cultivators. Although the British government kept political (1) Calculated from Season and Crop Reports, 1941-42, 1944-45 and the Census of India Report 1941, Vol.VI.
considerations in view and "yeomen" and service grants to loyal persons were made and although military requirements of animals for the cavalry and transport also played their part, the main object of establishing canal colonies in West Punjab was to relieve the pressure of population upon the land in those districts that were congested. The scheme took great ingenuity, patience and perseverance in its execution. "The disposal of the colony land, its survey and its assessment, the settlement of the immigrants, the planning of villages, markets and towns, the provision of the means of communications" all called for the utmost care on the part of the government.

The plan that was developed in the colonization of the Rechna Doab has remained the prototype for later enterprises. To recognise the share of the native inhabitants in the settlement of new land, to call only agricultural classes of men to settle and to choose immigrants of good character, to arrange that so far as possible a colony village should be composed of one body of men headed by their leader, to foster the growth of tidy villages - all these have remained the chief principles of colonization and were developed in the Lower Chenab Colony.

The Settlement of the Colony The lower tract between the Chenab and the Ravi rivers was formerly known as Sandal Bar and constituted a barren steppe in which semi-nomadic tribes of a criminal character grazed their cattle and sheep. Some of the pre-irrigation changes in their mode of life were described earlier. When the colonization of the area started in 1890, the nomadic population tried all in their power to make things difficult for the

(i) Deva Singh, Op.Cit. page 3
settlers. Difficulties of obtaining labour and of transport made life still harder. Steady progress was made however and by 1895, over 428,000 acres had been allotted. The soil proved its fertility and as the news spread, colonists eager to settle in the area began to pour in from all parts of the province. By 1909, when allotments were almost complete, 1,341,938 acres had been settled.

The Selection of Colonists Because of the excess of applicants over the number required, the government was able to exercise choice. Agriculturists with a good background and character were selected from the congested districts - mostly in Eastern Punjab. In the distribution of settlers, the government took care to avoid possibilities of incessant communal conflict. Generally speaking, the peasant grantees (abakars) in each village belonged to the same tribe, professed the same religion and originated from the same home district. Exceptions to this rule were often the source of trouble. Military pensioners were settled, according to (i) regiments as well as tribal affiliations. Among the tribes or classes of cultivators selected, those with a reputation for hard work on the land were given preference e.g. Jats, Arains and Rajputs.

The rights of the indigenous groups were not ignored. After a period of repression due to their hostility to the settlers, they were given generous grants of land and have since settled down to a peaceful agricultural life. Thus in 1903 the area held by them covered 253,752 acres. The tribes known as Hitharis which already practised sedentary cultivation in the riverain tracts were recognised in their proprietary rights and owned 135,578 acres in 1903. The former nomads have proved to be adaptable and have become

(1) Ibid p.19.
good cultivators.

Disposal of Colony Lands The several considerations that determined the colonization policy were outlined at the beginning of this section. One factor which was not mentioned was the desire of the government to obtain returns for its huge capital outlay on the project which amounted to 25.2 million rupees by 1900. This coupled with the desire to settle a better class of loyal cultivators who could invest money into the land resulted in grants being made to yeomen, capitalists and auction-purchasers. Thus it is that small peasants, yeomen, capitalists and horse- and mule-breeders were the principal grantees of land.

It was decided to make rights in the land inalienable along with the policy of settling resident cultivators. The bulk of the land was granted to peasant settlers to preserve the tradition of the province as a country of the small peasant. Proprietary rights were conceded after a period of probation during which they were required to pay only limited dues. Conditions of clearing the land, breaking it into fields and doing all the necessary work to bring it under cultivation were enforced. The area of a peasant grant was fixed from 14 to 83 acres (half a square to three squares).

Yeomen grantees came from families of large proprietors in other districts and also included a considerable number of pensioned Army officers chosen by their commanding officers. They were not expected to cultivate the land directly nor was their residence on it enforced. Allotments were considerably larger to this class of cultivators. They were charged a nazrana (money
upon entry) which was really a token price because the real object of these grants was to settle a class of influential landlords loyal to the government.

*Capitalists* differed little from yeomen and had to be men with resources, influence and a record of meritorious service to the British government. Army officials were also eligible. The area of allotments varied from 6 to 20 squares or 166 to 566 acres.

*Auction-purchasers* were those buyers who wanted to invest money without residing on the land or supervising its cultivation through tenants. They paid the full price of land as bid in an open auction.

Among Service Grants to cater to the needs of the Army were camel grants made to Biloches to rear camels for army transport which did not work—and mule-breeding grants which were a conspicuous success.

As most of the natural vegetation was cleared, a fuel famine threatened the settlers. The government therefore enforced tree planting conditions on one hand and also gave small parcels of land to each village to maintain tree nurseries. The consequence was that the Chenab Canal Colony is one of the best wooded parts of the plains of the Punjab.

*Planned villages* It was the object of the government to create villages of a type "superior in comforts and civilization to anything which had previously existed in the Punjab" At first they contented themselves with allotting a village site of liberal
dimensions but when unsightly and unhygienic villages began to develop, the need for a standard plan was realized. Several types of villages were planned for different parts of the colony with provision of an open square in the middle of the village, wide straight lanes and houses of specified dimensions.

The Colonization Process in other canal colonies

The system which finally emerged from the Chenab Colony experience has become more or less standardized. Before the canals were dug, the tract to be irrigated was divided into large squares or rectangles for purposes of determining the approximate position of the main line and branches in relation to potential colonies of settlers. Each of these divisions was a multiple of the smaller rectangle or square into which the land would later be divided for purposes of allotment. The smaller divisions varied in area from 22 1/2 acres as in the Sidhnai Colony to 27.8 acres in the Lower Jhelum and Lower Chenab colonies. In the Triple Canal Colonies, the rectangles were 25 acres each. In the selection of colonists the same considerations that were described earlier were always kept in view. The preservation of the community or tribal spirit was given special attention. Land was then granted in these units and of 22 1/2 to 27 1/2 acres to small peasants and to the various other classes of settlers described under the Lower Chenab Colony. In the Triple Canal Project for example the Government announced the following plan of distribution:

1. For peasant colonists of older irrigated areas, 680,000 acres (of this 175,000 acres for service conditions)
2. To relieve congestion in other areas - 80,000 acres
3. To be sold at auction - 125,000 acres

(i) Faustian, Op.Cit. 62-63
4. Reserved for agricultural and regimental farms - 100,000 acres
5. 75,000 acres for landed gentry.
6. 40,000 acres for irrigated forests and fuel reserves
7. For the semi-nomadic tribes that formerly lived in those areas - 40,000 acres
8. For ameliorating the condition of depressed classes - 40,000 acres
9. For Service in First World War - 22,000 acres

Comments

This system of settlement in irrigated colonies has worked very well. The improved appearance of the landscape, the preservation of the traditional spirit along with the introduction of improved crops and methods is a great tribute to its merits. It is of interest to note that after the distribution of land, the government did not enforce any startling changes in the mode of cultivation such as the compulsory use of fertilizer or machinery as in Beni Amir. By demonstration and propaganda, however, better varieties of wheat, American cotton and lately citrus fruits have been introduced. The larger landlords have given the lead in the introduction of improved techniques.

Chapter 12

THE PROBLEMS OF WATERLOGGED AND SALINE LANDS

In the agricultural landscape of Barbary and West Punjab, one comes across low-lying plains ideally suited for cultivation by their situation, climate and soil conditions lying barren and unutilized. These are the waterlogged lands which exist naturally in the former but have developed in the latter through irrigation. While large tracts become uncultivable through a surfeit of water, extensive areas in the semi-arid parts of both our regions suffer from an excess of salts in the soil which renders them sterile and unproductive. In this case again the salt exists naturally in Barbary while the natural salinity of the West Punjab soils has become greatly accentuated through the extension of irrigation. Both these types of land present major agricultural problems and offer great possibilities for reclamation through technical and agricultural devices.

We shall now study these two problems one after the other in relation to the regions under survey.

WATERLOGGED LANDS

Some of the largest low-lying plains of Barbary are or have been swampy due to the lack of natural drainage. The plains of Bone, Mitija and Oran in Algeria and the lower Gharb plain in Morocco are cases in point. These regions were hardly utilized fully before the advent of the French and were partly used for grazing because of their excellent pastures. Although dismayed at first by their unhealthy character, the
French administrators applied themselves to the task of reclaiming these potentially rich lands by means of drainage channels. They cleared the Mitija plain of its marshes during the very first decades of colonisation and the rich agricultural centre of Boufarik stands in the centre of what were formerly malarial swamps. It is now kept healthy and protective by a network of drains.

The existence of these extensive water-logged areas is due mainly to the causes that have been cited under hydrography to have led to the formation of the merjas, i.e. impermeability of the clayey deposits, the inability of the intermittent streams to maintain a constant base level and finally natural obstacles in the shape of coastal dunes and uplands.

**THE PROBLEM OF THE HABRA PLAIN**

The water-logged lands in the well-watered regions of Bone and Gharb lie in the comparatively humid parts of Barbary receiving 20"-50" of rainfall. The lower plain of the Habra in Western Algeria receives less than 15" of rainfall and owes its water-logged state as much to imperfect drainage on account of lack of adequate slope as to over-irrigation. This offers a close parallel to West Punjab. Its reclamation, however, has presented great obstacles. The river empties itself into the Macta marshes that are separated from the sea by sand hills built through marine deposition. It has been found impossible to create an opening towards the sea as coastal currents tend to maintain deposition. It is proposed to erect tube-wells
in circles and pump out the water from the sub-soil. If official experiments succeed, the colonists who own most of the plain are expected to follow suit. A bore-hole 130-160 feet deep is being planned to study the nature and permeability of strata. Waterlogging in the Habra plain has been accompanied by the upwelling of salts in large quantities. That is a question for the second part of this chapter.

