A MODEL FOR ESTIMATING AND PROJECTING THE HOUSING
DEMAND OF AN URBAN AREA IN CEYLON

Dissertation by:

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Acknowledgements

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Addendum:

An explanatory note on the concept of "primary housing demand" and "secondary housing demand"

In estimating housing requirement it is generally accepted that each household that needs a separate dwelling should be provided with one. When using this concept of need two basic facts are not considered. They are that,

(1) Need is based on a set of qualitative standards, that may be above or below what is demanded.

(2) Need does not consider the ability to pay i.e. the economic level of the population to whom the concept is being applied.

As I have stated in the introduction developing countries like Ceylon have (1) limited resources to invest in housing and (2) a low per capita income. Thus (2) results in a demand for housing of a lower standard than that specified by need. Further need may deem that the extended household should in fact be a number of separate households requiring separate units, but demand is not only governed by the economic condition but also on the socio-cultural habits of household formation. It thus becomes evident that a country like Ceylon demands less houses of a lower standard than estimated by need. This led to the definition of "primary housing demand". Since less houses of a lower standard are required, thus the greater probability of solving the problem with the limited resources available. On the other hand once economic conditions reach a high level, and the habits of household formation change such that the basic family begins to split into smaller households, we begin to see that the demand for housing both quantitatively and qualitatively supercedes the requirements estimated by need. This then led to the definition of "secondary housing demand".
Introduction

0.1 Like most developing countries the world over, Ceylon is trying to solve its housing problem with limited resources. The efforts so far have failed miserably and can be put down not to the lack of resources, but due to the fact that all housing programmes are based on providing the need, which is based on an obsolete set of standards. This has resulted in the provision of too few houses with the limited resources available.

0.2 "Primary housing demand", "housing need", and "secondary housing demand"

For the purpose of this study two phrases have been coined. They are:

(1) "Primary housing demand"; the demand by each household formed within the cultural and socio-economic framework of the country or area for a separate housing unit. This level of demand falls below what we term "housing need" which is based on an arbitrary set of standards.

(2) "Secondary housing demand"; is the provision of each household as defined in "primary housing demand" with a separate unit, but this level of demand is higher than "housing need".

All countries, or areas within countries will go through the three stages parallel to their economic growth, i.e. (1) "Primary housing demand" (2) "housing need", (3) "Secondary housing demand".

We in Ceylon have "tried to jump the gun", by trying to provide need, when the economic situation in Ceylon is such that we should be trying to meet the "primary housing demand".

Even a developed country like Britain made a similar mistake, as shown by Eversley, Jackson, and Lomas in the study of the West Midlands region. In this case the housing requirements were based on Cullingworth's estimates of need, and were found to fall short, as
this area was already in the stage of "secondary housing demand". Hence if we are to solve the housing problem in Ceylon with the limited resources available, we must as an initial step meet the "primary housing demand".

0.3 Towards a solution of the urban housing problem in Ceylon

Ceylon is a country with a marked difference between the rural areas and the urban areas. Thus if we are to meet the "primary housing demand" in these areas, our approach to estimating this demand will differ substantially to warrant separate methods. This study has thus been limited to the urban areas of Ceylon, and will aim at building a model for estimating and projecting the primary housing demand. These estimates could then be used in formulating a programme within the limited resources available.

0.4 The study

Chapter 1 of the study deals with urban household fission in Ceylon, and traces the change in average urban household size from 1946 to 1963. The conclusions reached in this chapter are used as a basis for selecting the factors used in building the model. Chapter 2 deals with the application of models built for use in the developed countries to the urban areas of Ceylon. From the conclusions drawn in this chapter it will be seen that none of the models were directly applicable, but that the methodology used in the study of the West Midlands region of Britain namely multiple regression analysis was useful for the building of a model for the urban areas in Ceylon.

The conclusions reached in Chapters 1 and 2 are used for building a set of models in Chapter 3. Out of the four models discussed the model using the number of households as the dependent variable was 2.
the most successful. This model is used for preparing a nomogram, and its use is explained in Appendix 2. Appendix 1 gives the data and computer print out for the analysis of this model.

Chapter 4 deals with the practical use of the model for formulating a government aided urban housing programme in Ceylon, and shows that it could be used for guiding government policy regarding private development.

Finally it will be seen that this study has been practical in its approach, and it is hoped that it will form a basis on which other developing countries may approach their urban housing problem.
Chapter 1

Analysis of Urban Household Fission in Ceylon

1.0 Definitions

1.01 Primary Household size

The size of the household formed within the socio-economic conditions of the area. This definition incorporates the idea of the extended family, and includes lodgers, and resident domestic help as part of the household.

1.02 Census household size

The census household size, as defined for use in the censuses of Ceylon for 1946, 1953 and 1963 is as follows.

"A family household comprises the members of a household forming the nucleus of the household, including resident domestic servants. Persons living alone are to be counted as separate family households. Other persons sharing the rooms occupied by the family are to be counted as members of the family household. Family households will be counted as such only if they have five or less lodgers, those with more shall be counted as lodging houses."

Thus it is evident that the primary household size is more or less the same as the census enumerated household size in Ceylon.

1.03 Primary housing demand

Primary housing demand is the demand by each primary household for a housing unit. Thus the number of units when estimating primary housing demand will be equal to the number of primary households. This in turn will be equal to the number of census households, when applied to Ceylon.

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1 Census of Ceylon 1946, Vol. 1. Part II.
1.1 The importance of analysing household fission

The idea of meeting "primary housing demand" as an initial step towards solving the housing problem of a country with limited resources has been put forward in the introduction. In order to put this idea into practice one must be capable of estimating and projecting the primary housing demand. It has been shown earlier that "primary housing demand" is directly related to the number of census households when applied to Ceylon. The number of census households \( H \) will be equal to the census population \( P \) divided by the average census household size \( h \) for a specified area. As an equation it can be written as:

\[
H = \frac{P}{h}
\]

1.1

Hence the number of census households \( H \) are inversely proportional to the census household size \( h \). This shows the importance of household size \( h \). Household fission is breaking up the household into its different elements. In order to be able to estimate \( h \) for different socio-economic conditions it is therefore necessary to

1. break up \( h \) into its elements
2. study the variation in each element over time due to change in these conditions, and
3. try to predict future variations of these elements. This then shows that an analysis of household fission is a prerequisite to estimating and projecting "primary housing demand".

1.2 Household fission of an urban area

1.21 Cultural and socio-economic characteristics

Household fission of an urban area in Ceylon is controlled by two factors (1) the cultural background of the people and (2) the socio-economic conditions of the urban areas. These two factors have
$H =$ NUMBER OF HOUSEHOLDS
$F/H =$ FEMALES FROM (20-49) PER HOUSEHOLD,
$M/H =$ MALES FROM (25-64) " "
$M_1/H =$ MALES FROM (15-14) " "
$F_1/H =$ FEMALES FROM (15-19) " "
$C/H =$ CHILDREN FROM (0-14) " 

**FIG. 1. POPULATION STRUCTURE OF A HYPOTHETICAL URBAN AREA**
combined together, resulting in the following observations that can be made in a typical urban area.

1. The average age of marriage of males is 25 years
2. The average age of marriage of females is 20 years
3. The age of retirement from active services for males is 55 years
4. Parents after retirement form part of a married child's household or alternatively young marrieds form part of the parents household.
5. All children between the ages 0 to 15 live with their parents
6. Females between the age of 15 to 20 live with their parents whether they are employed or not
7. Males between the ages of 15 to 25 live with either their parents or lodge with relatives, whether they are employed or not.
8. Urban areas with a high economic activity attract married males between 25 to 55. They live as lodgers forming part of the household during the week, and move to their homes situated in other towns during the weekends, where their wives and families are resident. These males generally belong to the middle income group.
9. Divorced men and women, bachelors and spinsters do not generally live alone but join a relative as part of the main household.

1.22 The demographic elements of fission

The cultural and socio-economic characteristics previously mentioned show up clearly as different demographic elements in household fission. Using these characteristics let us break up the population of an urban area into its different elements.

Figure 1 shows the arbitrary population structure of an urban area of population (P) divided into 5 year age groups. This structure is

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2 Registrar Generals Report for 1964 Table 18.

