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THE HOUSING QUALITY SIMULATION MODEL: BASIC DESCRIPTION

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FOREWORD

This paper describes a small-scale computer simulation model developed to analyze the impact of government interventions in the housing sector on the quality of housing occupied by households in different economic, tenure, and initial housing quality circumstances. Importantly, the effects of government actions to improve the efficiency of financial markets and to expand the volume of mortgage credit are among those that can be analyzed.

Construction of this model was undertaken as part of a larger project to develop a systematic approach to formulation of housing finance strategies in developing countries by officials in those countries and in the donor community. The other parts of this larger project deal with the possibilities and consequences of mobilizing additional financial resources for the housing sector.

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1. INTRODUCTION

This report describes the Housing Quality Model, designed to assist in the evaluation of alternative strategies for government intervention in the housing markets of developing countries. The Model will ultimately be used in conjunction with the Housing Needs Assessment Methodology, which calculates the annual flow of resources required to bring all households to a designated quality standard over a ten- to twenty-year period. Once this level of resources has been estimated, policy makers are still faced with the problem of how best to deploy these funds, and may still be uncertain about how rapidly improvements in housing quality can be achieved.

The Housing Quality Model attempts to address these issues by allowing policy makers to simulate the changes in housing quality that would result from alternative intervention strategies. Before delving into the specifics of this model, we broadly define it in relation to other types of housing simulation models. First, the Housing Quality Model can best be understood as a record-keeping or accounting model, rather than as a behavioral model. While some behavioral assumptions are incorporated into the model, most must be explicitly supplied by users as part of the data entry process. Second, this is primarily a demand-side model, focusing on the capacity of households to achieve significant improvements in housing quality, either independently or through participation in publicly-sponsored assistance programs. Housing supply constraints are reflected in the cost of various housing options, and in interest rate trends, but the Model does not attempt to

represent supply behavior endogenously or to simulate the market clearing process. Finally, the Housing Quality Model is designed to reflect, not a particular housing market, but the housing sector as a whole. However, in most applications, separate simulations will be conducted for urban and rural sectors, due to critical differences in housing problems, demographic trends, and feasible programs.

Four specific features of this model make it particularly useful for policy analysis in developing countries. First, it categorizes households by income, tenure, and dwelling quality, and analyzes transitions by households between tenure and dwelling quality classes under various government programs. Second, the model operates on an annual basis, so that alternative policies can be compared with respect to the rate at which housing improvements are achieved. Third, the model focuses on the transition of households from unacceptable dwelling and infrastructure conditions to acceptable conditions, rather than on more abstract, continuous measures of housing quality. Finally, in order to simulate specific government programs, the model requires analysts to formulate detailed specifications, encompassing eligibility requirements, funding levels, costs of participation, and assumptions about the distribution of assistance among households. Experience with the Needs Assessment Methodology suggests that this process of policy formulation, which requires many assumptions to be made explicit, often proves to be as useful as the model results themselves.

In this report, we describe the model in considerable detail, including data requirements, solution steps, and model outputs. Data and results were obtained from an illustrative application of the model

for the urban housing sector in Sri Lanka for the 1983-1993 period. The remainder of the report consists of three chapters. First, we outline the "No Government" components of the Housing Quality Model, which comprise the core of the simulation process. Then, we discuss the model's specification of housing assistance policies, including (1) expanded formal financing, (2) infrastructure upgrading , and (3) sites and services or direct construction programs. Finally, the model's hardware requirements and operation are outlined.

2. "NO GOVERNMENT" SIMULATIONS

The primary usefulness of the Housing Quality Model is as a tool for analyzing alternative strategies for government intervention in the housing sector. However, policy alternatives can best be assessed relative to a base case in which government plays no active role. Moreover, many dynamics affecting housing conditions and investment levels persist whether or not government intervenes to address a nation's housing problems. Therefore, the Housing Quality Model begins with a series of "no government," or "natural" solution steps, which can then be supplemented by policy simulation steps. This chapter describes the "no government" components of the Housing Quality Model, focusing first on input data requirements, then on solution steps, and finally on model outputs.

Model Inputs

Model inputs fall into two basic categories -- base-period household data and annual transitions data. These two categories are now addressed in turn, with illustrations for Sri Lanka's urban sector.

Base-Period Household Data. The model's primary data structure is a three-dimensional matrix for classifying households. Each cell in the matrix represents the intersection of a particular income class, tenure category, and dwelling status. The model classifies income by decile. Then, for each decile, households can fall into one of four tenure categories:

- owner with clear title;
- owner without clear title;

- unit renter; or
- room renter.

In our Sri Lanka implementation, all owners are assumed either to hold title to their properties or to be virtually certain of their rights to retain possession of their property. Therefore, no households are classified into tenure category #2 -- owners lacking clear title.

Within each tenure category, six dwelling statuses are possible, defined on the basis of both structural adequacy and infrastructure adequacy. These are:

(1) structure and infrastructure both adequate;

(2) structure adequate, infrastructure inadequate;

(3) structure upgradeable, infrastructure adequate;

(4) structure upgradeable, infrastructure inadequate;

(5) structure inadequate, infrastructure adequate; or

(6) both structure and infrastructure inadequate.

The definitions of structural and infrastructure adequacy will vary from one country to another, and will be obtained from the Housing Needs Assessment performed prior to implementation of the Housing Quality Model. For Sri Lanka, dwelling quality is rated as permanent, semi-permanent, or improvised, on the basis of building materials. These definitions, and the accompanying infrastructure acceptability standards are discussed in detail in Appendix A. Table 2.1 presents the resulting distribution of households by income, tenure, and dwelling status for urban Sri Lanka in 1983.