The reclamation of the several marshy tracts around Bone has recently been undertaken. The eastern part of the plain covers an area of 50,000 acres of which it is expected to bring 40,000 under cultivation. The three systems of drains now being dug by means of mechanical excavators will discharge their contents respectively into Wadis Bu-Tamira, Bu-Allalah and Besbes. Several aqueducts and siphons will have to be constructed to make drains cross natural channels and flood-control measures taken. (1) The draining of the western Bone plain which has an area of 24,700 acres was also commenced in 1948. Similar reclamation enterprises are in progress in the regions of Lakes Petzara and Tonga to the west of Bone.

The merjas in the Gharb plain cover 220,000 acres and that they can be fully reclaimed for agriculture was proved by the draining of a merja of 30,000 acres by a large company some years ago.

**WEST PUNJAB**

Water-logging through natural causes has existed in the West Punjab and the Shakargash tehsil in the north-east

(1) Service de la Colonisation et de le Hydraulique, Compte Rendu 1947, P.11-15
has long suffered from it through the accumulation of flood water from hill torrents in Jammu State into Khadir depressions. (i) This is, however, a comparatively humid tract in the foothills. The recent extension of water-logging in the irrigated canal colonies was one of the consequences of irrigation. With the channels flowing several feet above the level of the surrounding plain, hydro-static pressure was exerted by water seeping through the permeable channels into the sub-soil. Continuous additions to the underground reserves finally raised the water table so near the surface that cultivation became impossible over large areas. As distress spread to more and more villages especially in the Rechna Doab, remedial measures were suggested and sporadic efforts made to apply them. It was only after the abnormal rains of 1925 when large areas became waterlogged that the seriousness of the problem was realised and a Waterlogging Enquiry Committee formed to investigate the extent of damage and explore various remedies. In his report, Mr. Lindley, one of the members, reported the area already damaged in West Punjab tracts to amount to 146,200 acres, 128,000 of these being along the two Chenab canals. (ii) It is interesting to note that damage was very slight in the lower part of the plains and the Lower Bari Doab Colony was hardly affected. He estimated the areas threatened by 1937 to be at over 3,300,000 acres. Actually the area waterlogged by that year was considerably smaller.

(i) E.S. Lindley "An Estimate of the areas affected by and threatened with water-logging with their past history etc" Punjab, Irrigation Branch Paper No. 31, 1923, P. 11
(ii) Ibid, P. 18
Since then extensive experiments have been conducted to find out the exact causes of waterlogging and try out various remedies. The results of these are summarised in the following account.

A geodetic survey by Messrs. Wilsdon and Bose\(^{(1)}\) showed the existence of an underground water ridge running across the plains at right angles to the direction of the flow of the rivers. This ridge divides the province into two parts; upstream of it the water-table has approached the surface over extensive tracts, while downstream the extent of water-logging is limited.

A systematic survey of the Rechna and Chaj Doabs upsteam of the rock ridge was made through recordings of water-level in wells and rain-gauge stations. The conclusion drawn was that both rainfall and irrigation contribute to the rise of the water-table but that the major cause of the rise was monsoon rainfall. Subsequent observations have confirmed this and Diagram 3\(^{\text{a}}\) shows the relation between the rise of water-table and the monsoon rainfall in the Upper Chenab area. As a result of this study, it was suggested that a drainage system should be constructed in this area to deal with the storm water of the monsoon period. Work has been in progress since 1936 and it seems probable that the water table in this area may be stabilized.\(^{(ii)}\)

Irrigation affects the water-table in two ways. A certain amount of water is lost by seepage directly from the

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(\(^{(1)}\) Wilsdon, B.H. & Bose, N.K., Punjab Irrigation Research Institute, Research Publications Vol. 6, No.1 1934

Monsoon Rainfall and the Rise of the Water-table: Upper Chenab Canal Area

From: Taylor and Mehra
"Some Irrigation Problems in the Punjab"
canals. Of the water used for irrigating crops, a certain amount also passes to the sub-soil. Since seepage and irrigation are almost constant from year to year, it is impossible to analyse their effects by statistical methods.\(^{(1)}\) Recent surveys in the Rechna doab showed that although seepage was the main cause of water-logging it could not be guaranteed that the lining of canals would be an effective remedy. Experiments with the effects of irrigating crops of rice and cotton have shown that 11.3\% of the total water used for rice and 3.5\% of the water used for cotton are added to the water-table. This proves irrigation water to be an important factor in water-logging.\(^{(ii)}\)

Lindley's forecast of large-scale deterioration has happily proved to be wrong on account of a feature of West Punjab soils. The impermeable soil crust has been found to be 10 feet or more in thickness and the water-table does not rise above the crust. On the basis of this it may be said that areas in which the soil crust is at least 10 feet thick are in no danger of water-logging.

Since Wilsdon and Bose's geodetic discovery, it has been found that water-logging has been spreading even downstreams of the ridge. A suggestion has been made that the underground ridge may have caused the heading up of the sub-soil stream and that the rise of the water-table downstream has been taking place due to sub-soil water flowing over the crest.\(^{(iii)}\)

\(^{(1)}\) Ibid
The various remedies for water-logging that have been suggested since the earliest enquiries are as follows:

1. Restriction of irrigation supplies.
2. Excavation of drains.
3. Lining of canals.
4. Pumping from the sub-soil.

Of these the first has been found to be impracticable as it limits agricultural production. Drainage has until recently been the only effective means of checking waterlogging. A large network now exists in the areas affected. Experiments are still in progress with various lining materials. The new canals constructed since the problem of waterlogging became serious have been lined with bricks to restrict seepage losses. Most notable among these are the Haveli canals. Finally tube wells offer an attractive possibility and several experiments in pumping the deep water back into the canals have on one hand lowered the water table and also increased irrigation supplies. The Rasul Hydel Project envisages the utilisation of a large part of its electric output in tube-wells in the water-logged areas of the Rechma and Shaj Doabs. The water-logged area has been diminishing steadily in recent years as a result of the success of reclamation measures.

**SALINE AND ALKALINE LANDS**

Such lands are widespread in the world in low-lying semi-arid regions and the problems of their reclamation have recently been studied by the Food and Agriculture Organisation of the United Nations. (ii)

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(ii) F.H. Greene - "Using Salty Land", Washington, 1948
It is significant to note that tracts included in West Punjab have been quoted especially in this work as problem areas wherein notable advances in reclamation have been made. We shall apply some of the principles developed in this work in the course of the following region-wise analysis.

**BARBARY**

Saline lands occur extensively in Barbary and even where the lands themselves are not impregnated with salt, saline water in the steams presents problems in its utilisation. The existence of innumerable such wadis in Barbary was pointed out earlier under Hydrography. The problem, apart from the closed basins of the interior, is most serious in lowlands near the coast, particularly in western Algeria. Here extensive tracts are impregnated with salt on account of the lack of drainage in the depressed basin.

A study made some years ago for Morocco treats the problems of Barbary as a whole and, in fact, derives most of its factual basis from Western Algeria. It ascribes the occurrence of saline lands to two factors:

1. **Geological** - The outcrop of triassic strata is everywhere marked by salinity as these rocks are rich in salt and gypsum, having been formed during a period of intensive evaporation from closed basins. Primary rocks exposed in Morocco are also saline.

2. **Climatic** - The climatic regime of Barbary is marked

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Influence of Salinity on the Limits of Irrigated Land.

- Limit of irrigated sector.
- Salt less than 1 gram per litre
- 1 - 3 grams

Scale approx. 1:200,000
by an excess of evaporation over percolation. This has resulted in a concentration of salts near the surface particularly in the great inland closed basins. Low-lying lands tend to have a high salt content if drainage is not adequate.

The most common salt found in Barbary is sodium chloride which is highly soluble in water. It usually forms a hard impermeable crust at or near the surface. Sodium carbonate is rare in Barbary.

The saline lands do not normally support ordinary vegetation but have plants specially adapted to the salinity of the soil known as halophytes. It may be added, however, that the suitability or unsuitability of saline land for agriculture depends upon its salt content. Certain plants and crops can withstand a fairly high amount of salt in the soil, notably date-palms and lupin. Cotton and rice can grow if salinity is low and cereals such as wheat and barley also flourish. Fruit trees, however, do not grow successfully on salt-impregnated lands. Citrus trees are particularly sensitive to salty land. Saline water has been successfully utilised to irrigate vines, cotton and lucerne in the Oran region provided that salinity not exceeds 3 grams per litre. This appears to be exceptional. In the Habra plain in the same region, over-irrigation has raised the water-table and impregnated the soil with alkali. Tens of thousands of acres have been rendered sterile by a salt content that exceeds 10%.

This last example indicates that if large-scale irrigation is expanded and practised long enough,
it may become a major factor in spreading waterlogging and salinity of the soil. This may affect the total area of irrigation. The existence of salty lands in the region of Relizane has limited the extent to which irrigation can be extended over the alluvial plain through utilising water from the Bakhadda dam.

Reclamation:— The saline lands cover very large areas, particularly in the lowlands of Oran. Various measures have been tried and their effectiveness may now be described.