3 In Ceylon the average difference in age at marriage between males and females is estimated at 5 years. This difference is applicable to all minority ethnic groups (Asians). S. Vamathevan - Some aspects of recent fertility changes in Ceylon.
based on census data. Let the actual number of census households be \( H \) then from equation 1.1 the average household size is \( h \). Let us assume that institutional populations are small, and in the case where they are large their relevant numbers have been deducted from the corresponding age group of the population.

Incorporating the observed characteristics we can now break up the population \((P)\) into six main groups, which in turn reflect the six elements of household size, when divided by the number of households \((H)\).

1. All males between \((25-55) = M\); will be economic household heads or lodgers in this age group, i.e. \( \frac{M}{H} \) per household.
2. All females between \((20-49) = F\); will be the physical household heads around whom the nucleus of the household is built, and resident domestic help together with a small number of relatives, i.e. \( \frac{F}{H} \) per household.
3. All males \( 55+ \) and females \( 50+ = E \); will join the female between \((20-49)\) as part of the household of which she is the physical head, i.e. \( \frac{E}{H} \) per household.
4. All males from \((15-25) = M_1\); are children, or lodgers, lodging with relatives, i.e. \( \frac{M_1}{H} \) per household.
5. All females from \((15-20) = F_1\); are between the school leaving age and marriage, who even if employed stay with their parents, and form part of the household. This group will also consist of a few resident domestic staff, i.e. \( \frac{F_1}{H} \) per household.
6. Finally all children between \((0-15) = C\); are definitely part of the household, and live with their parents, i.e. \( \frac{C}{H} \) per household.
FIG. 2. MAP OF CEYLON SHOWING THE 14 TOWNS
The above can be expressed mathematically as follows.

The total population \( P \) is equal to the sum of the populations in each group.

\[
P = M + F + E + M_1 + P_1 + C
\]

i.e. \( P = M + F + E + M_1 + P_1 + C \)

but from equation 1.1 \( h = \frac{P}{H} \)

Therefore \( h = \frac{(M + F + E + M_1 + P_1 + C)}{H} \)

i.e. \( h = \frac{M}{H} + \frac{F}{H} + \frac{E}{H} + \frac{M_1}{H} + \frac{P_1}{H} + \frac{C}{H} \) \( 1.22 \)

This equation now enables us to (1) examine the variation of household size in the urban areas from 1946 to 1963; (2) guide us towards selecting relevant factors for building a model for projecting housing demand and (3) enabling us to examine the future of the urban household size in Ceylon.

1.3 Analysis of the variation of household size from 1946 to 1953 and from 1953 to 1963 of 14 selected urban areas

1.31 The areas and the data

Figure 2 is a map of Ceylon showing the urban areas to be studied. Data giving (a) the population structure and (b) the number of households was obtained from the relevant census publications. The fourteen towns for which the data was used were those of over 10,000 inhabitants in 1946, and that from a knowledge of the areas they did not have any unusual institutional populations.

1.32 Method of analysis

The method of analysis consists of (1) calculating each of the six elements from census data for the years 1946, 1953 and 1963, for a set of urban areas. (2) Tracing the changes in each element, and explaining the changes with references to the socio-economic changes that occurred during the period.
<table>
<thead>
<tr>
<th></th>
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<th>2</th>
<th>3</th>
<th>4</th>
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<td>M/H</td>
<td>F/H</td>
<td>E/H</td>
<td>M₁/H</td>
<td>F₁/H</td>
<td>C/H</td>
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<td>6.34</td>
<td>1.801</td>
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**TABLE.1.**

**HOUSEHOLD SIZE & THE BASIC ELEMENTS OF FISSION. 1946. 1953 & 1963**
Calculating the basic elements

The basic elements were calculated for each town for the years 1946, 1953 and 1963, by dividing the population in each group by the census household size \((h)\). Table 1. shows each element grouped together and tabulated for the different years so that changes may be observed easily. Column (1) of the table shows the average census household size \((h)\) for the towns, again grouped together for convenient observation.

The period 1946 to 1953

Preparation of Table 2

Table 2 shows the variation in household size, between the year 1946 to 1953, and the variation in each element. This is shown by a positive sign for an increase and a negative sign for a decrease. This table was prepared in this manner as we are interested in the nature of the change not its absolute value. Column 8 of the table shows the immigration into a town as a positive sign and out migration as a negative sign.
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<th>HOUSEHOLD SIZE (H)</th>
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<th>F/H</th>
<th>F/H^2</th>
<th>M/H^2</th>
<th>F/H^2</th>
<th>C/H^2</th>
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**Table 2**

Changes observed between 1946 and 1955.
1.342 Factors causing socio-economic changes during the period
There were two important occurrences in 1948 which influenced internal migration. They were
(1) the gaining of independence from British rule
(2) the complete irradication of malaria.
Thus the period was one of resettlement and movement, which caused socio-economic changes.

1.3421 Some of the conclusions drawn by S. Vamathevan in his article "Internal Migration in Ceylon" published by the Department of Census and Statistics Ceylon in 1960, are
(1) As elsewhere in the world the younger age groups in the Ceylonese population are more mobile than the older age groups.
(2) In Ceylon males are much more migratory than females.

1.3422 Some inferences that may be drawn from the figures presented by him are
(1) That urban areas of net out-migration consisted of the low income urban out-migrant being replaced by the rural in-migrant creating a population with more rural characteristics.
(2) Areas of net in-migration consisted both of low income urban migrants and rural migrants creating population characteristics of the low income urban population.

1.343 Variation in the elements of household fission due to the socio-economic changes
(1) Due to reasons (1) and (2) in 1.3421. In-migration and out-migration areas showed a tendency towards having more males (from 25-55) per household, as can be observed in Table 2, column 2.
(2) The change in the number of females from (20-50) per household was not consistent with migration. Many reasons can be put forward for this.

(a) Males leaving the area generally left their wives as physical household heads, and lodged in the new urban area forming part of a household.

(b) Rural females in this age group came in to work as resident domestic help both in in-migration and out-migration areas. These two reasons may be responsible for the increase in this element.

Hence out-migration, and in-migration areas may show an increase.

A decrease in an in-migration area may be due to a predominantly male in-migration, and a decrease in an out-migration area may be due to the movement of young low income couples out of the area, leaving only the elderly population and the unmarried females between (15-20).

As can be seen in Table 1, column 3, the element is far from consistent.

(3) The irradication of malaria, 1.342(2) was responsible for an increase in the life expectancy of the population from 43.9 to 58.8 for males, and 41.6 to 57.5 for females.\(^4\) This, together with the fact that younger age groups are more mobile than the older population, 1.3421(1), resulted in the older population assuming the role of household heads vacated by the outgoing younger population and thus producing an increase in the element E/H. In-migration towns showed an increase in E/H mainly due to the fact that the low income migrants brought their parents to

\(^4\) Statistical Pocket Book of Ceylon, Table 14.
stay with them once they had settled down, and due to the increase in the expectancy of life at birth. This is evident from column 4 of Table 2.

(4) Males in the age group (15-25) have also been rather irregular in their pattern of change. However, comparing column 3 and 5 of Table 2 there seems to be a degree of similarity between them and the females between (20-50). This irregular pattern of change may be attributed to the job opportunities available to this age group. Certain towns that showed a net out-migration, showed an increase in this age group per household. This may be attributed to the growing interest in further education, and the opportunities afforded by these towns for this purpose.

(5) Column 6 of Table 1 shows that the decrease in the females (15-20) per household was in towns of net in-migration except for Colombo. This may be attributed to the fact that females are less mobile than males, $1.3421(2)$. The increase in out-migration districts may be attributed to the same cause.

(6) All towns showed an increase in the number of children per household. This may be explained by the small urban to large urban and rural to urban movement. The result was that the overall demographic characteristics varied to produce those of a low income rural average. The fact that the average number of children born per urban fertile woman was 5.53 against 6.62 to the rural fertile woman $^5$ proves the point.

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$^5$Table 19, Fertility trends in Ceylon - Monograph No. 8, published by the Department of Census and Statistics, Ceylon.
The following figures regarding income and fertility reinforce the point made.