Using this income/tenure/dwelling status classification matrix to organize household data within the simulation model has two important

TABLE 2.1

DISTRIBUTION OF HOUSEHOLDS: URBAN SRI LANKA--1983

Decile 1 (Low): 60462 households

	Owner	Unit Renter	Room Renter
Permanent/Pass	5.04	3.09	6.47
Permanent/Fail	25.17	20.01	8.25
Semi-Perm/Pass	0.60	0.37	0.77
Semi-Perm/Fail	10.21	7.90	4.50
Improvised/Pass	0.07	0.04	0.09
Improvised/Fail	3.32	2.55	1.56

Decile 2: 60462 households

	Owner	Unit Renter	Room Renter
Permanent/Pass	5.37	1.49	3.90
Permanent/Fail	23.66	18.62	15.01
Semi-Perm/Pass	0.64	0.18	0.46
Semi-Perm/Fail	9.75	7.02	6.30
Improvised/Pass	0.07	0.02	0.05
Improvised/Fail	3.18	2.23	2.07

Decile 3: 60462 households

	Owner	Unit Renter	Room Renter
Permanent/Pass	9.43	8.84	5.18
Permanent/Fail	25.30	13.37	5.92
Semi-Perm/Pass	1.12	1.05	0.61
Semi-Perm/Fail	11.31	6.90	3.36
Improvised/Pass	0.13	0.12	0.07
Improvised/Fail	3.76	2.37	1.17

Decile 4: 60462 households

	Owner	Unit Renter	Room Renter
Permanent/Pass	9.64	5.59	2.60
Permanent/Fail	28.87	12.91	8.43
Semi-Perm/Pass	1.14	0.66	0.31
Semi-Perm/Fail	12.63	5.96	3.64
Improvised/Pass	0.13	0.07	0.03
Improvised/Fail	4.18	2.00	1.20

Decile 5: 60462 households

	Owner	Unit Renter	Room Renter
Permanent/Pass	9.62	8.80	4.61
Permanent/Fail	23.74	14.25	7.01
Semi-Perm/Pass	1.14	1.04	0.55
Semi-Perm/Fail	10.80	7.20	3.61
Improvised/Pass	0.13	0.12	0.06
Improvised/Fail	3.61	2.46	1.24

Decile 6: 60462 households

	Owner	Unit Renter	Room Renter
Permanent/Pass	10.33	11.09	5.39
Permanent/Fail	24.19	15.21	1.81
Semi-Perm/Pass	1.22	1.31	0.64
Semi-Perm/Fail	11.13	8.10	1.94
Improvised/Pass	0.14	0.15	0.07
Improvised/Fail	3.73	2.80	0.74

Decile 7: 60462 households

	Owner	Unit Renter	Room Renter
Permanent/Pass	11.60	13.18	1.31
Permanent/Fail	31.62	6.56	3.77
Semi-Perm/Pass	1.37	1.56	0.15
Semi-Perm/Fail	14.09	5.50	1.66
Improvised/Pass	0.15	0.18	0.02
Improvised/Fail	4.69	2.03	0.55

Decile 8: 60462 households

	Owner	Unit Renter	Room Renter
Permanent/Pass	17.96	14.69	1.00
Permanent/Fail	23.21	10.42	0.77
Semi-Perm/Pass	2.13	1.74	0.12
Semi-Perm/Fail	12.60	7.25	0.51
Improvised/Pass	0.24	0.20	0.01
Improvised/Fail	4.37	2.62	0.18

Decile 9: 60462 households

	Owner	Unit Renter	Room Renter
Permanent/Pass	29.46	12.90	3.92
Permanent/Fail	20.36	0.37	1.02
Semi-Perm/Pass	3.49	1.53	0.46
Semi-Perm/Fail	14.34	3.22	1.30
Improvised/Pass	0.39	0.17	0.05
Improvised/Fail	5.19	1.31	0.50

Decile 10 (High): 60462 households

	Owner	Unit Renter	Room Renter
Permanent/Pass	54.29	6.05	0.00
Permanent/Fail	7.69	0.01	0.00
Semi-Perm/Pass	6.43	0.72	0.00
Semi-Perm/Fail	15.74	1.45	0.00
Improvised/Pass	0.72	0.08	0.00
Improvised/Fail	6.22	0.60	0.00

advantages. First, it focuses on the differences among households that are of greatest importance to policy makers, and does not attempt to simulate the marginal effects of other, less critical, household attributes. At the same time, however, this approach avoids the problems of "lumpiness" found in some other housing simulation models, such as the Urban Institute Housing Market Simulation Model (Turner and Struyk, 1985). Specifically, since an actual number of households is entered into each cell in the classification matrix, and since any number of actual households can be shifted between cells, policies that affect only a small fraction of households can be accurately represented.

In addition to the distribution of households among cells, base period data requirements include the average annual income for each decile, and the share of income available for housing investment. Values of these data items for urban Sri Lanka in 1983 are presented in Table 2.2. These values were obtained from the Housing Needs Assessment Model implementation.[1]

Annual transition data. There are four general types of "natural" transitions that the model simulates. These represent various changes that occur regardless of government housing activities, and that can affect the distribution of households across tenure and dwelling

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1. Manson and Struyk (1984), p. 46. Share of income available for housing investment is computed as: percent of income available for housing less the percentage needed for recurring expenses. Income differences within quintiles (between adjacent deciles) were derived from the income distribution in the 1980/81 Socio-Economic Survey. However, the mean income for each pair of deciles is equal to the corresponding quintile mean income in Manson and Struyk.

TABLE 2.2

MEAN INCOMES AND SHARE AVAILABLE FOR HOUSING INVESTMENT: URBAN SRI LANKA -- 1983

Decile	1983 Mean Income	Share Available for Housing Investment
1 (low)	Rs. 6,467	14.4%
2	10,073	
3	10,881	13.6%
4	13,219	
5	15,807	11.6%
6	18,933	
7	24,770	14.0%
8	31,270	
9	46,370	19.5%
10 (high)	102,970	

status categories as well as the allocation of resources within the housing sector. To simulate "natural" housing quality transitions, the model requires exogenous estimates of the rates at which these changes occur.