1. **Cultivation methods** may be changed to reduce evaporation on one hand by planting trees and bushes and by frequent tilling to keep the soil permeable. Deep ploughed fallow has been found useful. The use of organic manure in large quantities counteracts the salinity and increases permeability. Lucerne and berseem have been grown under irrigation in several parts of Western Algeria with a markedly beneficial effect.

2. **Chemical means:** Addition of other chemical compounds has often helped to cure the land. Calcium chloride or calcium sulphate are among the useful substances that render the soil more permeable and thus facilitate improvement.

3. **Drainage** has been found to be the most efficient means of improving salt-impregnated lands as by allowing a free flow of sub-soil water, it helps the draining away of the soluble salt. At the experimental farm of Ferme Blanche in Algeria, the digging
of open trenches led to a progressive reduction of the salt content of the soil and the yields of cereals and forage crops were more than doubled by the fourth year of drainage.

Drainage also renders possible the removal of salts into the sub-soil by means of flooding the land.

A more detailed investigation of the possibilities of improving the extensive saline lands in Barbary is called for. Their utilisation offers great scope for the expansion of cultivation. The problem in its various aspects has been studied in greater detail in West Punjab and many of the methods evolved and discoveries made can be applied profitably to Barbary.

**WEST PUNJAB**

In has already been stated in the chapter on Soil and Vegetation that the alluvial West Punjab soils naturally tend to be alkaline. In many parts of the plain, the dry season is marked by the appearance of an efflorescence on the surface rendering it entirely unproductive or reducing yields. The salt which forms this efflorescence is locally known by several names such as Reh, Kallar or Usar. Most of the Kallar lands consist of white alkali - sodium chloride or sodium sulphate but the occurrence of black alkali or sodium carbonate is not uncommon. The former is known as Kallar Shor and the latter as Kallar Siah. Kallar siah is usually marked by a hard pan near the surface that gives the surface an unhealthy yellowish tint and is not suitable for crops at all. Kallar shor on the
other hand exists at the surface and can be used for cultivation after flushing. The concentration of these soluble salts near the surface depends upon the depth of the water table, the porosity of the soil, the state of sub-terranean drainage and lastly evaporation. (1)

It may be remarked here that the salt responsible for soil deterioration in the province is sodium sulphate. Sodium chloride and sodium carbonate are present but in very small quantities. Sodium sulphate is precipitated from a solution of mixed salts at a temperature of \(-3^\circ C\). This may mean that it was deposited at a time when glacial conditions prevailed over the province.

The hollows in the plain are marked by the formation of reh salts as water table is comparatively high and salts from the surrounding lands are washed down.

In the bet or riverain lowlands, good underground drainage and periodic flooding washes away any salts and alkalinity does not present a problem. It is in the more porous portions of the bar uplands that salinity is noticed through its effect on water from wells, as well as in the more widespread occurrence of kallar lands.

These conditions existed naturally and are at present in evidence even in unirrigated regions. The area of alkaline lands has, however, shown a remarkable expansion after the extension of irrigation in recent years. This has usually been explained as being due to the rise of the water-table bringing up with it the salts in the sub-soil which then accumulate as

Distribution of salts before and after a cotton crop at Jaranwala (West Punjab)

Distribution of salts before and after a rice crop at Jaranwala.

water evaporates at the surface. This explanation was accepted universally till investigations were extended to areas in which the water-table is at a considerable depth below the soil surface and hence contact between the water-table and the soil becomes out of the question.\(^{(1)}\)

To investigate further the relationship between the rise of the water-table and the formation of salt efflorescence, a series of villages with water-table at varying depths was selected for observation. The depth of the water-table in these villages varied from 9-40 feet. The examination of the soil conditions showed that the soil crust was 10 feet in thickness lying above a grey sand in which the water-table was situated. The zone of salt accumulation was found to be situated at a considerable depth in good lands whereas in the deteriorated lands, it approached up to within 2 feet of the surface. There was no salt present at the surface. The conclusion from these observations over a number of years were that the salt layer in the crust was not due to the water-table which does not as a rule rise above the bottom of the crust and that the formation of the salt efflorescence could therefore take place without the rise of water-table.

The effects of the irrigated cultivation of cotton and rice on the distribution of salts were then investigated. As the accompanying graphs show in the case of cotton a zone of salt accumulation has formed. In the case of rice which received heavier irrigation the salt appears to have been washed down into the underlying sand layer. These findings have an

\(^{(1)}\) Taylor & Mehta Op.Cit.
important bearing on reclamation as it was proved that if the irrigation water supplied is sufficient to balance the loss by transpiration and evaporation, then the zone of salt accumulation remains stationary or moves down but if irrigation supplies do not balance the loss of moisture by transpiration and evaporation the salt zone moves upwards. In other words it is the intensity of irrigation which determines the position of the zone of accumulation in the soil.

It cannot be denied, however, that even if not always accompanied by a rise in the water-table, alkalinity in the soil does tend to increase following irrigation. The alkaline soils which have developed in the canal-irrigated tracts are known as thur and have been extending at the alarming rate of some 30,000 acres a year. The following record of deterioration over four years in some selected districts brings out the seriousness of the problem. (1)

| District      | 1938-39 | 1939-40 | 1940-41 | 1941-42 |  |
|---------------|---------|---------|---------|---------| |
| Sheikhurpna   | 29,631  | 7,387   | 14,102  | N.R.    | |
| Gujranwala    | 6,864   | 4,364   | N.R.    | 13,513  | |
| Lyallpur      | 3,224   | 1,895   | 3,029   | 5,380   | |
| Montgomery    | 933     | 278     | 4,465   | 6,383   | |
| Ilahpur       | 1,579   | 4,908   | 3,545   | N.R.    | |

The districts listed are among those most heavily dependent on irrigation, hence the extent of deterioration caused by the very foundation of their prosperity is particularly alarming.

(1) Calculated from Season & Crops Reports 1939-1942
N.R. means not recorded in the report.
Experiments on reclamation have been in progress for several years and it has been shown that if reclamation is attended to immediately after deterioration commences, it can be successfully achieved in a year. The longer it is postponed, the greater is the difficulty experienced owing to increased alkalinity.

The basis of reclamation as now practised in the province is the growth of rice. Before the rice is transplanted, the area is leached until the salt content is considerably reduced. The heavy irrigations given during the growth of the rice crop completely eliminate the salt from the soil. The alkalinity which develops on the removal of salt appears to be removed by the action of the roots of the rice plant. The carbon dioxide formed by the roots converts the sodium salts in the clay to sodium bicarbonate and the soil becomes permeable. In the initial stages when permeability is not fully developed, the nitrogen quantity available is small. The nitrogen balance can be restored if a leguminous crop such as berseem or senji follows rice. Following this, a normal rotation of crops is introduced.

Mehta (1) classifies the alluvial soils of the Punjab into five types according to their alkalinity and ease with which they can be reclaimed:— (alkalinity expressed in terms of pH)

Type 1:— Good land capable of carrying normal crops.
Salt content below 0.2%, pH 8.5 or less

Type 2:— Land giving rather lower yields, reclaimed by a single rice crop; Salt content below 0.2%,

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pH 8.5 to 9.0.
Type 3:- Land requiring reclamation by two years under rice; salt content below 0.5%, pH between 9.0 and 9.5.
Type 4:- Salt land that can be economically reclaimed (thur soils); salt content above 0.2%, pH below 9.0.
Type 5:- Land difficult and costly to reclaim (rakkai soils); may or may not have high salt content, pH above 9.5.

The geographical distribution of these soils cannot be determined except by extensive field studies and analysis of soil samples. Even then the exact distribution will remain a problem as "salty soils have a spotty distribution, which has been described as a kind of smallpox on the soil" (i)

Growing rice under intensive irrigation has not proved efficacious everywhere and in the Montgomery district, alkalinity was cured only by scraping off the efflorescence, watering and ploughing the land and turning in cuttings of Bermuda grass (Cynodon dactylon). The grass is grazed for three years by sheep and cattle. It may then be ploughed and cereals followed by lucerne and cotton grown. (ii)

(i) Op.Cit.P.3
(ii) Ibid P.13-14
THE PROBLEM OF SOIL EROSION

The ultimate basis of agriculture is the soil, the top few inches of which provide most of the essential food to plants. Being exposed to wind and water, the soil has always been subject to some erosion. Under natural conditions, undisturbed by man, there exists a delicate balance in the extent of erosion through the protective action of vegetation so that the soil-formative processes keep pace with soil removal. The interference of man and his animals upsets this balance resulting in the acceleration of erosion and the consequent impoverishment and even complete destruction of the top-soil. This interference has become intensified in recent times through the increase of population, the extension of grazing and cultivation at the expense of the natural forest cover, and careless or faulty methods of farming. Widespread erosion has resulted in many parts of the world, and many an eminent scientist has raised the cry of civilization in peril - no mere slogan but a dreadful possibility if the two trends of increasing population and destruction of productive area continue.

In the two regions under review, this problem is present in some of its severest forms and constitutes a serious menace to their agricultural prosperity. The area subject to severe erosion in Barbary has been estimated at over 20 million acres. In West Punjab, lands suffering from wind or water action occupies 6½ million acres. (1) The problem is particularly

(1) Calculated from R.M. Gorrie "Soil and Water Conservation in the Punjab" from table on P.146-147
serious in West Punjab where the pressure of population on the land is very much greater, and the area already damaged by erosion constitutes a substantial area.

Travelling in the Potwar Plateau, one cannot help being impressed by the desolate wilderness of ravines which stretches away for miles, a result of long-continued soil denudation. In many parts of Barbary, notably in the Algerian Tell, the mountain slopes present an equally dreary aspect with their deep gullies and ravines. One of the primary problems in both West Punjab and Barbary is to reclaim the eroded regions on one hand and to conserve, through rational cultivation methods, the soil of those areas that are susceptible to erosion.