<table>
<thead>
<tr>
<th>Income groups husbands per mensum</th>
<th>Average number of children born per fertile woman</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under Rs. 40</td>
<td>6.36</td>
</tr>
<tr>
<td>Rs. 40 to Rs. 120</td>
<td>6.59</td>
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<tr>
<td>Rs. 120 to Rs. 300</td>
<td>6.40</td>
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<tr>
<td>Rs. 300 to Rs. 600</td>
<td>5.67</td>
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<tr>
<td>Rs. 600 and over</td>
<td>5.28</td>
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</tbody>
</table>

1.34. General conclusions for the period 1946 - 1953

Household size has increased in the urban areas. This increase may be attributed to the following elements which have been consistent for most urban areas.

(a) the element M/H increased and was consistent in its change
(b) the element C/H increased and was also consistent in its change.

The other elements have not been very consistent and are therefore not very useful in the building of a model for future prediction.

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6Table 17, Fertility trends in Ceylon - Monograph No. 8, published by the Department of Census and Statistics, Ceylon.
The preparation of Table 3 was similar to that of Table 2. Here the figures for 1953 and 1963 were compared. No study of internal migration for the years 1953 to 1963 has yet been completed, and as such column 8 has been omitted.

<table>
<thead>
<tr>
<th>HOME OF HOUSEHOLD</th>
<th>Colombo</th>
<th>Kandy</th>
<th>Galle</th>
<th>Jaffna</th>
<th>Dehiwela Mt.</th>
<th>Kegalle</th>
<th>Megahombo</th>
<th>Mulleru Eliya</th>
<th>Kaduwela</th>
<th>Matara</th>
<th>Kotmale</th>
<th>Horatuna</th>
<th>Kalutara</th>
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<tr>
<td>H/F (1953-63)</td>
<td>+</td>
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The one and only major factor causing socio-economic change took place in 1958, with the change in government policy from encouraging agriculture to encouraging industry. This change in policy resulted in a tremendous industrial growth which (a) provided better paid jobs for the low income groups and (b) provided employment for women in the age groups (15-20) and (25-50) who were previously unemployed or employed as resident domestic help.

Contrary to what one might expect this did not cause a tremendous rural-urban movement. There are no figures to prove this, but a physical observation shows no tremendous increase of rural population in the urban areas.

What may have happened is that

(a) Low income males, employed in industry began to earn better wages, and were thus able to marry within their socio-economic class and set up their own households.

(b) The women they married were those who were previously employed as resident domestic help who had now moved into the industrial sector.

(c) This stabilisation of low income households, was followed by a wave of parents of the householders from the rural areas, coming to the urban areas to live with their children.

(d) Younger males not having much employment in the industrial sector did not migrate to these areas and those who were already in these areas were divided over a larger number of households than before. (a) and (b) above.

(e) Young females could gain employment and thus moved into the urban areas, and lived within the households of relatives, as lodgers.

(f) An increase in income and a higher standard of literacy produced lower fertility rates.

16.
Changes in the elements of household fission due to the changes in socio-economic conditions

Table 3 shows that between 1953 and 1963 there has been a drop in urban household size.

A closer examination of the elements will explain these changes with reference to the socio-economic changes undergone during this period.

1. The element $\frac{M}{H}$ has decreased and can be explained by (a) of 1.352. Column 2, Table 3 shows that this has happened.

2. Column 3 of Table 3 shows a decrease in $P/H$ and can be explained by (b) of 1.352.

3. Column 4 of Table 3 shows an increase in $\frac{F}{H}$. This may be explained by (c) of 1.352, together with the fact that the expectancy of life of males at birth increased from 58.6 to 61.9 and that of females from 57.5 to 61.4 during this period.

4. Column 5 of Table 3 shows a decrease of $\frac{H}{H}$, and can be explained by (d) of 1.352.

5. The element $\frac{E}{H}$ was generally found to increase due to the reason given in (e) of 1.352. However, from column 6 of Table 3 one observes that this is not a consistent observation. We may explain this by arguing that the areas directly connected with the industrial sector showed an increase, while those not affected by it showed a decrease.

6. The factor $C/H$ would be expected to decrease in most cases due to 1.352(f). However, a small amount of rural urban migration may have overshadowed these effects to produce more children per household. Column 7 of Table 3 shows this inference to be fairly correct.

---

7 Statistical Pocket book of Ceylon - Table 19.
General conclusions for the period 1953-1963

Household size in most urban areas has decreased during this period, the causes of which have been explained in 1.353.

A glance at Table 3 shows that change has been consistent in the basic elements of nearly all the areas. They are as follows.

(1) The number of males between (25-55) per household are decreasing.

(2) The number of females between (20-50) per household are decreasing.

(3) The number of males 55+ and females 50+ per household are increasing.

(4) The number of males between (15-25) per household are increasing.

(5) The number of females between (15-20) per household are increasing.

(6) The number of children from (0-15) are decreasing.

Factors that may influence the building of a model

In Ceylon the cultural background of the people is stronger than the socio-economic influence in the formation of households.

One very striking fact that can be observed from Table 1 is that the ratio $\frac{F}{H}$ was between $-10\%$ and $+20\%$ of 1 in 1946, and between $-15\%$ and $+15\%$ in 1963. In 1953 this factor varied due to the unsettled conditions prevailing. This should be noted, as the number of females between (20-49) gives a fair approximation of the number of primary households proving the observation made initially that females in this age group form the nucleus around which households form. This factor will be used later in the building of two models.
The factors $\frac{M}{N}$ and $\frac{C}{H}$ are still decreasing towards a limit stage and are thus at the moment to premature for very intensive analysis.

Eventually once $\frac{C}{H}$ reaches its limit stage it will be followed by $\frac{M}{N}$ and $\frac{F}{H}$.

1.5 The future of the urban household size in Ceylon

1.51 The major factors

There are three major factors which will influence the size of the urban household. They are:

(1) Continuation of the policy on industrialisation.

(2) In 1965 the government began to foster agriculture and at the same time went in for vast rural colonisation schemes to nip rural urban migration in the bud.

(3) In 1965 Ceylon officially adopted family planning in its effort to lower the rate of population growth.

Other side effects to be considered are:

(1) A reduction in crude death rates due to improved medical facilities

(2) An increase in the level of education of the general population.

1.52 The effect of these factors on the basic elements of fission

(1) The element $\frac{M}{N}$ will reduce and tend ultimately to 1.

(2) The ratio $\frac{F}{H}$ will, as it is now, stabilise itself around 1.

(3) $\frac{E}{H}$ will increase due to (a) the reduction in death rates and (b) that family planning will produce less children, and therefore a greater probability that they will have one or more of their parents living with them. It may reach values of 1 to 1.5.

---

8Some aspects of recent fertility changes in relation to Ceylon, S. Vamathavan.
(4) $\frac{N^F}{H}$ and $\frac{F}{H}$ will both reduce due to the long term effects of family planning and may attain values of about 0.7 to 0.8 in total.

(5) $\frac{C}{H}$ will reduce due to (1) the family planning programme, (2) to higher levels of education, and (3) increased incomes. This may reach levels of about 1.5 as it was in 1946.

1.521 The net effect on urban household size

Hence we may conclude that in the distant future cultural background predominating over the socio-economic forces we may reach a household size of between 5.2 to 5.8 in the typical urban areas, not very much smaller than in 1963.
A discussion on "some models used in the developed countries when applied to the urban areas of Ceylon"

Most developed countries have begun to consider the provision of adequate housing a social obligation as well as an impetus to economic growth. This has led them to investigate ways and means of estimating and projecting their housing requirements.

This chapter deals with three methods that have been developed for estimating quantitative housing requirements in the developed countries, and discusses the application of these methods for estimating the housing demand of the urban areas in Ceylon.

2.1 The system of headship ratios

2.10 Development of the system

The system of headship ratios was evolved in Britain, in consultation with the technical staff of the Ministry of Housing and Local Government, who were directly concerned with the assessment of housing requirements for the preparation of development plans. The system was developed for the application to Britain as a whole, and was later adjusted for application to the small areas controlled by the local authorities.

The system and its application have been discussed by J.B. Cullingworth and A.H. Walkden. The system is now widely used in Britain for estimating and projecting housing needs.