In thinking about these data requirements, however, it is helpful to keep in mind that initial transition estimates will almost certainly be somewhat judgemental, and that they can be revised through a model calibration process. In other words, model users are required to come up with initial guesses at the various transition rates, and can then revise these guesses to make the resulting model outputs more consistent with other exogenous information about housing quality, new construction levels, and housing investment. Finally, it is important to note that the model concerns itself with net changes in the distribution of households across cells in the household classification

matrix, not with the actual behavior of individual households moving between cells.

The specific transition estimates that must be supplied include:

(1) The rate of real income growth.
This estimate can vary by income class, or it can be the same for all deciles. In our Urban Sri Lanka implementation, household incomes grow 2.85 percent annually from 1984 to 1988, and 3.01 percent annually from 1989 to 1993.[1]

(2) Net change in the number of households.
This includes net in-migration, new household formations from population increase, and changes in the distribution of households among tenure classes. Separate estimates of net change must be provided for each income/tenure class. Note that the net change in the number of households could perfectly well be negative, for the system as a whole or for any income/tenure cell. In addition, note that this set of data inputs allows users to specify the tenure class (or classes) most likely to be selected by newly forming or in-migrating households. In the current implementation, each decile increases by 1315 households annually from 1984 to 1988, and by 1349 households annually from 1989 to 1993.[2] Table 2.3 presents the tenure distribution of new households by decile. We have assumed that no new rental units are produced, and that the share of room renters relative to owners remains the same as in 1983.

(3) Dwelling unit replacement rate.
This represents the share of the housing stock that must be replaced annually to counteract depreciation. We have used a rate of 0.9 percent for consistency with the Needs Assessment Model.[3]

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1. Manson and Struyk (1984), p. 39.
2. Manson and Struyk (1984), p. 20.
3. Manson and Struyk (1984), pp. 23-24.

TABLE 2.3

TENURE DISTRIBUTION OF NET NEW HOUSEHOLDS
BY INCOME DECILE: URBAN SRI LANKA

Decile	Owners	Unit Renters	Room Renters
1 (low)	67.2%	0	32.8%
2	60.6	0	39.4
3	75.8	0	24.2
4	77.7	0	22.3
5	74.2	0	25.8
6	82.7	0	17.3
7	89.5	0	10.5
8	95.9	0	4.1
9	91.0	0	9.0
10 (high)	100.0	0	0

4) The rate at which dwelling units change status.
In other words, for each dwelling status, what share of units can be expected to change to each alternative dwelling status? Estimates of these transition rates for urban Sri Lanka are discussed in Appendix B. Table 2.4 presents the resulting matrix of original dwelling status cells by target dwelling status cells.

5) Availability of formal finance.
The final annual data requirement is an estimate of the volume of formal loans available, and the allocation of these loans among household classes. For our Sri Lanka simulations, we assume that about Rs.95 million are available each year to owners of fully adequate dwellings in the top three income quintiles.

All of the transition data are assumed to be in annual terms. The simplest application of the model would involve no changes in these transition rates from year to year. However, increases or decreases can be incorporated for any year in the simulation period if there is reason to expect such a discontinuity to occur. Moreover, as discussed further in a subsequent section, government policies can affect any or all of these transition data.

TABLE 2.4

DWELLING STATUS TRANSITION RATES: URBAN SRI LANKA
(percent)

Original Status	Target Status					
	Perm/Pass	Perm/Fail	Semi/Pass	Semi/Fail	Imp/Pass	Imp/Fail
Perm/Pass	0	0	0	0	0	0
Perm/Fail	0.43	0	0	0	0	0
Semi/Pass	0.43	1.64	0	0	0	0
Semi/Fail	0.43	1.64	0.16	0	0	0
Imp/Pass	0	0	0	0	0	0
Imp/Fail	0	0	0	0	0	0

Note: To illustrate, this table indicates that 0.43% of "Perm/Fail" units can be expected to be upgraded to "Perm/Pass" status each year.

Solution Steps

The model operates on a year-by-year basis. In other words, it starts in an initial year with the base data provided, updates these data each year based on annual transition estimates, and reports the year's outcomes. Some cumulative totals are retained for reporting purposes, but, for the most part, each year's solution is self-contained. Therefore, this description of solution steps refers to a single year's simulation.

Adjust real incomes. Using the exogenously provided estimates of real income growth, the model inflates mean income for each income decile. If only a single growth rate is provided, mean income in each cell will change by the same amount. If, on the other hand, income growth varies by income class, all tenure/dwelling status cells within an income class will experience the same change in mean income. Note

that, as real incomes increase, the implied values of "entry level" -- discussed below -- dwelling units also increase, since these values are based on affordability calculations.

Calculate entry costs for each dwelling status. The minimum cost of obtaining a unit in a particular dwelling status -- in the absence of government assistance programs -- is defined as the entry cost for that status. The model initially computes entry cost as the capitalized value of income available for housing investment among households in the lowest decile comprising at least ten percent of a dwelling status population. For example, in 1984, decile 8 is the lowest decile to make up at least ten percent of all households with fully acceptable dwellings. Therefore, the model defines the entry cost of this dwelling status as the capitalized value of the share of decile 8 mean income available for housing investment.[1]

Following the initial computation of entry costs, the user is given an opportunity to revise the assigned values, using any decile's capitalized income value as the benchmark for any dwelling statuses entry cost. Table 2.5 presents 1984 entry costs for the Sri Lanka implementation. After the initial year of a simulation period, the model simply updates entry costs as incomes increase.