Before a detailed analysis of the causes of erosion in these regions, their effects and their cures, the principal processes of erosion may be described briefly.

EROSIONAL PROCESSES

The two active agents of erosion are water and wind.

1. Water erosion is the transposition of soil by rain water (including melting snow) running rapidly over exposed land surfaces. It is conditioned by factors of slope, soil type, land use and intensity of rainfall and is confined to sloping areas. Water erosion is most severe in mountainous regions denuded of vegetation. The following types of water-erosion may be noted:

   (a) Rain-drop Erosion - When rain-drops fall on bare slopes they remove the loose particles of soil and also loosen

(i) See last chapter
the crumbs by their impact. Rain-drop erosion may increase by as much as 1200% with increase in the size of individual rain-drops. (1) Thus erosion in this manner is bound to be intense under torrential rains characteristic of Barbary and West Punjab.

(b) **Sheet Erosion** is the more or less even removal of soil in thin layers over an entire segment of sloping land. Often, there is a gradual change in the colour of the soil from dark to light as the humus-charged top soil is removed, a change accompanied by a progressive decline in crop yields. Steep lands and those subject to heavy rainfall are most liable to suffer. Ploughing is a deterrent to large-scale sheet erosion through furrowing but fallow or uncultivated land is stripped of its soil cover very rapidly. Sloping, unterraced fields also lose heavily. The loss of plant nutrients by sheet erosion varies from 3 to 31 times the amount of mineral elements extracted by harvested crops. (ii)

(c) **Rill Erosion:** Run-off water tends to concentrate in streamlets of sufficient velocity and volume to generate cutting power. Rill erosion is the result, marked by small incisions left in the land surface.

(d) **Gully Erosion** takes place when the concentrated run-off on an unprotected slope is large enough in volume and velocity to cut deep incisions or gullies into the surface. Prolonged rill erosion may have the same

(ii) Ibid, P.8
effect. Gullying is the arch-weapon of destruction of the soil and gives rise to those spectacular landscapes that are so striking a feature of badly eroded regions.

2. Wind Erosion develops on level or slightly sloping areas with an arid climate. It is most intense in relatively flat treeless regions where the sweep of the wind is unbroken by topographic irregularities, and loose soil or sand is removed from drier areas or from sandy beds of streams to arable lands over long distances. Thus wind erosion takes the form not only of soil removal but also its deposition over distant areas, resulting in the deterioration of land in both cases. In regions like Barbary and West Punjab where prolonged heat and drought tend to break up the surface soil into loose dust and sand, this danger becomes specially grave.

Most of these processes are in evidence in these two regions in varying intensities as the following account will show.

THE CAUSES OF EROSION:-

The entire responsibility for existing erosion cannot be placed on the carelessness or ignorance of the present occupants of the land. The practices and faulty methods that are today seen to cause soil erosion have been in vogue over centuries. That these practices are now causing more damage than ever is certainly true. The most fundamental reason for the present intensification of erosion must be
sought in the great increase of population which caused man to encroach on the vegetation of marginal lands in order to make a living by grazing his animals or by cultivation. The simple statement that deforestation, overgrazing and careless cultivation of slopes are the chief causes of erosion does not penetrate to the mainsprings that are economic and social. Hence even while studying these immediate causes, we must make an appeal to their historical development, as well as to the social and economic conditions prevailing.

**Historical background:** In the chapter on Soils and Vegetation we have already reviewed briefly the progressive diminution during historical times of the forest cover in Barbary through the extension of cultivation, the consumption by pastoral tribes and by large cities of considerable areas of wooded land. We may also recall that this is not the first age which has discovered the problem of erosion and worked out its solutions. Soil conservation practices reached an astonishing perfection during Roman times as countless ruins in central Tunisia and south-eastern Algeria testify. The system of terraced cultivation of olives, developed during Islamic domination, is an ideal means of conserving both soil and water. These devices were, however, either lost or not practised widely enough and the reckless clearing of vegetation continued accompanied by widespread denudation of the soil. The problem has dawned upon us again in all its seriousness owing to the high stakes involved - being the very survival of the race, rooted as it is in the soil.
We may now make a historical survey of soil erosion in West Punjab. When the Aryan invaders from the steppes of Central Asia crossed the north-western mountains and came into the province, the greater part of the Potwar Plateau was covered with forests and cultivation was confined to the river valleys. (i) The area was gradually cleared of its vegetational cover, a process which has continued till today—no suitable land is left for the expansion of the population. In an undulating region, soil was eroded quickly by gully erosion. As arable land began to be lost, the farmers tried to hold it by terracing and embankments but the quick run-off from the bare slopes destroyed these efforts so that today, the plateau is fretted with ravines over a considerable part. As agriculture was laborious and difficult large flocks of sheep and goats and herds of cattle were kept on the excellent pastures available in the forest. The increase in their numbers and the reduction in forest area lead to overgrazing so that widespread erosion was again the result. The Himalayan outliers in the Murree Hills were also largely deprived of their forest cover by clearings for cultivation and by overgrazing. There are records of the practice of shifting cultivation when selected portions of forests were felled, the land cultivation till sterile by erosion and then fresh fields created by burning. This practice was put a stop to long ago. (ii)

(i) Sir Harold Grover "Erosion in the Punjab, Its Causes and Cure" Lahore, 1946, P.11
(ii) Ibid, P.12
The main immediate causes may now be treated in relation to our two regions:

1. Deforestation: - This has been caused by the need to cultivate more land for an increasing population as has been stated before or by lopping. Lopping is a serious menace in West Punjab where despite strict forest regulations, wandering shepherds and herdsmen do great damage to the trees. "In Murree, the oak (Quercus dilatata) near Bhurban has been lopped to death in recent years and blue pine trees have replaced it whilst lower down the slopes are completely barren" (1) Extensive destruction of trees in the forests is also caused by sheep and goats and is inter-related with the much more grave danger from overgrazing. The role of forest fires that would be frequent at the end of a hot dry summer must have been considerable in causing deforestation in Barbary. As for West Punjab the writer has had occasion to observe some such conflagrations after a period of drought in the Murree Hills, causing extensive losses of the tree cover.

2. Overgrazing: This has been a major cause of erosion in both West Punjab and Barbary where before the great development of irrigation and agriculture pastoral pursuits supported a large part of the population over the semi-arid regions covered with a bushy vegetation.

In Barbary, collective lands have always been grazed by large numbers of cattle, sheep and goats, not to forget the camel who can reach up to almost any tree. The large-scale

(1) Ibid P.10
This photograph from Algeria shows the erosion of the 47 bare slope in the foreground while the ground further up is protected by compact brush. The photograph from Algeria shows the erosion of the
Isolated trees and bushes are not enough to protect the land from erosion. This slope in Algeria has been eroded by rills.
clearings for cultivation and even more important, the extensive acquisitions for French colonisation have resulted in these animals being restricted to smaller areas so that whereas formerly different parts of the pastures were used every year, now there is no choice except to graze excessively within the same areas from year to year. This change in the case of the Sherarda has already been cited. The case of the semi-colonised is another of the many examples.

The Muslim cultivators in West Punjab particularly those in the Potwar Plateau and the sub-montane tract graze a much larger number of animals in the forests and collective lands (shamlat) than the vegetation can support. Grazing rights are possessed by farmers and professional graziers but there is no effective means of limiting the number of animals grazed. During the monsoon there is a flush of grass and there is enough to feed the cattle adequately but during the long periods of drought, the grass is grazed to the ground and the hungry cattle tear out the roots. When the drought is broken by storms of "tropical intensity", the soil is washed away from the bare pastures and they deteriorate. Good quality grasses are replaced by progressively poorer types like spear grass (Heteropogon contortus), lambh (Aristide depressa) etc.(i)

The sheep and goats graze not only the grass but also browse on bushes; the goat feeding on almost anything it can

(i) Ibid P.14
Badly eroded landscape in Rawalpindi district. The original plateau surface can be noticed in the foreground as well as in the residual pieces of land standing among the ravines.

These Jand (trees show the extent of erosion in the Potwar region during their life-time. In 40 years a thickness of soil equal to the height of exposed roots has been removed since they first took roots.
Another wilderness of ravines in the Potwar Plateau. This is in the Attock District. Notice stratification revealed by gullies. White layers are the resistant clays while dark layers are lighter loams.
reach which gives it a considerable range for it is amazingly acrobatic and scales the most difficult slopes and eats everything that is not poisonous or very unpalatable.

The sheep and goats and the cattle also break the surface of the soil with their hoofs and the paths they habitually follow often become the starting points of gullies. 3. Faulty Methods of Cultivation:- When studying these methods, we should remember that the peasant, rooted as he is in the soil and adapted to the environment through hereditary experience, does not act contrary to nature. Given a long enough time to settle, he instinctively takes steps to protect the soil of his fields. Thus regions wherein cultivation on slopes has been carried on for a long time show adaptations to the natural conditions by means of terraces and stone walls to restrain erosion. The peasants in many valleys in the Murree Hills in West Punjab have practised terraced cultivation for ages. In many parts of Barbary, notably the well watered valleys of the Middle and High Atlas, terraced cultivation has similarly been carried on for centuries. The writer visited some of these valleys south of Marrakech and found with what effectiveness the soil had been protected by the fellahaen who, unaware of all the technical details of angles and gradients, practised methods that worked and kept their fields in good production.