9 Housing needs and Planning Policy - J.B. Cullingworth 1960.

The System

The system aimed at estimating the number of households, working on the assumption that each of them needed a separate housing unit. For the purpose of this study we are interested in the system as it was developed for application to the local authority areas of Britain. Its main features were.

Dividing the population into the twelve age, sex and marital condition groups specified below, based on the 1951 census data

1. Married M and F (15-39)
2. Married M and F (40-59)
3. Married M and F (60+)
5. Single M (40-59)
6. W/D M (40-59)
7. Single M (60+)
8. W/D M (60+)
9. Single F (40-59)
10. W/D F (40-59)
11. Single F (60+)
12. W/D F (60+)

Where:
M = Male
F = Female
S = Single
W = Widowed
D = Divorced

In order to ease the tedious work of population projections required for future estimates, they were projected in the following broad age groups.

Males (15-44), (45-64) and (65+)
Females (15-44), (45-69) and (60+)

The twelve groups mentioned in 2.111(1) were then calculated as percentages of the 1951 census figures of the above broad age sex groups in combination, as follows.
Persons enumerated in defence establishments were excluded where they exceeded 2%.

With the ratios \( r_1, r_2 \ldots r_{11}, r_{12} \), a projected population of a local authority could be broken up into the twelve main groups in 2.111, assuming no change in the ratios.

The next step was to analyse the twelve groups in (2.111) using the 1951 census data to obtain the ratio of household heads in each group to the total.

This was carried out as follows.

(1) From the 1951 data the enumerated heads in each group were noted.

(2) It was assumed that 75% of the one person heads in groups 4 to 12 shared with other households and were thus subtracted from the enumerated number.

(3) The potential households in each group had to be estimated, and this was accomplished by estimating the number of married couples not containing a household head. These were added to the respective groups of enumerated households.

The resulting number of household heads in each group were then estimated as a ratio of the total persons in the respective group.
as specified by 2.111. These resulted in the ratios \( p_1, p_2, \ldots \), \( p_{11}, p_{12} \).

2.114 The resulting number of household heads estimated in 2.113 were assumed to be equal to the required number of units in 1951.

For the purpose of projection, the age groups shown in 2.112 were obtained and built up to form the twelve combinations shown in 2.112 (1) to (12). These combinations were then multiplied by the ratios \( r_1, r_2, \ldots, r_{12} \) assuming no change to give the twelve groups 2.111(1) to (12). These in turn were multiplied by the ratios \( p_1, p_2, \ldots, p_{11}, p_{12} \), to give the number of household heads in each group, and thus the number of housing units required. The total of these was increased by 0.5% to eliminate households that were not accounted for during the census, due to temporary absence.

2.12 Application of the system to the urban areas of Ceylon

2.121 Existing conditions

The application of the system for estimating and projecting the primary housing demand of an urban area in Ceylon, under the existing conditions is not suitable for the following reasons.

(1) The system aims at estimating need and not primary demand as can be seen in 2.113 where care has been taken to estimate and include potential households, which do not demand separate units.

(2) The system is based on elaborate statistical data. This data is not available for each urban area separately, and is only partly available for the whole of Ceylon on a mixed urban-rural basis.

(3) The changing scene, as can be seen in Tables 1, 2, and 3 of Chapter 1 indicate that both the ratios \( r \), and \( p \) will be far from constant, and will thus be far from accurate for the purpose of projecting housing requirements.
Future conditions

However the system will be useful in the future once,

(a) conditions stabilise and the values of p and r remain fairly constant, or follow a predictable path as in Britain today.

(b) More elaborate census data is available on the urban areas.

(c) Population projections can be made fairly accurate, i.e. once steady conditions of natural increase and migration are attained.

(d) The system is altered to fit the socio-economic framework, resulting in a set of groups which will indicate the number of "primary household heads", thus estimating the "primary demand" for housing units and not the need.

2.2 The Netherlands Model

2.20 Development of the model

Census data in the Netherlands showed that household sizes were decreasing from 1899 onwards. The problem arose in estimating the future number of households, as no one was sure whether the trend would continue and if so, to what limit. It was estimated that the population in the Netherlands in 2000 would be 20 million, and an error of 0.1 in household size, would result in an error of about 200,000 households. Thus it was necessary to look for a more accurate method of estimating the number of households, which led to the investigation of the relationship which population structure by sex, age and family status bore to the number of households and thus to the quantitative housing requirements.
2.2.1 The Model

The model as described by L.H.J. Angenot\(^\text{11}\) consisted in estimating the number of household heads, and thus the housing requirements on the basis of a housing unit per household, allowing a 2% vacancy rate.

2.2.11 The basic principles on which the model was built were based on the following observations.

(1) For the population as a whole, virtually the entire demand for housing is accounted for by three groups:
   (a) married couples
   (b) unmarried persons who are heads of households
   (c) unmarried persons living alone

   It was found that in general the demand for housing in groups (b) and (c) comes from the adult group in this category, and this category was defined by the unmarried people aged 25 years and over.

(2) Married couples account for more than 80% of the demand. Their number represents nearly half of the number of married persons, and in 1899, 1909, and 1960, 96.6% of married couples desired independent dwellings.

(3) The percentage of unmarried persons who were 25 years and over, and who were heads of households, was found to be 22.5 in 1930 and 20.5 in 1960.

(4) The percentage of unmarried persons who were 25 years and over, who demanded independent dwellings and lived alone was found to be 14.2 in 1930 and 21.1 in 1960. This group was less stable.

\(^{11}\)Age structure and the number of dwellings in the Netherlands by L.H.J. Angenot; paper presented at the World Population Conference 1965 and published in the proceedings (U.N. Sales No. 56.XII.8) Vol. IV.
than the others. It was also seen that this group increased with the size of the city, but that for those below 250,000 the figure was close to the national average of 21.1% in 1960.

Based on these observations the following equation was derived

\[ H = \frac{m}{2} \times 0.966 + n (0.025+0.211) - f \]

where

- \( H \) = number of housing units
- \( m \) = number of married persons
- \( n \) = number of unmarried persons 25 years and over
- \( f \) = number of households not demanding housing units, but living in boats and caravans

Using this equation the number of dwellings demanded in 1961 was estimated at 3,016,342, and the special survey showed that it was 3,016,500. This shows the tremendously high level of accuracy reached.

Based on the consistency observed in the constants of the equation, it was to be used for projecting the future housing demand of the Netherlands.

2.22 Application of the model to the urban areas of Ceylon

2.221 Existing conditions

A direct application of the model to these areas at the present is not possible due to the following reasons.

(1) \( \frac{m}{2} \) will not represent the number of married couples, as certain towns have large numbers of married males living as lodgers, and in others the married males have left for work outside, leaving the females behind. Evidence of this can be seen in column 1, Table 1, Chapter 1.

(2) Married males (55+) and females (50+) will not generally demand a separate housing unit as they form part of an extended household.
(3) n, the number of unmarrieds 25 years and over will not play as important a role, as they generally form part of the extended household, as shown in Chapter 1.

(4) The development of a model universally applicable to all the urban areas of Ceylon requires
(a) Similar conditions in all the areas, which do not exist.
(b) Steady conditions for the purpose of projection, which have not been reached as yet.
(c) The relevant statistical data which is not available.
However, from the meagre data available, and the analysis as shown in Table 1, Chapter 1, the relationship between the number of females (20-50) and the number of households has been fairly consistent over all the urban areas and over time. This then confirms the conclusion reached in Chapter 1 that the ratio $(F/H)$ will be the most suitable for developing a model for estimating and projecting the housing demand of an urban area in Ceylon.