Simulate net change in the number of households. This step uses the exogenous estimates of net change in the number of households. As discussed earlier, a user of the model must specify the number of net new households for each income/tenure class. The model

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1. Income available for housing investment is capitalized at market interest rates (17% in the Sri Lanka base case), assuming an 80 percent loan to value ratio.

TABLE 2.5

1984 ENTRY COSTS BY DWELLING STATUS

	Decile[a]	Entry Cost
Permanent/Acceptable	8	Rs.31,674
Permanent/Unacceptable	1	6,738
Semi-Perm/Acceptable	6	15,890
Semi-Perm/Unacceptable	1	6,738
Improvised/Acceptable	4	13,007
Improvised/Unacceptable	1	6,738

then allocates these newcomers among dwelling status categories according to the base period household distribution. In other words, if 50 percent of decile 1 owners initially occupy permanent units with unacceptable infrastructure, then 50 percent of the incoming decile 1 owners are assigned to this dwelling status each year.

When households are added to a particular cell, the model computes the implied level of investment required to house these "newcomers." In other words, as the number of households increases, resources must be generated in the housing sector as a whole to pay for the incremental units. At this stage, the model is not concerned with the source of funds for additional units; it merely records the resource requirements generated for each cell in the household classification matrix. A later solution step concerns itself with the allocation of resource requirements among sources of funds.

The "No Government" components of the Housing Quality Model assume, based on historical evidence, that all households can afford their assigned dwelling status, and that incoming households to a cell

a. Highest income decile is 10.

obtain at least an "entry level" unit for that dwelling status. Since the "no government" model's purpose is to simulate transitions that occur regardless of the policy environment, newcomers by definition represent those households that have somehow succeeded in overcoming affordability hurdles. Therefore, in calculating the resource requirements generated by the addition of new households to the system, we assume that all newcomers have amassed sufficient resources to meet at least the entry cost of their assigned dwelling status. If the capitalized value of income available for housing investment is higher than the entry cost, households pay this higher amount, up to a ceiling of three times the entry cost.[1]

Each net newcomer to the housing sector generates a dwelling unit requirement as well as a resource requirement.[2] Dwelling unit requirements are recorded by tallying the total number of households entering and/or leaving each tenure/dwelling status category. To the degree that the number of incoming households exceeds the number of outgoing households for any dwelling status, the production of new dwelling units will be required. A subsequent solution step is responsible for final calculations regarding the net level of new construction in each dwelling status category. At this stage, the model simply records additions to and subtractions from the number of dwelling units required to accommodate the households in each cell.

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1. This ceiling was imposed to limit the level of housing investment among the relatively small number of affluent households living in poor housing circumstances.

2. Newcomers assigned to the "room renter" tenure category generate neither resource requirements nor new dwelling construction. They do, however, reduce the incidence of crowding observed in the housing sector.

When this solution step is completed, each cell in the household classification matrix has an updated number of households, as well as data entries reflecting net new dwelling unit requirements and resource requirements generated by the addition of new households.

Simulate dwelling unit replacements. The next solution step is to estimate the resource requirements and new dwelling production levels necessary to replace units removed from the housing stock. Based on the distribution of dwelling units at the beginning of the current year, a fixed proportion of the units in each status must be replaced by new units.

The model computes replacements for each cell in the household classification matrix, incrementing the resource requirement and new dwelling tallies for that cell. Resource requirements are again set to the entry cost for the dwelling status, unless the capitalized value of income available for housing investment is higher. In this case, the higher value is used, up to a maximum of three times the entry cost. Replacements have no impact on the count of households in each classification cell.

Simulate dwelling status transitions. Based on the exogenously specified dwelling transition rates, the model shifts dwellings between cells, keeping track of owners' net resource requirements. Transitions are performed for one income/tenure category at a time. These transitions do not generate new dwelling unit production requirements, because they are all assumed to be accomplished by means of upgrading. In other words, for each transition, some number of units is simply subtracted from one dwelling status cell and added to another. However,

these transitions do generate net resource requirements equal to the difference between the entry cost in the initial dwelling status and the investment level in the target status.[1] This effectively sets a household's "equity" in its prior dwelling status at the lower bound, and may therefore overestimate resource requirements necessary for upgrading units from one dwelling status to another.

Tabulate net new dwelling requirements. After all possible dwelling transitions have been accomplished, the model tallies up the total dwelling unit production requirements by tenure class and dwelling status. The results of this step will reflect new construction levels and -- if applicable -- vacancy rates. Moreover, to the degree that units are vacant at the end of any year's solution, the model retains them for subsequent solutions. Thus, these units can be occupied by incoming households without creating the need for new construction in subsequent years. Vacant units are retained in the system for two full years before they start to decline in quality. Specifically, after standing vacant for two full years, permanent units become semi-permanent, semi-permanent units become improvised, and improvised units drop out of the stock.[2]

Compute total investment requirements. In its final "no government" solution step, the model tallies up all resource requirements and allocates them between private sector formal financing

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1. As before, the investment is at least the entry cost, and may be higher if the capitalized value of income available for housing investment is higher, up to a maximum of three times the entry cost.

2. Infrastructure acceptability does not decline during periods of vacancy.

and savings/informal investment.[1] First, all resource requirements incurred by the owners of rental property are assumed to be generated from savings/informal financing. Then, owner-occupants' resource requirements are summed across cells in the household classification matrix. Next, the pool of formal loans is allocated across owner-occupied cells. This is accomplished by applying any lending restrictions specified exogenously. For example, in the Sri Lankan simulations, SMIB lending is limited to households in the top three income quintiles, occupying units with fully adequate structure and infrastructure. Each cell is assumed to use up the formal financing allocated to it, with all remaining resources obtained from savings/informal financing.