Faulty methods result when peasants habituated to one environment are transplanted to a different one and
Erosion of the deep alluvial soils in the Sahel region of Tunisia. The trees in the valley and on the higher ground are olives.
Soil Conservation in Algeria. In the basin of Wadi Mellah a check-dam has been constructed across a gully. Notice the generally bare hillside.
continue to practise the same methods as before. Much of
the unturrenced cultivation of slopes now observed in the
Algerian Tell above the fertile valleys may be traced to the
fact that the native cultivators were deprived of their lowland
fields by colonisation and driven to plough the sub-marginal
hill-side land formerly reserved for grazing or lying unused.
Indeed this admission is made in an official publication of
the Algerian Government on the problems of the conservation
of the soil when it asks for cooperation of the colonists
"It should not be forgotten that the degradation of the
mountains is an indirect result of the colonisation of the
plains. It is only just that these rich and fertile plains
should contribute their share to the restoration of the
mountains in this way to repair the damage they have
indirectly and involuntarily inflicted" (i)

While colonisation is the main cause in Barbary, the
increase in the population has also driven the peasants
in both Barbary and West Punjab to till the sloping marginal
lands without any of the precautions necessary to conserve their
soil. Thus deforestation followed by unturrenced cultivation
completes the ruin of these lands.

The social and economic causes behind careless or
faulty cultivation relate mainly to the land tenures and the
size of holdings as well as to social practices that drain
away the reserves of the farmer or cause heavy indebtedness.

(i) "Défense et Restauration des Sols", Gouvernement Général
de l'Aldérie, Service de la Defense et de la Restaurations
des Sols, 1941, P.33
The recent F.A.O. survey of the problem gives several possible economic reasons for the deterioration of the soil of which the following apply to the regions under consideration.

1. **Size of holdings** - The struggle to make a living from a small parcel of land leads to over-cropping or cultivation of steep slopes, both resulting in the deterioration or erosion of the soil. The writer came across several small holdings in the Shelif valley in Algeria and in the coastal lands to the north on which the land was already broken up considerably by incipient gullies. On inquiry, it was found that the sloping land had recently been tilled for cultivation due to the increase in the size of the family which now required more food than could have previously been produced by the fields on level lands.

Similar uneconomic exploitation of valley-sides without proper precautions against erosion is found widely in both Barbary and West Punjab. As the entire holding planted presumably with one crop, becomes bare after the harvest, torrential showers remove large quantities of the fertile top soil by sheet and rill erosion, developing, in extreme cases, into gullies. More varied land-use, possible on larger holdings provides a safeguard against this permanent waste of productivity.

2. **Insecurity of Tenure**  

Attention was drawn in the chapter on Land-ownership and Tenures to the indifference

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(1) Soil Conservation, an International Study, Washington 1948, 13-30
shown by tenants, at-will or temporary labour to the future of
the lands worked. Large land-holders either do not find it
possible or do not bother at all to supervise the exploitation
of their properties. Changes in land-tenure can bring about
a tremendous improvement in the care and maintenance of the land
as has already been indicated in the chapter mentioned above.

Instances of land-deterioration through the
insecurity of tenure are frequent in the Potwar Plateau where
large land-holders are numerous. The practice of leasing
land on _khammes_ in Barbary is in general conducive to careful
cultivation although if the lease changes hands too frequently,
soil deterioration may set in through the lack of interest
of the tenant.

Heavy Taxation:— The burden of taxation may yet be another
reason for over-cropping or encroachment on marginal sloping
lands. The writer got the impression in Barbary that the
small holder was heavily taxed. Large proprietors and colonists
practising mechanised cultivation are accorded tax-reductions
on the ground that they were incurring capital expenditure.
The question of land-taxation is far too complicated to allow
of more than this general statement as the writer could not
undertake a detailed study which would be a subject for
research by itself. In West Punjab, the taxes on the land
are not excessive at the present time as they still stand at
the pre-war rates while the prices of agricultural products
have gone up 300% and more.
The F.A.O. survey lists *price depressions* (1) as an economic cause of soil deterioration through indebtedness of the cultivator or his failure to maintain the fields in proper condition through lack of interest. During the last World War, a sudden increase in price due to shortage was noticed in Barbary to have resulted in an extension of cultivation even to marginal and sloping lands by peasants anxious to reap the full profit from the situation.

Rural indebtedness was a serious evil in West Punjab till recently when the 1937 legislation curbed the moneylenders. Social practices mainly relating to marriage customs and similar festive occasions (birth of a son etc.) led to heavy expenditure quite beyond the means of the cultivator who borrowed money at exorbitant rates of interest. So high was the interest or so great the gerrymandering of the figures that the peasant might spend a life-time paying his earnings to the moneylender. The need to get one's livelihood as well as the interest or capital of the loan out of one's land frequently led to incessant cultivation of the soil to the point of exhaustion and encroachments on marginal lands. Happily rural indebtedness is no longer the serious problem it was (11) in West Punjab but it must have caused considerable deterioration of the soil while it lasted.

Indebtedness caused by similar social customs or by successions of bad harvests is still widespread in Barbary.

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(1) Ibid. P.21. Most of the observations in this manual relate to large farms typical of the United States of America.
Its detailed study is again beyond the scope of this work but its ill-effects on the soil should be noted.

It would appear from this survey of the causes of soil erosion and deterioration that almost all aspects of the cultivator's life - his methods of cultivation, his animals, even his social customs have a direct influence on the soil. The need therefore is not only for measures against erosion itself but also against its deeper causes.

The Rates of Run-off and Erosion

The main factors in the extent to which water run-off the land and the soil is removed were referred to under erosion processes, i.e. slope, soil type, nature of vegetal cover and intensity of rainfall. How far these different factors affect the rate of erosion has been determined by means of experiments conducted in the United States of America and in the Punjab. The percentage run-off under different types of vegetation and crops has been calculated to be as follows: (1)

<table>
<thead>
<tr>
<th>Vegetation Type</th>
<th>Run-off Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forest</td>
<td>3</td>
</tr>
<tr>
<td>Wheat and oats</td>
<td>25</td>
</tr>
<tr>
<td>Grassland</td>
<td>5</td>
</tr>
<tr>
<td>Maize and cotton</td>
<td>50</td>
</tr>
</tbody>
</table>

Experiments with sample trays in East Punjab disclosed the following figures (2) of soil removal according to quarterly periods of rainfall:

(1) M. Gosselin "La Defense des Sols Cultives contre l'Erosion" Tu.Agr. 1942, P. 43

The loss of soil from the bare tray was about 10 times that from the grass and scrub-covered trays. The greatest loss of soil was recorded during the monsoon months. The approximate total loss per acre from bare soils could be 20 tons of soil for 18 months as compared to the loss of only 2 tons from the covered areas. It was also noticed in the course of the same experiment that the proportionate run-off from the bare trays tended to increase from 40% in the first six months to 50% during the next six months and ultimately reaching 60% during the last six months.

The erodibility of soils depends upon their absorptive capacity (greater run off from impermeable soils causes greater erosion) the percentage of clay (heavy soils do not generally absorb plenty of moisture and are easily gullied) and the organic content which greatly enhances the water-holding power of the soil.
THE EFFECTS OF EROSION

The direct and indirect consequences of erosion are far-reaching in their effects on the landscape, water-regime of rivers, irrigation, crop-production and even the climate of a region amounting in their totality to its complete economic ruin. How serious these effects are in a region depends upon how far erosion is advanced. In Barbary and West Punjab, from the decreasing production of areas subject to sheet erosion or incursions of sand to the complete destruction of the productive capacity in other regions, we have all the gradations of the damage caused by this peril. The following account summarises the effects of erosion.

1. Loss of Soil and Fertility of Arable Land:— This effect has already been described under erosion processes and to some extent under their causes. It is not measurable quantitatively over a short period but its long-range influence in productivity is easily noticed. The loss of the soil is the loss of the capital of crop-production that cannot be replaced. Once the stream catchments become eroded, the fields further down cannot be saved even by embankments and terraces as the immediate run-off in the shape of floods breaks them down. "Hundreds of broken dams, embankments and weirs bear witness to the destruction which has occurred in the past in the cultivated uplands of the Rawalpindi Division (Potwar Plateau)." (1)

(1) Glover Op.Cit. P.17
The writer noticed several cases in Algeria where the stony sub-soil had been exposed by sheet erosion in the hill-side holding of a peasant, and the fields were producing miserable crops. Here and there gullies were developing as well. Similar effects are noticeable widely in the Potwar Plateau. In the Jhelum district there has been actual decrease in the arable area.

2. Inundation of Land in the Plains:— The denudation of the hills increases the violence of floods which bring down coarse sand and silt and deposit it over the fertile fields. This has been commonly experienced during floods both in West Punjab and Barbary. The soil lost by the hill-farmer thus does not always enrich the peasant in the plains as is sometimes supposed but often chokes up the cultivated fields with infertile rubble.

3. Silting up of Reservoirs and Canals:— The seriousness of this problem has already been pointed out in the case of Barbary where large irrigation works constructed at great cost have become useless over a short period of time. The problem, though eased in the case of West Punjab by the type of weirs employed, is nonetheless present in another form as the beds of the rivers are being raised and the canals being choked. In the case of the Upper Jhelum Canal, special arrangements have had to be made to prevent the torrents which come from the Pabbi Hills Gujrat from depositing their load of silt in the canal. (1)

(1) Ibid p.18
4. **The Shortage of Fodder and Deterioration of Cattle:** As pastures deteriorate, the cattle get less to eat and become weaker. The numbers of cattle tend to decrease as also their quality. This has its effect on the quality of ploughing as animals are the chief means of tilling the land both in Barbary and West Punjab. It may also be added that if natural pastures were preserved, it would not be necessary to devote an increasing area to fodder crops so that more food could be grown for the rising population.