2.222 Future conditions

If as concluded in Chapter 1 the present trend in the change of the elements of household fission continues, reaching a stable state, the development of a model using similar methodology will be possible. However, the basic elements of the model will depend on whether household formation in urban Ceylon will follow the same pattern as exists in the Netherlands today, or as concluded in Chapter 1. the cultural background will have the same influence as it does today, resulting in little or no change. If no change occurs we would then have to look for, by obtaining and analysing more detailed statistical data the relevant elements for building such a model.
2.3 The "Model" developed for the West Midlands region of Britain

2.30 The development of the Model

Subsequent to the 1961 census it was found that the application of the 1951 headship ratios for the 10 year projection from 1951 to 1961 gave housing estimates far lower than the demand. This was attributed to (a) the changing socio-economic conditions and thus change in the ratios, and (b) forecasts that depended on detailed population projections that were inaccurate. Application to the smaller local authority areas within the West Midlands region showed a greater degree of error. In view of this the West Midlands social and political research unit, of the University of Birmingham approached the problem of estimating and forecasting housing demand from a new angle. This study led to the methodology and model briefly described below.12, 13

2.31 The Model

2.311 The application of the 1951 headship ratios to different areas of the conurbation produced results with an inconsistent degree of error. This proved that the ratios changed at different rates which were found to depend on the socio-economic changes experienced within the areas.

The model was thus based on an analysis of the socio-economic conditions of the areas, together with their demographic characteristics. From this analysis emerged certain measurable variables which were connected to the average household size of each of these areas via multiple regression analysis.


13 Paper presented by D.E.C. Eversley and Valerie Jackson to the World Population Conference in 1965 titled "Problems encountered in forecasting housing demand in an area of high economic activity, published by the U.N. (Sales No. 66.XIII,8)
From this analysis emerged an equation connecting household size, with various other factors. The equation was:

\[ Y = 2.827 + 0.653x_c - 0.51x_d - 0.027x_e \]

where

- \( Y \) = average household size of area
- \( x_c \) = the fertility ratio of the area, i.e. the number of children from (0-15) per women from (15-49)
- \( x_d \) = the percentage of the population 15+ whose terminal education age was 20
- \( x_e \) = the percentage of the population 60+ years within the area

This equation rejected the independent variables with interdependances, and took into consideration a situation which could not be subject to the desirable randomised experimentation procedures. However, it showed a multiple correlation coefficient of 0.869 explaining about 75% of the variation in household size and was highly significant.

2.312 Advantages of the model

The model had three main advantages over the system of headship ratios. They were:

(a) it estimated demand and not need
(b) it did not require a highly accurate population projection
(c) it took into account the socio-economic level of the population of the area, and could thus incorporate changes in this level.

2.32 Application of the model to the urban areas of Ceylon

In considering the model applied to the urban areas of Ceylon, of greatest interest is the methodology used in building the model, i.e. multiple regression analysis.

The variables used in the West Midlands study will explain little or nothing of the variation in household size of these areas. Consider the three variables in turn.

(a) **Fertility ratio**

As explained in Chapter 1 women within the age (15-49) may consist partly of resident domestic help. In the richer urban
areas this category will be greater than in the poorer areas. Thus the fertility ratio of the richer area will be reduced due to the presence of this resident domestic help. Hence though one may expect household size to increase with fertility ratio, it may actually remain the same, or even decline. This statement may be proved from the actual regression analysis of household size on fertility ratio carried out for the fourteen towns for the years 1946 and 1963 separately. The coefficient of linear correlation in 1946 was -0.340, and in 1963 it was -0.0562.

(b) The percentage of the population 15+ whose terminal education age is 20.

From the observations made in Chapter 1, (1.21 (6) and (7)), it will be seen that this category will not affect household size, as they would tend to either reside with their parents or lodge with a household, till marriage at approximately 25 years. This will be proved conclusively in the next chapter.

(c) The percentage of the population 60+

Here again referring to the observation made in Chapter 1, (1.21(4)) it will be expected that this factor will tend to increase household size, and not decrease it. This can be proved from the simple regression analysis of household size on the percentage of population 60+, carried out on the data for 1963 for the fourteen towns. It gave a coefficient of correlation of +0.417. This variable would be useful in the building of a model, which would explain the variation of household size in the urban areas of Ceylon.

It now becomes evident that the methodology will be useful, but that detailed data is necessary to select the variables that will describe...
completely the variation in household size in the urban areas of Ceylon. Another important factor is that these variables must be easy to project with time, or must be independent with time if the model is to be of any practical use.

2.4 Conclusion

From this discussion we can reach the following conclusions.

(1) None of the models can be used to estimate the primary housing demand of the urban areas in Ceylon under the present conditions.

(2) Once conditions stabilise and the relevant data made available from future censuses, they may be adapted for use.

(3) A model under the present conditions should make use of the simple statistical data available.

(4) The model should be versatile in order to cover the wide range of conditions existing in the different urban areas of Ceylon. This could be attained by using regression analysis as a method for building the model.
Chapter 3

A model for estimating and projecting the housing demand of an urban area in Ceylon

3.0 The conclusions reached in Chapters 1 and 2 show that under the present circumstances none of the models discussed are applicable to the urban areas of Ceylon. They also showed that a model for these areas should use simple statistical data, and suggested a methodology for building such a model.

The first part of this chapter will be devoted to defining the scope of the model, and explaining how the method of multiple regression analysis can be applied to this particular problem. The second part will deal with the four attempts at building the model and isolate the most successful one. The data and computer print out for this model are shown in Appendix 1. Appendix 2 explains the practical use of this model.

PART 1

3.1 The scope of the model

3.11 The aim of the model

The aim of the model is to be able to estimate and project the primary housing demand of an urban area in Ceylon, i.e. it must be capable of estimating and projecting the number of primary households as defined in 1.01.

3.12 The time limit for projection

The time limit in using the model for the purpose of projection is limited to 10 years.

The reasons for this are:

(1) The intercensal period is 10 years

(2) Changing conditions may render the model invalid, and hence
if it is limited to 10 years the following census data may be used for checking its validity at the end of this period.

(3) The aim of the model is to meet the primary housing demand. Once this is met, and we begin to consider need or secondary demand, the model becomes automatically obsolete.

3.20 The methodology for building the model

The conclusion reached in Chapter 2 was that multiple regression analysis would be the best approach towards constructing a model. The method adapted to this particular problem is briefly described below.

3.21 The Method

The method as applied to the particular problem is as follows.

(1) A dependent variable that was directly related to the number of primary households was selected.

(2) From the analysis in Chapter 1 the basic independent demographic variables which were felt would explain the variation in the dependent variable were selected.

(3) Other physical factors, for which data was available, and which were thought might explain a part of the dependent variable were included.

(4) A regression equation was then obtained for the dependent variable in terms of the independent variables.

(5) This equation was then analysed in order to estimate

(a) The percentage of dependent variable explained

(b) The level of significance reached by the coefficient of multiple correlation.

Models 1 and 2 in Part II were calculated using an electronic desk calculator. Models 3 and 4 were built by the use of an electronic computer, using the programme prepared at the Edinburgh regional computing centre.
The advantages and disadvantages of using multiple regression analysis

3.221 The advantages

(1) A single model can be built to cover the existing and future conditions of all the urban areas, provided the necessary data are available.

(2) The factors that do not significantly affect the dependent variable can be eliminated using this method.

(3) The model can be checked at each census, and either eliminated or adjusted by the use of the new data.

3.222 The disadvantages

The values of the independent variables for which the model is valid must lie within the range used for building the model. Hence the necessity for a wide range of observations for a wide application of the model.

For a high level of significance the number of independent variables used must be very much less than the number of observations. Hence with a small number of observations as in this case (14) the number of independent variables that can be used is about 2 or 3 the most.

PART II

3.3 The basic data for building the models

Fourteen urban areas ranging in size from 10,000 to 400,000 population, for which data were available were selected. The areas are as shown in the map in Figure 2.

The data for the census years 1946 and 1963 are in detail and are reliable. The data for the census year 1953, does not provide sufficient detail and was hence rejected for the purpose of building the models.
Tables 3 and 5 give the relevant demographic and physical data that was required, for the years 1946 and 1963 respectively. This data was obtained from the relevant census publications.

3.40 The selection of the dependent variables

From the conclusions reached in Chapter 1 and 2 there were three possible dependent variables, related to primary housing demand which could be chosen for building the models.

They were

(1) Average household size \( (h) \)

(2) The ratio of the females \((20-49)\) to the number of households i.e. \( (F/H) \) and

(3) The number of households \((H)\)

Models 1 and 2 were based on the use of the dependent variable (1) i.e. \( (h) \)

Model 3 was based on the use of the dependent variable (2) i.e \( (F/H) \)

Model 4 was based on the dependent variable (3) i.e \( (H) \)

As will be shown later the most successful model was developed by the use of dependent variable (3).