By definition, formal financing -- in the aggregate -- is constrained by the exogenously defined control totals. Savings/informal investment, on the other hand, may differ from exogenous estimates. At this point, a user can run the "no government" model in an iterative calibration mode, to achieve transition rate assumptions and savings/informal investment totals that are consistent with one another and with exogenous evidence.

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1. Ideally, one would like to distinguish savings from informal financing. However, it is generally very difficult to make such a distinction, for two reasons. First, housing data bases do not always gather exhaustive information on financing other than from formal sources. Second, even when efforts are made to collect data on informal housing finance, difficulties are encountered differentiating intra-family lending from gifts or other reciprocal arrangements. Since intra-family sources often constitute the major share of informal financing, such definitional problems are significant. Therefore, the model is currently designed to lump savings and informal financing together. If reliable data could be generated to differentiate these two sources, the model could easily be refined to treat them separately.

The issue of what is included in the Housing Quality Model's total investment measure is a difficult one. To the greatest degree possible, investment levels reflected in the Housing Quality Model should match the estimates generated by the Needs Assessment Model, which are designed to correspond to national income accounts. This would mean that resources devoted to "unauthorized" upgrades and construction would be excluded. The Housing Quality Model diverges from this treatment by including in its resource estimates any upgrades that shift a dwelling unit from one status to another as well as any new construction, even of unconventional units. Therefore, our estimates of housing investment levels will be higher than those generally reflected in national income accounts, but will still exclude incremental upgrades that do not change a unit's dwelling status.[1]

Model Outputs

The Housing Quality Model produces two classes of tabular outputs -- year-by-year tables, and cumulative tables for multi-year simulations. Most of the year-by-year tables are useful primarily for diagnostic purposes. In other words, as a user develops a data set, detailed results can be examined for each simulation year for

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1. It is very possible that a significant share of a nation's housing improvements may be achieved through continuous incremental upgrading that yields shifts in dwelling status only after a number of years. In such cases, the Housing Quality Model will actually come quite close to reflecting the true situation, since a small share of units will be shown to shift status each year, with the resource cost for each transitional unit roughly equal to the value of the accumulated upgrades required to achieve the transition. Only the resources invested by households in the highest dwelling status, who continue to upgrade their units incrementally will be entirely excluded from the model's calculations.

reasonableness and consistency. Once a satisfactory data set has been developed, however, most of the year-by-year tables are of little interest, and need not be produced. Therefore, the full set of year-to-year tabulations have been relegated to Appendix D. Only two are discussed further here.

Tables 2.6 and 2.7 reproduce the two annual tables of primary interest -- the distribution of households by income and tenure, and the distribution of households by income and dwelling status. These two tables make it possible to track progress in reducing crowding and in improving housing conditions. In particular, a model user can pinpoint the income deciles that are experiencing progress from year-to-year. Note that these tables are produced for policy simulations as well as for base case, "no government" simulations. Therefore, year-to-year changes in housing conditions under various policy regimes can be compared to the base case.

Tables 2.8 through 2.10 present the cumulative tables produced at the end of multi-year simulations. These tables report, respectively, annual resource requirements (Table 2.8), annual new construction levels by dwelling status (Table 2.9), and annual counts of room renters by dwelling status (Table 2.10).

TABLE 2.6

SRI LANKA -- BASE CASE

HOUSEHOLDS BY INCOME AND TENURE -- 1984
(count,row percent,col percent)

INCOME	TENURE secure owners	squatters	unit renters	room renters	total
low 1	27736	0	20524	13515	61775
	44.90	0.00	33.22	21.88	
	7.64	0.00	11.70	17.07	
2	26588	0	17873	17316	61776
	43.04	0.00	28.93	28.03	
	7.32	0.00	10.19	21.87	
3	31860	0	19735	10187	61781
	51.57	0.00	31.94	16.49	
	8.77	0.00	11.25	12.86	
4	35241	0	16441	10089	61770
	57.05	0.00	26.62	16.33	
	9.71	0.00	9.37	12.74	
5	30623	0	20484	10669	61776
	49.57	0.00	33.16	17.27	
	8.43	0.00	11.67	13.47	
6	31767	0	23371	6632	61770
	51.43	0.00	37.84	10.74	
	8.75	0.00	13.32	8.37	
7	39581	0	17543	4653	61777
	64.07	0.00	28.40	7.53	
	10.90	0.00	10.00	5.88	
8	37838	0	22317	1620	61776
	61.25	0.00	36.13	2.62	
	10.42	0.00	12.72	2.05	
9	45473	0	11798	4504	61775
	73.61	0.00	19.10	7.29	
	12.52	0.00	6.72	5.69	
high 10	56389	0	5387	0	61776
	91.28	0.00	8.72	0.00	
	15.53	0.00	3.07	0.00	
total	363095	0	175472	79184	

SRI LANKA -- BASE CASE TABLE 2.7

HOUSEHOLDS BY INCOME AND DWELLING STATUS -- 1984
(count,row percent,col percent)