5. **Shortage of Timber and Fuel** as a result of erosion has an indirect effect on cultivation, particularly in West Punjab. Large quantities of natural manure available from cattle-dung is burnt to meet this shortage and thus denied to the heavily cropped fields. Shortage of timber means poorer housing for the peasant and his family.

6. **Floods:** There is every evidence that floods in Barbary and West Punjab have been becoming more violent through the denudation of river catchments. Some of the indirect effects of floods have been described before, but the direct destruction caused by them is equally considerable. Fields and villages are carried away, cattle drowned and thousands rendered homeless by the floods which frequently come down West Punjab rivers, specially the Ravi and the Indus. The great fluctuations in their water regime during floods have already been described under Hydrography. Similar facts have been quoted before for the rivers of Barbary. Apart from the
direct damage to fields and settlements, dams have been destroyed by them so that the present reservoirs are being equipped with expensive devices to withstand their sudden force. Excess of water in one season, taking the shape of floods in one season, means shortage during the dry season. Preservation of vegetation could regulate this supply to the benefit of irrigation and general water supply for domestic use.

7. Lowering of the Water-Level:— With the numerous outlets provided to the sub-soil water to escape by deep gullies as also the smaller amount of percolation from the higher lands, water-level is bound to fall. This has been noticed widely in West Punjab and doubtless exists in Barbary as well. In the Potwar Plateau, terracing and embanking of ravined fields in the Gujar Khan area produced a rise of 15 feet in the wells. (1) Similar rises have been reported from the neighbourhood of other soil conservation works.

These mainly economic and agricultural consequences of soil erosion amount in effect to a lowering of the standard of living.

Far-fetched as it may sound, erosion actually brings about a change in the climate. When the trees disappear the earth gets heated up more quickly and strong convection currents hinder precipitation from clouds. The effect of vegetation on rainfall in Algeria was described in chapter on Soils and Vegetation wherein it had been proved

(1) Ibid P.22
by meteorological observations that deforested areas had, 8% less rain than those covered with forests within the same natural region.

The effect of wind erosion has recently been noticed particularly as *shifting sand* from the Thar desert advances to the irrigated lands fringing it. At the Indian Silvicultural Conference of 1945, Lt.Col. Westland Wright produced a map of the Punjab on which was entered the record of sand movement since 1870 (i) The indication is that desert conditions are steadily advancing in the direction of the great cities of Lahore and Delhi. Due to the disappearance of vegetation in the unirrigated lands of the desert, sand dunes formerly fixed by bushes have begun to move northwards. Incursions of sand usually take place during the dust storms of the summer. It should not be imagined that sand just swallows up the fertile land. "The actual process is a less spectacular but more insidious one of gradual decay from an ecologically stable forest destroyed to make way for cultivation whose fertility dwindles till the land is merged into the adjoining desert" (ii) The map opposite shows the regions affected by shifting sand. Similar incursions are frequent in the desert fringe in Barbary, particularly in Tunisia where the protective barrier of the Saharan Atlas does not exist. Shifting dunes are also a source of danger to agriculture on the Atlantic coast of Morocco and the entire coast of Tunisia.

(i) R.M. Gorrie "Countering Desiccation in the Punjab" G.R. 1948, P.30

(ii) Gorrie, Soil & Water Conservation in the Punjab" P.217
SOIL CONSERVATION:

Soil conservation practice goes beyond the simple fight against erosion and indeed as one of the greatest authorities on the problem, H.H. Bennet has observed, "Soil conservation in the modern sense is not just controlling erosion; it means doing that and whatever else needs to be done to keep the land permanently productive" (i) He has also warned against several misconceptions about erosion, the most serious being the belief that soil conservation can be attempted successfully by individual farmers without technical assistance, a belief that appears to prevail even among soil-erosion experts, at least in Barbary. In Algeria, which is the only territory in that region in which soil conservation work has been going on for some time in an organised manner, the Service de la Défense et de la Restauration issued a manual for the use of the farmer, setting out the simple lines of elementary constructions and embankments to be undertaken and the nature of trees to be planted. (ii) This type of guidance may not lead to perfect results but it is certainly preferable to no guidance at all in face of the present inadequacy in numbers of technical staff to fight a problem of such great magnitude.

Modern soil conservation practice is of American origin. Some of its principles will therefore be described as evolved through the American experience (iii)

(i) "Soil Conservation in a Hungry World" G.R. April 1943, V.38, P.311-317
(ii) "Manuel Simple de Défense et de Restauration des Sols en Algérie"
We shall then take up the different territories in turn and see how these principles are applied, what adaptations or modifications affected to suit the local conditions.

1. The most important principle of soil conservation is the control of run-off. By the maintenance of vegetal cover, by increasing the permeability of the soil and by means of checks to run-off like terraces, diversion banks and ditches, the amount and velocity of run-off is kept low. Whether it is in the fields or outside the fields, the excess water is made to flow into natural channels.

2. The covering of steep or eroded slopes with permanent vegetation to delay run-off on one hand and to hold the soil together on the other. It is the steeper slopes which need greater initial care.

3. Means to be adopted by which a part of the cultivated lands is always under some sort of cover and no bare fallows are left exposed to erosion. This takes the shape of strip-cropping or suitable crop-rotations.

4. Contour cultivation even on very gently sloping soils as a safeguard against sheet erosion.

5. Control of gullies and streams.

6. Control and development of pastures by rotational or reduced grazing.

7. Removal of the social and economic handicaps in the way of the above improvements like small or scattered holdings, over-cropping, etc.
In addition, in conformity with the larger purpose of maintaining or even improving productivity, measures like the use of manures and the preservation of crop residues are adopted to conserve the fertility of the soil.

3. To provide for defence against wind erosion by means of shelter belts, fixation of sand-dunes and improved dry-farming.

Gorrie (1) divides the actual methods into two main categories - upstream and downstream engineering, the upstream works being those dealing with mountainous areas and catchments. This is a useful concept for conducting operations in the field.

Before any drive for soil conservation can succeed it is essential to awaken the populations concerned to its dangers. Surveys of the land should be made and the soils classified according to their degree of productivity and erosion. The task of conserving the soil on a large enough basis can only be undertaken by the State.

BARBARY

Due to its mountainous relief and special climatic conditions, Barbary is highly susceptible to erosion. How progressive diminution of the vegetation cover and the local economic and social conditions have brought this evil on in all its various forms has also been demonstrated.

The first country in which this problem attracted attention was Algeria where in 1384, the then Governor-General

(1) Op. Cit. P.20
advocated afforestation as a protection against floods and to regulate water flow. (1) An effort was made to re-afforest denuded regions and 24,000 acres have since been planted. But this action was hardly in proportion to the gravity of the problem and it was not till 1941 that the Service for controlling soil erosion (mentioned before) was established. Since then a general survey of the areas subject to various stages and types of erosion has been made and it has been established that 13,000,000 acres need attention. Most urgent is the necessity of controlling erosion in the large catchments from which water is collected in the great reservoirs.

The Manual of Soil Conservation issued for the lay farmer advocates certain measures and gives fairly detailed instructions as to how they are to be put into effect. It draws special attention to the danger of depriving sloping lands of their vegetative cover and by means of photographs (See opposite), demonstrates how scattered bushes and isolated trees are no protection against sheet erosion. It recommends that the natural cover may be preserved but wherever extension of cultivation and pastures is sought, the following steps are advocated:

(a) All plantations of fruit trees, vine etc. shall be made along contour lines. The stones extracted from the ground should not be thrown away but employed in making contour ridges. In brief whether it is by hedges, or rows of planted trees or stone ridges, the run-off should be controlled. Even where bush is cleared, it advocates leaving

(1) Documents Algeriens - Le Reboisement en Algerie et la Restauration des Sols. Serie Economique etc. 1945 No. 1
Soil conservation by the native population.

The bare slope has been terraced along the contours. A gully is visible in the foreground.
Terraces established in the catchment area of the Hamiz Dam by the Service de la Defense et Restauration des Sols.
lines of bushes every 75 feet or so along contours.

(b) It is possible to go one better than merely protect soils; one can restore soils by constructing terraces. These could consist of earthen embankments or low walls of stone with ditches behind them. On very steep slopes, steps could be created. The earth dug out to make the step should be deposited as an inclined bank. These can then be fixed with bushes, cactus or other small trees. Check-dams of various types are advocated for ravines to break the velocity of run-off.

The manual lists a number of fruit trees as useful for fixing the foundation of stone embankments, notably olives, figs, table vines, cherries etc. These are also recommended for planting on the earthen embankments above steps on a hill-side, thus offering a temptation to the cultivator, or at least a reward for his trouble.

The problem of soil erosion and deterioration is a serious one in Algeria from which the small Muslim peasants on the hill-sides are particularly bad sufferers. Re-afforestation is the best economic use of many a slope the writer saw scratched with the primitive ploughs but the human conditions created by colonization do not allow of this.

Happily the practice of terraced cultivation is being adopted widely and is especially popular in the Kabyle region.
The colonists have the means and the resources to practice all the methods the manual advocates to perfection.