3.5 The models based on average household size \((h)\) as the dependent variable.

3.51 Model 1

Once the dependent variable was selected, the next part was to ascertain the independent variables.

Fertility ratios as mentioned in Chapter 2 showed a decreasing effect in average household size and was thus selected as the first independent variable \( x_1 \).

The ratio of the population 60+ had showed an increasing effect and was selected as the second independent variable \( x_2 \).
The observation that the males in the population lived as household heads or lodgers led to the idea that an increase in the male to female ratio would lead to an increase in average household size, and hence this ratio was included as the third independent variable $x_3$.

Involuntary doubling up of households occurred mainly in the middle income groups, due to their social status demanding a permanent house and their economic status being unable to pay for it. This led to the idea that urban areas with more permanent houses will have more doubled up households and thus a larger average household size. Hence the fourth variable introduced was the ratio of the (temporary + semi-permanent) houses to the permanent houses in the area, i.e. $x_4$.

Thus a linear regression equation of the form

$$h = a + bx_1 + cx_2 + dx_3 + ex_4$$

was to be developed, where $a, b, c, d,$ and $e$ are constant.

This model was built using the 1946 data only. On completing the basic analysis of the equation the independent variables were found to explain only 39.6% of the dependent variable. Checking for significance would have reduced this percentage.

This model was thus rejected, showing that the independent variables selected were either incorrect or insufficient.
Model 2

The dependent variable is the same as used for model 1.

In this model all the demographic variables were combined to form a demographic factor $x_1$. The factor was built up as follows from a known population structure.

From the population structure let:

- $n_1 =$ the number of females from (20-49)
- $n_2 =$ the number of children from (0-15)
- $n_3 =$ the number of females 20+
- $n_4 =$ the number of males 25+
- $n_5 =$ the number of females from (15-20)
- $n_6 =$ the number of males from (15-25)

From the conclusions reached in Chapter 1 the following assumptions were made.

1. That the children ($n_2$) were divided among the households whose physical heads were the women from (20-49) i.e. $n_1$.
2. That the balance population was divided among the total number of households, whose physical heads were all the women 20+ i.e. $n_3$.

Then the demographic factor $x_1$ was defined as

$$x_1 = \left[ \frac{n_2}{n_1} \right] + \left[ \frac{n_4 + n_5}{n_3} + \frac{(n_6 - n_2)}{n_3} \right]$$

where $n_6 \geq n_3$. If $n_6 < n_3$ the term $\frac{(n_6 - n_2)}{n_3}$ was neglected

i.e. $x_1 = \left[ \frac{n_2}{n_1} \right] + \left[ \frac{n_4 + n_5 + n_6}{n_3} - 1 \right]$  

For the same reason given in 3.51 the second independent variable $x_2$ was taken to be the ratio of the number of permanent houses to the total in the area.

The third variable $x_3$ was taken to be the gross density of the area. This variable was used to incorporate an idea of the land available for building. It was assumed that there was no significant difference in the plot ratios of the different areas. A physical observations shows that this assumption is fairly correct.
Using these variables a linear regression equation of the form,
\[ h = a + bx_1 + cx_2 + dx_3 \] (a, b, c and d are constants)
was developed using the data for 1946 only.

Analysis of this equation showed that the independent variables explained 33.96% of the dependent variable. Checking for significance would have reduced this percentage, though not to the same level as in model 1, as only 3 independent variables were used.

This model was also rejected on the basis that it did not explain enough of the dependent variable.

3.6 The model based on the ratio \( \frac{F}{H} \) as the dependent variable

3.61 Model 3

The dependent variable for this model is the ratio \( \frac{F}{H} \). The idea was to try to explain the variation of \( \frac{F}{H} \). If this was possible then a knowledge of \( \frac{F}{H} \) and F would lead to an estimation of \( H \).

The choice of the independent variables for this model were based on the observation in Chapter 1, Table 1, that the ratio \( \frac{F}{H} \) lay within \( \pm 20\% \) in 1946 and 1963.

The first independent variable \( x_1 \) was selected as the percentage of this group of women to the total population of the area. It was assumed that \( \frac{F}{H} \) would be equal to 1 at an optimum percentage, and would thus increase or decrease accordingly as the percentage increased or decreased.

The second independent variable selected was the ratio of the number of males from (25-55) to the females (20-49) i.e. \( x_2 = \frac{M}{F} \). This was selected on the basis that area with a high \( \frac{M}{F} \) ratio may have more males living independently and thus reduce the ratio \( \frac{F}{H} \) by increasing \( H \).
If the total population is \( P \)

The theoretical model developed was of the form

\[
(P_H) = a + b(P_P x 100) + c(M_P) \quad \text{(where } a, b, \text{ and } c \text{ are constant)}
\]

The analysis of this model was carried out using the data for 1946 and 1963 combined, giving 28 observations and 2 independent variables, using the computer.

The initial regression equation obtained was

\[
(P_H) = 0.1906 + 0.05035 (P_P x 100) + 0.06628 (M_P)
\]

explaining 50.21% of the dependent variable. In checking for significance the variable \( (M_P) \) was eliminated at the 10% level. At the 0.1% level of significance the model was

\[
(P_H) = 0.042955 + 0.054447 (P_P x 100)
\]

and explained 49.29% of the dependent variable.

In order that the model was to be of practical value 49.29% was considered insufficient, and the model was thus rejected, even though it was better than 1 and 2. Another reason for the rejection of the model was that it depended too much on a population projection for its use in projecting housing demand. Both the number of females from (20-49) as well as the number of males from (25-55) had to be estimated, together with the total population.

3.7 The model based on the actual number of households \((H)\) as the dependent variable

3.71 The theoretical model

The last dependent variable selected was the actual number of households \((H)\). We have observed earlier that the ratio of the number of females from (20-49) to the number of households was nearly equal to 1. The variation in both 1946 and 1963 was between ± 20%. This indicated that the number of households in an urban area both in the
industrial and preindustrial period was nearly equal to the number of females between (20-49).

Therefore, using the number of actual households as the dependent variable we can select the number of females (F) between (20-49) as the first independent variable.

Looking back at model 3 we see that the percentage of those females to the total explained 49.29% of the variation in (F/\text{HH}). We can therefore select the second variable as the percentage of this female population to the total i.e. \(\left(\frac{F}{\text{HH}}\right)\times 100\).

The third independent variable selected was the ratio of the number of males (25-55) to the females (20-49). This was selected so that we may be able to account for the number of males setting up independent households if any in areas where this section of the population was large.

The fourth independent variable selected was the ratio \(\left(\frac{C}{F}\right)\). This was included to account for areas with a high proportion of resident female domestic staff between (20-49) who were not physical heads of households. As we have seen earlier there is very little difference in the average number of children per woman from (15-49) among the urban areas. But the presence of this resident domestic help will show up by lowering this ratio below the average.

Using these variables we can now build the theoretical model for analysis as follows

\[ H = a + b, F + c \left(\frac{100F}{\text{HH}}\right) + d \left(\frac{M}{F}\right) + e \left(\frac{C}{F}\right) \]

where a, b, c, d and e are constant.

It is useful to note that the model is purely demographic and is based on the cultural habits of household formation that have shown little or no change with change in the socio-economic conditions.
The practical model

The data for building the practical model was a combination of the data for 1946 and 1963, resulting in 28 observations. The actual data used, and the computer print out is shown in Appendix 1.

The basic regression equation obtained was

\[ H = 7120 + 0.98186F - 408.02 \left( \frac{100X}{P} \right) + 815.62 \left( \frac{Y}{P} \right) - 480.95 \left( \frac{Z}{P} \right) \]

The coefficient of multiple regression was 0.9994 explaining 99.88% of the dependent variable.

This analysis also proves the points made in Chapter 1 and agrees with the assumptions made at the beginning for building this model.