INCOME	DWELLING STATUS perm-pass	perm-fail	semi-pass	semi-fail	imprv-pass	imprv-fail	total
low 1	9262	33074	1073	13659	120	4586	61775
	14.99	53.54	1.74	22.11	0.19	7.42	
	5.26	13.38	5.25	10.77	5.16	10.25	
2	6889	35447	797	13935	89	4619	61776
	11.15	57.38	1.29	22.56	0.14	7.48	
	3.91	14.34	3.90	10.98	3.84	10.32	
3	14642	27699	1698	13035	193	4515	61781
	23.70	44.83	2.75	21.10	0.31	7.31	
	8.31	11.21	8.31	10.27	8.28	10.09	
4	11195	31138	1297	13433	147	4560	61770
	18.12	50.41	2.10	21.75	0.24	7.38	
	6.35	12.60	6.35	10.59	6.33	10.19	
5	14395	27941	1669	13062	191	4517	61776
	23.30	45.23	2.70	21.14	0.31	7.31	
	8.17	11.30	8.17	10.30	8.18	10.10	
6	16722	25611	1940	12790	221	4486	61770
	27.07	41.46	3.14	20.71	0.36	7.26	
	9.49	10.36	9.49	10.08	9.48	10.03	
7	16182	26154	1878	12855	214	4494	61777
	26.19	42.34	3.04	20.81	0.35	7.27	
	9.19	10.58	9.19	10.13	9.17	10.04	
8	20891	21446	2425	12307	277	4431	61776
	33.82	34.72	3.93	19.92	0.45	7.17	
	11.86	8.68	11.86	9.70	11.88	9.90	
9	28646	13690	3326	11405	380	4326	61775
	46.37	22.16	5.38	18.46	0.62	7.00	
	16.26	5.54	16.27	8.99	16.32	9.67	
high 10	37351	4985	4339	10393	498	4210	61776
	60.46	8.07	7.02	16.82	0.81	6.81	
	21.20	2.02	21.23	8.19	21.36	9.41	
total	176175	247186	20441	126875	2330	44744	

SRI LANKA -- BASE CASE

TABLE 2.8

ANNUAL RESOURCE REQUIREMENTS (in millions)

	Total Sector	Owner-Occupants	Unit Landlords
1984			
Total	574.55	525.69	48.86
Formal Financing	95.00	95.00	0.00
Savings/Informal	479.55	430.69	48.86
Govt. Subsidies	0.00	0.00	0.00
1985			
Total	594.91	544.53	50.38
Formal Financing	95.00	95.00	0.00
Savings/Informal	499.91	449.53	50.38
Govt. Subsidies	0.00	0.00	0.00
1986			
Total	615.97	564.02	51.94
Formal Financing	95.00	95.00	0.00
Savings/Informal	520.97	469.02	51.94
Govt. Subsidies	0.00	0.00	0.00
1987			
Total	637.74	584.19	53.56
Formal Financing	95.00	95.00	0.00
Savings/Informal	542.74	489.19	53.56
Govt. Subsidies	0.00	0.00	0.00
1988			
Total	660.26	605.04	55.22
Formal Financing	95.00	95.00	0.00
Savings/Informal	565.26	510.04	55.22
Govt. Subsidies	0.00	0.00	0.00
1989			
Total	695.53	638.51	57.02
Formal Financing	95.00	95.00	0.00
Savings/Informal	600.53	543.51	57.02
Govt. Subsidies	0.00	0.00	0.00
1990			
Total	721.17	662.29	58.88
Formal Financing	95.00	95.00	0.00
Savings/Informal	626.17	567.29	58.88
Govt. Subsidies	0.00	0.00	0.00
1991			
Total	747.73	686.92	60.80
Formal Financing	95.00	95.00	0.00
Savings/Informal	652.73	591.92	60.80
Govt. Subsidies	0.00	0.00	0.00
1992			
Total	775.23	712.44	62.79
Formal Financing	95.00	95.00	0.00
Savings/Informal	680.23	617.44	62.79
Govt. Subsidies	0.00	0.00	0.00
1993			
Total	803.70	738.87	64.84
Formal Financing	95.00	95.00	0.00
Savings/Informal	708.70	643.87	64.84
Govt. Subsidies	0.00	0.00	0.00

SRI LANKA -- BASE CASE

TABLE 2.9

NET NEW DWELLING UNITS CONSTRUCTED ANNUALLY

	DWELLING STATUS						
	perm-pass	perm-fail	semi-pass	semi-fail	imprv-pass	imprv-fail	total
1984	4178	6342	495	3269	56	1122	15463
1985	4217	6394	496	3267	56	1130	15559
1986	4255	6445	497	3266	56	1137	15656
1987	4294	6496	498	3264	57	1144	15752
1988	4332	6547	500	3262	57	1151	15848
1989	4444	6713	510	3319	58	1178	16222
1990	4483	6765	511	3318	59	1185	16321
1991	4522	6817	512	3317	59	1192	16419
1992	4561	6869	514	3315	60	1199	16518
1993	4600	6921	515	3314	60	1206	16617

SRI LANKA -- BASE CASE

TABLE 2.10

ANNUAL COUNT OF ROOM RENTERS BY DWELLING STATUS

	DWELLING STATUS						
	perm-pass	perm-fail	semi-pass	semi-fail	imprv-pass	imprv-fail	total
1984							
count	21663	32601	2513	16374	286	5748	79184
percent	27.36	41.17	3.17	20.68	0.36	7.26	
1985							
count	22544	33765	2567	16527	295	5925	81622
percent	27.62	41.37	3.14	20.25	0.36	7.26	
1986							
count	23426	34929	2621	16679	304	6102	84060
percent	27.87	41.55	3.12	19.84	0.36	7.26	
1987							
count	24307	36094	2674	16832	312	6279	86498
percent	28.10	41.73	3.09	19.46	0.36	7.26	
1988							
count	25188	37258	2728	16985	321	6455	88936
percent	28.32	41.89	3.07	19.10	0.36	7.26	
1989							
count	26087	38447	2784	17151	330	6637	91437
percent	28.53	42.05	3.04	18.76	0.36	7.26	
1990							
count	26986	39637	2840	17318	339	6818	93938
percent	28.73	42.19	3.02	18.44	0.36	7.26	
1991							
count	27884	40827	2896	17484	349	7000	96439
percent	28.91	42.33	3.00	18.13	0.36	7.26	
1992							
count	28783	42017	2952	17650	358	7181	98940
percent	29.09	42.47	2.98	17.84	0.36	7.26	
1993							
count	29682	43207	3008	17816	367	7363	101442
percent	29.26	42.59	2.96	17.56	0.36	7.26	

3. SIMULATING GOVERNMENT ACTIVITIES

Standing alone, the "No Government" components of the Housing Quality Model enable a user to develop an internally consistent and reasonable set of "natural" transition estimates, and to generate base case simulation results. However, the real value of the Housing Quality Model is its capacity to simulate the effects of alternative strategies for deploying housing assistance resources. This chapter describes the Model's treatment of three broad classes of housing assistance programs:

(1) Expansion of formal housing finance. This type of policy can take many forms, ranging from an increase in the volume of loans issued without any meaningful change in terms to a targeted lending program with subsidized interest rates.