The Government's efforts are mostly concentrated on preventing the silting up of reservoirs. Apart from the recent bench-terraces around the Wadi Fodda Dam, the catchments of the Hamiz Barrage and of Wadi Mellah have been terraced since 1940 by the Service des Irrigations. The collaboration of all interests concerned - colonists, local peasants and tribal groups with the administration has been solicited by a decree of 1941 which prescribes three steps to be taken by the Services de la Defense et de la Restauration des Sols about treating threatened areas. The first step is a decision to start anti-erosion measures in a catchment area. The catchment is then declared to be a public utility and contour-cultivation and the construction of stone-ridges is enforced; grazing and lopping as well as new extensions of cultivation are prohibited. The pastures are regulated and growth of olive and other trees encouraged. The last step consists of the official measures for conserving the soil such as construction of steps, terraces, diversion ditches etc. The task of re-afforestation is still being pursued. Map shows those parts of Algeria where erosion is in progress and also the areas where soil conservation work is being done.

TUNISIA:-

The dangers of erosion have been known in Tunisia since long and particularly the fixation of advancing dunes

was undertaken as long ago as 1888 by the Forest Service in southern Tunisia. Since then the fixation of dunes has been the main preoccupation of the authorities, particularly along the north coast and in the Cap Bon region. Several types of grasses have been utilised particularly Amnophile arenaria and Saccharum biflorum. Once dunes have been fixed plantations of Aleppo pine, Canaries pine and Eucalyptus have been established which not only provide wind-breaks but also constitute a valuable economic resource.

The menace of water erosion has increasingly been recognised in recent years and a visit from Dr. Lowdermilk, Deputy Chief of the U.S. Soil Conservation Service in 1939 stimulated interest in soil conservation work on the lines followed in the United States. He advocated among other things the employment of tractors etc. already in use on the larger estates to construct contour-terraces. He noticed the ravages of erosion, as did the writer himself, among the olive-growing regions of the Sahel (see photo) and recommended terracing and more widespread use of the existing device - that of muskat.

The commencement of soil conservation work in Algeria in 1941 has since led to increasing efforts to organise the fight against erosion by means of setting up a

(i) "Les Forêts de la Tunisie" 1931, P.30
(ii) M. Lesculoyer "Les Dunes de Tunisie" Unpublished 1944
separate department. Although this has not yet been achieved, a grant was made in 1947 and initial work commenced in the regions of Kairwan and Cap Bon. It is planned to make practical demonstrations to cultivators, to give technical assistance and lend machinery for undertakings by landed proprietors. At the same time closure to grazing has been applied in several regions, notably in Zaghwan south-west of Tunis and the preservation of forest ensured through several decrees.

It may be said in conclusion that the most imminent task in Tunisia is the prevention of wind erosion as water erosion is not as advanced as in Algeria due to a less mountainous relief.

MOROCCO:

Morocco ranks second among the territories of Barbary from the point of view of erosion and the estimated area on which erosion is in progress is over 7,500,000 acres. Over-grazing is the greatest single cause although cutting of forests and careless cultivation are widely in evidence. The organisation of the fight against erosion has been undertaken after the last war and entrusted to a Conservateur of the Forest Service (Service des Eaux et Forêts) but the co-operation of the department of animal husbandry (Service de l'Elevage) and of other services concerned has been enlisted. Soil conservation work, consisting primarily of step terraces has been started in the Rif region around Wezzane as well as
in the Marrakesh region where the Nfis Barrage is in danger of being rapidly stifled up. The control of stream-beds has also been carried out in the plain surrounding Marrakesh. The work is as yet in its infancy and is hardly adequate to meet the requirements of the country. Coastal dunes in the region of Mogador have been fixed.

WEST PUNJAB

How far the province has been affected by water and wind erosion may be judged from the following estimated district-wise figures (1) of lands ravined, those in need of terracing and others at the desert fringe subject to incursions of sand. It may be added that Gorrie lists them as "Reclamable land", possibly implying that there are further areas so badly eroded that reclamation may be out of question.

<table>
<thead>
<tr>
<th>District</th>
<th>Gross Area</th>
<th>Requires Terracing</th>
<th>Ravines</th>
<th>Desert fringe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lahore</td>
<td>1,667</td>
<td>100</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sialkot</td>
<td>1,005</td>
<td>50</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Gujranwala</td>
<td>1,474</td>
<td>200</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Sheikhupura</td>
<td>1,479</td>
<td>200</td>
<td>200</td>
<td>-</td>
</tr>
<tr>
<td>Gujrat</td>
<td>1,458</td>
<td>200</td>
<td>200</td>
<td>-</td>
</tr>
<tr>
<td>Shahpur</td>
<td>3,071</td>
<td>-</td>
<td>100</td>
<td>400</td>
</tr>
<tr>
<td>Jhelum</td>
<td>1,771</td>
<td>200</td>
<td>400</td>
<td>-</td>
</tr>
<tr>
<td>Rawalpindi</td>
<td>1,312</td>
<td>200</td>
<td>300</td>
<td>-</td>
</tr>
<tr>
<td>Attock</td>
<td>2,680</td>
<td>700</td>
<td>500</td>
<td>-</td>
</tr>
</tbody>
</table>

(1) R.M. Gorrie, "Soil and Water Conservation in the Punjab" P.146-147
<table>
<thead>
<tr>
<th>District</th>
<th>Gross Area</th>
<th>Requires Terracing</th>
<th>Ravines</th>
<th>Desert fringe</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mianwali</td>
<td>3,436</td>
<td></td>
<td>100</td>
<td>700</td>
</tr>
<tr>
<td>Montgomery</td>
<td>2,721</td>
<td></td>
<td></td>
<td>300</td>
</tr>
<tr>
<td>Lyallpur</td>
<td>2,249</td>
<td></td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Jhang</td>
<td>2,169</td>
<td></td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Multan</td>
<td>3,604</td>
<td></td>
<td></td>
<td>500</td>
</tr>
<tr>
<td>Muzaffargarh</td>
<td>3,559</td>
<td></td>
<td></td>
<td>400</td>
</tr>
<tr>
<td>Dera Ghazi Khan</td>
<td>3,475</td>
<td>50</td>
<td></td>
<td>300</td>
</tr>
</tbody>
</table>

Total 37,130 1830 1,650 2,800

The problem is most urgent in the Potwar Plateau and the neighbouring sub-montane tracts wherein ravines alone cover 1,600,000 acres and are still extending. Another zone of danger is the desert fringe where the problem is one of wind erosion.

The Evolution of Soil Conservation Work:— As early as 1870-80, Baden-Powell prepared a soil conservation programme after seeing the ever-extending hold of this menace in the foothills. In 1900 a Land Preservation Act was passed to stem the process of erosion by controlling forest-cutting and grazing, by the training of streams and by the "levelling, terracing, drainage and embanking of fields"(1) Thus it may be noticed that the fundamental principles of soil conservation had already been set out. Not much was done about the matter because of a lack of public interest on one hand and lack of

co-ordination between the government departments on the other. On the report of the Forest Commission pointing out the increasing gravity of the situation, a special branch of the Forest Department was created to conserve the soils of the forests, pastures and cultivated fields. The Soil Conservation Circle has done some effective work up till now but a much greater amount of popular and government interest is required to reclaim the badly ravined darrar lands, to prevent the washing away of the fertile soil from the sloping fields and to stem the advancing sea of sand from the south.

Soil Conservation in Theory and Practice:— It is now proposed to lay down the principles on which soil conservation work can best be planned for West Punjab conditions and to illustrate the theoretical solutions with what has actually been achieved in the field. The main guides in this survey are the recent studies by Sir Harold Glover and Dr. A.M. Gorrie, both of whom have contributed greatly to the organisation of soil-conservation work in West Punjab. Before the actual field operations can be undertaken some initial spade-work is essential on the following lines:—

Propaganda:— The peasant or the pastoralist whose lands are threatened by destruction are independent-minded individuals who, like all men, resent interference into their properties. The danger has got to be explained to them and persuasion used rather than compulsion. The most effective

(1) Both cited before.
means of propaganda is actual demonstration in the field. Once the landholders know the value of conservation methods, the task of organisation becomes much easier. Popular support can also be enlisted through acting through village representatives (panchayats) or local notables.

Official Co-ordination:— The field operations connected with soil conservation encroach on the domain of several government departments notably those of Forests, Agriculture, Irrigation etc. and need the assistance of several others, notably the Co-operative and Revenue departments. Apart from official co-ordination in conducting work in the field, Gorrie considers that the best way of planning soil conservation is to make comprehensive surveys through field parties consisting of several experts on different aspects such as climate, landscape, vegetation, agriculture and the social and economic background of the region as was done in the case of U.S.A. (i) It may be added here that the geographer, by reason of his general grasp of the essentials of all these aspects is admirably fitted to advise on such detailed regional studies.

The Organisation of Soil Conservation must take a catchment area as the natural unit. On this, then, the work can be sub-divided into the following categories:—

1. Water-shed management — "The first principle in all soil conservation work must be to start at the top" (ii) These are usually steep marginal lands in which the main

(ii) Ibid, P.252
activity should concern the provision of an adequate vegetation cover and the restriction of grazing. Contour terraces may be required for very steep slopes.

This part of the work is almost entirely within the jurisdiction of the Forest Department. In West Punjab official closures of forests to grazing have been applied with great success. The most successful example of the reclamation of denuded hillsides is that of the Surla Forest in the Jhelum District. In 1938, 1000 acres were closed to grazing bousing and felling. With the help of a grant, 900 check dams were built along the principal gullies and ravines. Silt collected behind the dams on which were planted nara grass (Arundo donax), elephant grass and shisham (Dilbergia sissoo). The slopes were trenched. A complete transformation of the bare wilderness of ravines has taken place. Grass has covered the centre area and is stretching even on to the infertile clay slopes. Bhabar grass (Eulaliopis binata), a valuable product, is spreading naturally.