An automatic elimination was then carried out up to a 0.1% level of significance. At this stage the regression equation became

\[ H = 7109 + 0.98757 F - 401.43 \left( \frac{100X}{P} \right) \]

The coefficient of multiple correlation was 0.9993, explaining 99.87% of the variation in the dependent variable. The high level of significance excludes errors that may be involved due to the inability of using a set of random observations. It will also be observed from the correlation matrix (App. 1) that the correlation between the independent variables was -0.237 and could be thus considered as virtually nil, eliminating the effect of correlation between the independent variables.
Conclusions

The proceeding paragraphs have dealt with four different models, of which the fourth model produced the best results.

The model chosen has many advantages.

(1) It is capable of being used for estimating the immediate housing demand of an urban area in Ceylon, using a knowledge of the total population, and the number of females from (20-49).

(2) In projecting housing demand, the two factors that are required are the same as in (1). These do not need a detailed projection of the population by age and sex.

(3) If projections are limited to 10 years, the projection of $P$ can be made fairly accurate if migration is also considered as it does not depend on birth rates. However, the projection of $P$ may be erroneous, but once conditions stabilise it will be more reliable.

(4) If household formation patterns do not change, the model will be useful for a long time to come, and can be adjusted using the census data of the years to come.

(5) It uses relatively simple data, that can be obtained directly from a census report, or can be obtained simply by a sample survey.

(6) The model uses purely demographic data, and is therefore reliable under different socio-economic conditions.

The main disadvantage of the model as it stands is that it can be applied to the range of values for which it was built. However, it is my intention to run an analysis with a much wider range of data on my return home, and thus overcome this difficulty.

The planner is not a mathematician, and for this reason I have included Appendix 2, which explains the practical use of the model, and provides a nomogram which eliminates the necessity of any calculations in using the model.
Chapter A

Conclusion

4.0 The main objective of the study, "to build a model capable of estimating and projecting the primary housing demand of an urban area in Ceylon" has been achieved as shown in Chapters 1, 2 and 3. However, in order that it may be of practical use both to the Department of National Housing, and the local government authorities in Ceylon, it is relevant to conclude by showing (a) how the model may be used for formulating a government aided housing programme and (b) to discuss the use of such a model in formulating housing policy for an urban area in Ceylon.

4.1 The use of the model for formulating a government aided housing programme

As we have shown in the introduction, a country like Ceylon with limited resources to invest in housing should first aim at meeting the primary housing demand. Let us now consider how this may be achieved for an urban area within the existing administrative structure in the country, by means of a government aided housing programme. This is best done by analysing a typical hypothetical urban area.

4.11 The problem

It is intended to meet the primary housing demand of an urban area in Ceylon, by means of a government aided housing programme, within the next (n) years. How many units should the programme cater for per year? The term units includes (a) the actual houses to be built for rent or purchase by the government agency and (b) the number of plots of land with services to be provided by the same agency, for those who prefer to use self help methods. The agency in this case will be the Department of National Housing which has the administrative...
capacity, legal authority and financial resources for such a programme.

4.12 Data available

From a sample survey carried out the following data were made available,

(1) the total population = \( P_0 \)
(2) the number of females from \((20-49) = P_0\)
(3) the number of usable units in the area = \( U_0 \)

From a population projection made

(4) the total population in \( n \) years = \( P_n \)
(5) the number of females in \( n \) years, from \((20-49) = P_n\)

From an examination of the past records of the area

(6) the average number of housing units built privately per year = \( p \)
(7) the rate of obsolescence of housing units in the area per year = \( q \)

4.13 Calculation of the initial demand

From data (1) and (2) of 4.12 we can use the model to calculate the total initial demand \( H_0 \). (Details of this calculation are shown in Appendix 2) Using the data (3) the initial shortage = \( (H_0 - U_0) \), assuming \( H_0 \) is greater than \( U_0 \) which is the general use.

4.14 Calculation of demand to satisfy the increased population

From data (4) and (5) we can again use the model to estimate the primary housing demand \( H_n \), \( n \) years from the datum year selected.
The number of units required for the increase in population over the \( n \) years = \( (H_n - H_0) \).

4.15 Replacement due to obsolescence

Data (7) of 4.12 gives the average rate of obsolescence \( q \) of housing units in the area. This should also include units which would be demolished in the process of urban redevelopment.
Therefore replacement necessary in \( n \) years = \( qn \) units.
4.16 Total requirement

If primary demand is to be met in n years, the total requirement will be equal to the sum of (a) the initial shortage and (b) the requirements of the increased population and (c) the replacement due to obsolescence and demolition for redevelopment.

i.e. total requirement R will be,

\[ R = (H_0 - U_0) + (H_n - H_0) + nq \]

i.e. \[ R = H_n - U_0 + nq \] - (4.15)

Note

The calculation of \( H_0 \) is not necessary for obtaining R.

4.17 The number of units which the Department of National housing should invest in

The data in (6) of 4.12 gives the average rate of private house building per annum \( p \).

i.e. \( np \) units in \( n \) years

The total requirement is \( R \).

Therefore the number of units for which the Department of National Housing should be responsible for are = \( X \), given by

\[ x = (R-np) \]

i.e. \[ x = H_n - U_0 + nq - np \] - from equation (4.15)

and the average number of units per annum are \( \frac{x}{n} = x \)

i.e. \[ x = \left( \frac{H_n - U_0}{n} \right) + (q-p) \] - (4.16)

The above equation will provide the basic information necessary for formulating a government aided urban housing programme in Ceylon. The value of \( H_n \) in the equation must be obtained by using the model, showing that without such a model it will be impossible to formulate this programme. A complete worked example has been given in Appendix 2.
The use of the model in formulating a broad urban housing policy in Ceylon

Throughout this whole study two points have been stressed. They are:

(1) that we should first aim to meet the primary housing demand, before we consider need.

(2) that this idea was formulated due to the limited resources available for housing, and that we should thus maximise the use of these resources.

Based on the above let us try to formulate a broad set of policies, regarding (a) the ratio of the actual houses to be built to the number of plots of land to be developed and (b) private investment in housing.

Analysis leading to broad policies

Socio-economic consideration

The demand for government aided housing in urban Ceylon can be divided into two categories.

(a) Those whose social level demand permanent houses, but whose economic level prevent them from being able to meet this demand. Thus a government aided programme should provide them with permanent houses on rent or rent purchase.

(b) Those whose social level demand a temporary house, and whose economic level cannot meet this demand, due to the lack of capital for purchasing the necessary land. Here a government aided programme should provide the necessary land and services for the formulation of a self help programme.

Hence one of the basic policy decisions to be made is;

Out of the total requirements \( x \) per annum, equation (4.16), how many
of the units should be permanent houses, and how many should be plots of land with services provided for use in a self help programme?

Let the ratio of the permanent houses to be provided to the plots of land be 3.

To decide on a value of 3 is a complete study in itself depending on, not only the socio-economic conditions of the urban area under consideration but also on the physical, and political factors. This shows that this decision is independent of the use of the model.

4.212 Maximising the use of public resources, by minimising government investment in permanent housing

Once we are able to decide on a value for S for a particular area, the next step is to induce private investment in permanent housing, thus enabling the use of public capital for the development of land for self help housing programmes. This leads to the question, to what limit if any should private investment in housing be encouraged? This question will be answered by the following analysis.

Let the ratio of permanent houses to developed plots of land decided on be 3
Let the number of permanent houses required by \( x_1 \)
Let the number of developed plots of land be \( x_2 \)
Then \( \frac{x_1}{x_2} = 3 \)
But from equation 4.15 \( x_1 + x_2 = (H_n - U_0 + nq) \)

Solving the above equations
\[
x_1 = \frac{3(H_n - U_0 + nq)}{1+3} \quad \text{(the number of permanent units required)}
\]

If private building is encouraged, and the rate is \( p_1 \) per annum, then the number constructed in \( n \) years = \( np_1 \).

If \( np_1 \) is allowed to exceed \( x_1 \), the urban area under consideration will have too many permanent units and an insufficient number of
developed plots of land. This will lead to a section of the population being forced into houses above their socio-economic demand, thus recreating existing problems. Therefore, if \( np_1 \) should be less than \( x_1 \), then the public organisation concerned will have to provide \( (x_1 - np_1) \) permanent houses either for rent or purchase. Therefore the optimum value of \( p_1 \) is when \( np_1 = x_1 \)

\[
i.e. \quad np_1 = x_1 = \frac{S}{(1+i)} \left( H_n - U_0 + q \right)
\]

\[
i.e. \quad p_1 = \left[ \frac{S}{(1+i)} \left( \frac{H_n - U_0}{n} \right) + q \right] - (4.212)
\]

Hence the second policy decision, showing the use of \( H_n \) derived from the model, in the above equation.