(2) Provision of infrastructure, with recipients paying a fixed proportion of the total cost. Earmarked financing could accompany such a program, or infrastructure recipients could be assumed to finance infrastructure and any accompanying structural improvements out of savings/informal financing.

(3) Sites and services and/or direct construction projects. This category encompasses all programs in which the government sells sites offering adequate infrastructure accompanied by differing degrees of structure. Like the previous two types of policy, sites and services or direct construction may be accompanied by an earmarked pool of housing finance.

For each of these types of activities, a user must specify in considerable detail how much assistance will be available, on what terms, and to what groups of households. On the basis of this exogenous information, the model then allocates the available assistance among households, and simulates the resulting transitions in tenure class and dwelling status. As in the "No Government" version, these calculations are performed on a year-by-year basis, with each annual solution largely self-contained.

It is important to keep in mind that the policy components of the Housing Quality Model do not displace the "no government" components. The transitions discussed in Chapter 2 persist after government activities are added. A Model user may, however, wish to change some of the data elements required by the "No Government" components in light of policies being simulated. For example, a policy of financial reform would be expected to change interest rates throughout the housing sector, while other policies might affect income growth rates. The output tables discussed in Chapter 2 continue to be generated after policies are incorporated, with the reported results reflecting the combined effects of natural transitions and public assistance.

Because the data requirements and solution steps for each type of government intervention are rather different, we now consider the three types in turn. After discussing each type of government activity, we show how these can be combined into an overall housing assistance strategy, and what extra information the model generates in the course of a policy simulation.

Expansion of Formal Housing Finance

As indicated earlier, the expansion of formal loans for housing can take many forms. At one extreme, government policies could work to expand the volume of loans available and could continue to allow existing private lenders to allocate these funds with no change in lending practices or terms. At the other extreme, government could take on the role of raising and lending funds for housing investment, subsidizing interest rates and targetting loans to households not

already served by private lenders. Of course, many possible approaches to the expansion of formal housing finance lie between these two extremes. The Housing Quality Model has the capacity to simulate the expansion of formal finance on any terms. In fact, it is possible for users to specify more than one pool of formal loans, with different lending practices and terms associated with each.

To permit this kind of flexibility, the model must rely on the user for a detailed specification of how each pool of formal loans is to be allocated and on what terms. Therefore, the input requirements for this form of government housing assistance may seem rather onerous. In the discussions that follow, we define the input requirements and solution steps for a single pool of formal loans. Keep in mind that the model allows users to specify more than one such pool.

Table 3.1 identifies the loan terms that must be specified by the user and provides the 1983 values used in our Sri Lanka policy simulations.[1] Most of these terms are self-explanatory, but a few merit additional discussion. The market rate of interest should reflect the actual cost of funds to the lender. In combination with the programmatic interest rate, this market rate is used to compute the amount of interest subsidies, if any. The maximum savings/informal mobilization rate represents the maximum downpayment households can be expected to raise from savings and informal financing in response to the program's opportunity. This rate represents a share of annual income. Finally, the required dwelling status identifies the lowest dwelling

1. For each simulation year (from 1984 to 1993) dwelling unit and loan amounts were inflated by 2.4 percent to reflect real increases in construction costs.

status participants will achieve -- in this case, a permanent structure with acceptable infrastructure.

TABLE 3.1

LOAN TERMS FOR EXPANDED FORMAL FINANCE POLICY: 1983

Aggregate Amount of Loans	Rs.37,000,000
Interest Rate (annual)	17% (or 20%)
Market Interest Rate	17% (or 20%)
Repayment Period (in years)	15
Estimated Average Loan Amount	Rs.12,330
Max. Savings/Informal Mobilization	0.50
Required Dwelling Status	1
Minimum Dwelling Value	Rs.21,800
Maximum Loan Amount	Rs.15,260
Maximum Loan to Value Ratio	0.70

In addition to these loan terms, a user must specify the expected allocation of loans among the cells in the household classification matrix. In other words, what share of loans are expected to go to each income/tenure/dwelling status cell? The allocation matrix should reflect not only program eligibility requirements, but also reasonable expectations about participation rates and leakage.

Based on the user's specification of formal financing terms and eligibility, the model allocates the available funds among eligible households and records the resulting changes in tenure and dwelling status. This is accomplished in a six-step process:

(1) Confirm that all eligible households can afford to meet lending requirements.
In this step, the model considers each eligible cell in the household classification matrix (by income class, initial tenure, and initial dwelling status) to ensure that households in this cell can afford to satisfy the minimum requirements of the loan program. For example, a low-income group might be designated as eligible even though its income

is too small to support a mortgage loan at the specified terms. The model tests for affordability both to ensure that households have enough income (adjusted for expenditures on other essential items) to meet their loan payments, and to ensure that they can generate sufficient savings/informal finance to meet minimum downpayment requirements. Equity from the previous dwelling is considered in this affordability test, if applicable.[1] If some cells designated as eligible by the user cannot afford to participate in the program, the model reallocates the original pool of loans among the remaining eligible cells.

(2) Compute an initial estimate of the number of loans that can be made. This is simply the total volume of funds available divided by the user's estimate of the average loan amount per recipient household. Note that neither the average loan amount nor the number of loans to be dispensed can be known with certainty in advance, since loan amounts will depend on the characteristics of borrowers and the types of dwellings they can afford to acquire.