This was intended to be a demonstration area and its success is being followed up elsewhere. The methods adopted here have been tried at other places with equal success. The North Western Railway bought 1450 acres of denuded land in the Rabbi Hills and was able to restore vegetation by a similar closure.

Afforestation has been carried out on the Kalachitta Hills in the Potwar Plateau with species of trees imported

from other regions.

2. Management of Pasturelands:— Partial closures of state-owned pasturelands have not been successful, therefore complete closures have had to be applied. Rotational closures have also been tried and the scheme portrays in the one which ensures a long rest in each block.

Most of the pasturelands of the province are owned communally by villages and are known as shamilat. As the land is nobody's responsibility in particular it is habitually misused and overgrazed. Partition of shamilat has been tried among the individual proprietors. It has been successful in several parts of Jhelum district but has led to more intensive degradation in other areas. Voluntary closures under the supervision of panchayats or co-operative societies have been successful in restoring vegetation in several parts of the Potwar Plateau. The rational use of pastures, however, must remain a problem as long as the animal population is high and pastures limited. The growth of fodder crops is one solution but already the pressure of human population on the land is so great that this possibility is limited in scope.

The Control of Running Water and Gully-plugging:—

A considerable surface of the eroded lands is subject to inundations due to quick run-off from the denuded slopes. Torrent beds spread over large areas, engulfing cultivated lands. The headwaters of the torrents are usually in the shape of gullies which keep eating back. The torrent beds
Brushwood spurs built at $30^\circ$ to the line of the torren in order to slow down its velocity and cause deposition. Notice the wide sandy bed with steep banks.
Valley of a torrent in the Potwar Plateau at the point where it emerges to the plain surface seen in the background. This is a good site for erecting a bund to prevent loss of soil from the valley as well as to safeguard the fields in the plain from being choked with silt.
cannot be effectively reclaimed unless their water-sheds are under control. Afforestation and grazing-closures have already been mentioned as steps in this direction. Gully plugging is another effective measure. This is achieved by constructing check-dams. They store debris behind them, check the velocity of the water, stop further cutting back and promote plant growth. Some of the deposits behind check-dams have even been cultivated as for instance in the Attock district.

Torrent-bed reclamation chiefly takes the form of the stream-bed being limited by earthen bunds behind which are planted nara and sarkanna grass as well as shisham trees. In the Jhelum district, the Murid village was partly destroyed by torrent floods but it has been protected now in the above manner and the plantation has already become a dense forest.\(^1\)

In the Gujrat district, 11,000 acres of torrent beds have been closed to grazing and shisham plantations established.

The larger problem of shifting river courses may also be considered here. The five rivers of West Punjab keep cutting into the fertile land along their banks. Every year as denudation in the catchments makes progress, floods become more violent. The meanderings of the rivers extend within the confines of their flood plains. The best that can be attempted in the province is to plant belts of forest for widths of 200-600 feet on the banks of dangerous streams.

In Dera Ghazi Khan district, 300,000 acres of fertile lands

\(^1\) Glover Op.Cit. P.60
Carefully aligned contour ridges in the Attock District to prevent soil loss and to conserve moisture. The land has been closed to grazing and is designed to become a fuel and grass reserve.
The Sil river has been trained away from its bank where it was under-cutting the fields shown on the left.
lie along the Indus which are not utilised for crop-production because of the menace of bank-erosion. Gorrie is of the opinion that if one-tenth of the tract along the river could be forested, the rest of the land would become available for cultivation with complete security. (1)

Contouring and Bunding:— These methods are being considered mainly in relation to arable lands which may be divided into three classes according to their slope:

(a) Comparatively flat unirrigated land. Such lands are not considered susceptible to erosion but sheet erosion was proved to carry 130 tons of soil per acre per annum in a well tilled field with a slope of 1 in, 80.

(b) Gentle slopes of the sub-montane tract and the bare uplands of the Punjab Doabs. The need for contour terraces and contour ridges (wattbandi) is fully appreciated here but not practised consistently.

(c) Steep slopes where permanent cultivation is possible only with elaborate terrace walls i.e. in the Murree Hills.

Bunding of fields has been encouraged widely in the problem districts of the Potwar region. Means of enlisting popular support have been found by encouraging the natural sporting and competitive instincts of peasants. The Mangali in Attock district is a communal competition in which groups compete in raising watts and levelling fields to the rhythm of drums and the cheering of village crowds. Co-operative ravine

The value of communal effort in soil conservation. A large torrent has been dammed by a "mangli" (communal labour-cum-sports group) in the Attock District. Healthy competition between sportsmanlike Punjabis has been found a great help in safeguarding village lands against erosion.

A reclaimed torrent bed in Attock District is now under trees and fodder.
Bull-dozers levelling badly ravined land in the Gujrat District to make it suitable for cultivation. This particular enterprise was undertaken to train army drivers but the use of earth-moving machinery has been found an economical proposition for large scale reclamation.
reclamation societies have been established in villages and
demonstration centres set up at numerous places in those areas
where arable land is liable to serious erosion.

The American system of broad-based contour ridge is
out of the question for the Punjabi bullock power. Strip-cropping,
although useful for large properties, cannot be practised on
the average West Punjab holding.

On the basis of experience gained in the Rabbi Hills
with bull-dozers and other earth-moving machinery, Gorrie has
become convinced that badly ravined lands can be reclaimed
at an economical cost with mechanical equipment. (1) Accordingly,
several bull-dozers and terracers have been purchased and use
has been made of demobilised soldiers with experience of such
machinery. Owners of lands to be reclaimed have agreed to
share the cost.

Measures against Wind Erosion:— Fixation of dunes
by means of a vegetative cover on one hand and the establishment
of shelter belts to prevent sterilisation of cultivated
fields by sand are the two main steps against erosion and
deposition by the wind. Saccharum grasses including local
varieties such as kahi, kana etc. have been found suitable
for planting on dunes and grown long enough, their roots
penetrate deeply and hold the dunes. Shelter belts have to
be at right angles to the direction of the wind. A single row
of trees is hardly adequate, therefore, a row of smaller

(i) R.M. Gorrie "Rural Development in India" Progress in the
Punjab, Empire Forestry Review, Vol. 26, No. 1 1947
The advancing desert in southwestern Punjab. These ploughed fields have been invaded by sand, which is already accumulating in low dunes in the background towards the left. This is a stage of dwindling productivity followed, unless checked, by incorporation into the desert.
such as agaves followed by tall cane grass and the belt of trees is advocated. Trees should be combined with maximum screening effect such as kikar (acacia arabica) and mesquite planted alternately.

The desert fringe of West Punjab is still largely unprotected and much greater efforts are needed to prevent further incursions of sand. The technique of dry-farming aiming at reclaiming this fringe must go hand in hand with measures to control the movement of sand.

Future Possibilities: Soil conservation has at present become one of the chief pre-occupations of the administration and the people are awakening to its dangers. Intensive regional surveys with the help of air photographs are advocated by Gorrie who further considers that the fight against erosion will only be successful when its methods have become a part of the regular routine of the peasant.
Chapter 14

If we compare the rainfall and irrigation maps of Barbary, we find that over the larger part of the region, agriculture is still a gamble on the rainfall. In West Punjab, too, 32% of the cropped area is unirrigated and much of it situated in the zone of inadequate and insecure rainfall. The practice of dry farming offers a means by which these areas can be made productive and secure.

Dry farming is a system of specialised farming, developed for semi-arid regions which aims at utilizing fully the water of rainfall by reducing evaporation to a minimum. It also conserves the water of two consecutive years to produce one good crop in those areas where one year's rainfall is not enough to mature a crop. It is thus complementary to irrigation. Furthermore, as has been indicated in the previous chapter, the technique of water conservation has much in common with the practice of soil conservation. For these reasons we are considering it after having studied both irrigation and soil erosion.

Development of the Technique:

Modern dry farming methods were developed in the United States of America and their development is credited to the industrious Mormons who were uprooted from their homes in the humid eastern part in mid-19th century, and had to grow their requirements in the semi-arid climate of Utah (i) The technique was found to be ideal for the western United States

(i) Augustin Bernard "Le Dry-Farming et ses Applications Dans l'Afrique du Nord" Ann. de Geog. 1911, P.422
and through the experiments of several eminent agricultural experts, notably Campbell and Hilgard, was perfected into a science by the beginning of the 20th century. But the Americans can be credited with no more than the merit of conducting investigations methodically and enunciating the principles in a scientific manner. For dry farming is probably as old as agriculture. In many parts of the world there is evidence of people having adapted themselves to semi-arid conditions by adopting practices that conserved the moisture.

In Barbary, we have already noticed the perfection in cultivating arid and semi-arid regions attained to by the Romans. During the Islamic epoch, most of the great advances in agriculture took place among the Moors in Spain and later came to the Barbary lands. The most eminent of the Moorish writers on agriculture was Ibn-al-Awam. In his "Book of Agriculture", he describes in detail the practice of "qalib" or cycle of ploughings which envisaged four ploughings through the year, its object being to conserve moisture, to maintain the soil in a friable condition and to destroy weeds. As Bernard observes, this eminent writer set forth eight hundred years ago almost all the principles of modern dry farming down to the soil mulch (ii)

Even in modern times, some of the methods of dry farming have been practised in many parts of Barbary, notably in the growth of olives in Tunisia and the cultivation of cereals in the Sidi Bel Abbes plain in Algeria

(i) L.Colson & H.L.Eddy "Ibn-al-Awam", A soil scientist of Moorish Spain G.R. 1943, 100-109