4.3 Conclusion

In concluding this Chapter and the study as a whole, I wish to state

(1) That meeting the primary housing demand is the initial step to be taken in solving the housing problem of a developing country like Ceylon.

(2) That the model developed is essential for a government agency like the Department of National Housing, in order that a government aided housing programme could be aimed at meeting this demand.

(3) That the use of the model is not only limited to estimating the total requirement, but also in guiding the policy decision regarding private investment in housing.

(4) Finally, that this study may be useful to those trying to solve a similar problem in the other developing countries of the world.
This section deals with the data used in the building of model 4 in Chapter 3, and includes the computer print out of the analysis.

Table 4
The Table attached shows the dependent variable H in Column 1. The independent variables \( \frac{100F}{P} \), \( \frac{N}{P} \), and \( \frac{C}{P} \) are shown in columns 2, 3, 4 and 5 respectively.

The data numbered 1 to 14 are for the fourteen towns for 1946, while data 15 to 28 are for the year 1963.

Computer Print out
The computer print out shows the following

(1) the summary of the data
(2) the correlation matrix
(3) the analysis, using a system whereby the insignificant independent variables are automatically eliminated. Details of the analysis are also given.
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**Table 4 - Data Model 4**
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AUTOMATIC ELIMINATION

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10.0% SIGNIFICANCE LEVEL

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5.0% SIGNIFICANCE LEVEL
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1.0% SIGNIFICANCE LEVEL
NO CHANGE

0.1% SIGNIFICANCE LEVEL
NO CHANGE

END OF ELIMINATION

COMPUTER PRINT OUT, MODEL - 4 -
APPENDIX 2

The practical use of the model for estimating and projecting the housing demand of an urban area in Ceylon

In order that model 4 developed in Chapter 3 may be of practical use to both the local government authorities, as well as the National Housing Department of Ceylon, it is essential that its use be explained, and form simplified.

In order to do this the model will be transformed into a nomogram. This nomogram will then be used for (a) estimating and (b) projecting the housing demand of an imaginary urban area in Ceylon, which will explain its use.

(1) The nomogram

The final form of the model is

\[ H = 7109 + 0.98759F - 401.43 \left( \frac{100F}{P} \right) \]

let the percentage \( \left( \frac{100F}{P} \right) = r \)

Then \[ H = 7109 + 0.98759F - 401.43 \, r - (1) \]
can be treated as the final form,

where \( H \) = number of primary or census households

\( F \) = number of females from (20-49)

\( r \) = percentage of the females from (20-49) to the total population

\( P \) = total population

The range of values for which the model was built were

(1) \( 80,734 \leq H \leq 2045 \)

(2) \( 81,673 \leq F \leq 1846 \)

(3) \( 21.21 \leq r \leq 15.96 \)

These are also the ranges of values of \( H \), \( F \), and \( r \) for which the model is applicable.

In order to construct the nomogram we look at equation (1) again.

If \( p \) were constant then the model would be a simple two variable straight line graph. We make use of this fact by constructing a set of straight
CHART 1
NOMOGRAM FOR 18,000 > F > 1500

VALUES OF \( \tau \)

F IN THOUSANDS

H IN THOUSANDS

\( \tau = 16\% \)

2

1.5

8

10

18
line graphs for various values of $r \geq 15.96$ and $\leq 21.21$. The values of $r$ chosen vary from $r = 15.5$ to $r = 21.5$ in intervals of 0.5. The x axis of the set of graphs represents the number of females from (20-49) varying from 1500 to 82,000. The Y axis represents the number of households varying from 2000 to 81,000. Opposite is the completed nomogram.

(2) **The use of the model for estimating the housing demand of an urban area**

The primary use of the model is for estimating the immediate housing demand of an urban area.

Let us imagine a hypothetical urban area whose housing demand is to be estimated. The following steps show how it is done.

(1) estimate the total population $P$

(2) estimate the number of females from (20-49) $F$

**Note**

(1) and (2) will be obtained directly if the estimates are made just after a census. If an arbitrary time is chosen for making the estimate then either (a) a sample survey must be carried out, or (b) approximate estimates made with reference to past trends.

Let the total population of the area $P = 50,000$

Let the number of females $F = 8,000$

(3) calculate the percentage of $F$ to $P$ i.e. $r$

\[
    r = \frac{100F}{P} = \frac{100 \times 8,000}{50,000} = 16\%
\]

(4) (a) select the 16% line on the nomogram

(b) draw a vertical line through the point showing $F = 8,000$ on the x axis, to cut the line selected in (a).

(c) through this point draw a horizontal line to cut the Y axis, and read off the number of households indicated.
The lines on the nomogram show steps (a), (b) and (c). The number of households is 8,600. The calculated value is 8586. If a larger scale is used for the nomogram, this level of accuracy can be attained.

We may then calculate the average household size if required i.e.

\[
\frac{P}{H} = \frac{50,000}{8586} = 5.82
\]

The immediate demand in this town is then for 8586 units, and the average household size is 5.82.

For the sake of carrying out the exercise let us assume the town has 8,000 usable units. Then the immediate demand would be for

\[(8586-8000) = 586 \text{ units more.}\]

(3) The use of the model for projecting the housing demand of an urban area

Let us assume that it was required to estimate the demand for housing 5 years hence for this town.

Like any model this depends on assumptions made in the population projection. However, if the expert demographers of the Department of Census and Statistics are consulted they should be able to provide fairly reliable projections if future economic development and the resulting migration is taken into account. Information regarding economic development may be obtained from the Department of National Planning.

Let us assume that the figures provided were:

- total population \( P = 60,000 \)
- females (20-49) \( F = 12,000 \)

Then \( r = \left(\frac{100F}{P}\right) = 20\% \)

Selecting the line \( r = 20\% \), and repeating the procedure using \( F = 12,000 \) in the nomogram, we arrive at \( H = 10,900 \) (\( H = 10,931 \text{ calculated} \)). The average household size \( h = \frac{P}{H} = \frac{60,000}{10,900} = 5.51 \)

Then the number of units required in 5 years would be 10931, i.e. \( (10,931-8,586) = 2345 \text{ more than the immediate demand.} \)
(4) **Incorporating the results into a housing programme**

Finally the results of (3) and (4) will be used to estimate to what extent public intervention of some sort will be needed to meet the demand in a specified time.

Referring back to our hypothetical area, let us assume that the total primary demand was to be met in the 5 year period mentioned.

1. **The initial shortage**
   
   The initial shortage as calculated in (2) would be 536 units.

2. **The future requirements**
   
   The future requirements as calculated in (3) would be 2345 units.

3. **Replacement of obsolescent houses**
   
   Let us assume that from past records we have been able to assess the rate of obsolescence and that is is equal to 50 houses per year. Therefore total replacement at end of 5 years will be 50 x 5 = 250 houses.

4. **Total requirements**
   
   Therefore the total number of units to be built in this period in order to meet primary demand will be 536 + 2345 + 250 = 3181.

5. **Rate of private building**
   
   Here again by referring to past records of the area and considering the future economic level of the population let us assume that the rate of private building will be 200 a year. i.e. a total of 200 x 5 = 1000 during 5 year period.

6. **Public intervention necessary**
   
   3181 houses are required for the 5 year period to meet the demand. 1000 can afford to build their own houses, or build and rent them. We are thus left with (3181 - 1000) = 2181 houses to be built by public intervention. When I refer to houses to be built, this will include the actual building, as well as the other forms such as self help etc.
Therefore, if the demand is to be met, public intervention should provide approximately \( \frac{2181}{5} = 437 \) units a year. The actual form of building will depend on the economic level of the population as well as other physical factors of the area.

**Note**

This appendix has been geared to the form of administration, and house building practice prevailing in Ceylon at the present moment.
Bibliography