(3) Dispense half the estimated number of loans available across cells according to the proportionate allocation scheme specified by the user. To illustrate, suppose only two cells in the household classification matrix are eligible for loans, with each expected to receive half of the available loans. The model dispenses one fourth of the estimated number of loans available to each of these two cells, holding the remaining loans in reserve for the moment.

(4) Simulate tenure and dwelling status transitions resulting from the loans dispensed.
This step must be performed for each cell receiving loans. If the number of loans available to a particular cell is equal to one tenth of the number of households in that cell, then one tenth of the households are assumed to receive loans. Based on the income available for housing investment for households in the cell, and on the maximum level of savings/informal finance assumed to accompany the loan program, the model calculates the maximum affordable loan and maximum dwelling value under the terms of the financing program. Households that can afford to meet program requirements without the maximum level of savings/informal financing are assumed to mobilize smaller downpayments. Recipient households are then shifted into the highest tenure/dwelling status category possible, given their maximum affordable dwelling value and any restrictions built into the loan program. Note that the model has already confirmed that all eligible households can afford to meet minimum program requirements.

(5) Recalculate the average loan amount per recipient household. Based on the proportionate allocation of loans among eligible cells, the model now has the data necessary to calculate an actual average loan amount equal to the total volume of loans dispensed in step number 4

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1. Equity from a previous dwelling is estimated as the entry cost of the dwelling status category.

divided by the number of loans. This new average loan amount is now used to determine how many more loans can be dispensed from the total pool of funds remaining.

(6) Dispense the remaining loans among cells and simulate tenure and dwelling status transitions.

Provision of Infrastructure

Policies of this kind involve government provision of adequate infrastructure services to areas lacking such services. To participate, a household must pay a fixed portion of the cost of the infrastructure provided, and all recipients are assumed to shift to an "adequate infrastructure" dwelling status. In addition, some recipients will presumably be prompted to raise sufficient funds to achieve meaningful improvements in dwelling quality as well, thereby shifting from semi-permanent to permanent dwelling units.

Infrastructure programs may be accompanied by earmarked pools of formal financing. If earmarked loans accompany the provision of infrastructure services, all participants are assumed to receive loans. If formal financing is not explicitly provided in conjunction with the infrastructure program, recipients are assumed to finance infrastructure improvements as well as any accompanying structural improvements entirely out of savings/informal finance.

The specification of this type of policy assumes that all participants begin with inadequate infrastructure and end up with adequate infrastructure. Beyond these two built-in assumptions, the user controls the allocation of assistance, and the terms of any earmarked financing available.

Table 3.2 presents the program terms a user must specify each year for an infrastructure program, along with 1983 values used for our Sri Lanka simulation.[1] The cost of a structural upgrade refers

TABLE 3.2

TERMS FOR INFRASTRUCTURE POLICY: 1983

Number of Units	21,000
Required Household Contribution	Rs.3,000
Government Grant	Rs.1,450
Cost of Structural Upgrade	Rs.5,000
Share of Participants Achieving Structural Upgrade After 1 Year	0.20
2 Years	0.10
3 Years	0.10
4 Years	0.10
5 Years	0.10
Maximum Savings/Informal Mobilization	0.75

to the additional costs participants must incur to convert semi-permanent dwelling units to permanent status. Some participants will be able to afford such upgrades immediately. Of those that cannot, the user specifies the share expected to make this transition in each of the subsequent five years. As for formal finance policies, infrastructure program terms must be accompanied by the expected allocation of assistance among cells in the household classification matrix.

Based on the user's specification of the allocation and effectiveness of infrastructure assistance, the model dispenses the available funds by providing adequate infrastructure to eligible households, and records the resulting changes in dwelling status. No

1. If earmarked loans accompanied this program, a user would also specify the loan terms as discussed in the section on formal finance.

changes in tenure status are assumed to occur. The basic solution process consists of only four steps:

(1) Confirm that all eligible households can actually afford to participate in the program.
In other words, if no earmarked financing is available, make sure that households in each eligible cell can raise sufficient funds from savings/informal financing to pay their required share of infrastructure costs. If earmarked financing is available, ensure that all eligible household groups can meet both the downpayment and the monthly servicing costs of the smallest possible loan. If some eligible cells cannot afford to participate, reallocate the available units of assistance proportionately among the remaining cells in the household classification matrix.

(2) Allocate assistance to the total number of possible participants, according to the proportions specified by the user. Specifically, for every cell designated to receive assistance, calculate the proportion of households in that cell that will receive adequate infrastructure. If earmarked financing is also available, use the allocation procedures outlined in the section on formal financing policies.

(3) Simulate dwelling status transitions resulting from the allocation of infrastructure assistance.
By definition, all recipients shift to an adequate infrastructure dwelling status. In addition, however, some recipients also amass the funds necessary to upgrade the structure of their dwellings, thereby shifting to a "higher" dwelling status.

(4) Record the number of households scheduled to achieve additional transitions in each of the five next years. The number of scheduled upgrades for each subsequent year is based on the number of participants remaining in semi-permanent structures, and on the user's expected upgrade rates. In subsequent simulation years, the model completes the scheduled transitions, and records the incremental resource requirements, all of which are allocated to savings/informal financing.

Sites and Services or Direct Construction

This type of policy encompasses a fairly wide range of programs, all of which include the sale of fully-serviced sites to participating households. Under a sites and services program, a partial structure may also be provided, or only a foundation and "wet core" for subsequent construction. Under a direct construction program, a fully

adequate dwelling unit is completely constructed before a household purchases the site. Thus, fully adequate infrastructure is always provided automatically, while the amount of incremental investment required to achieve full structural adequacy differs between program variants. For any particular sites and services or direct construction program, the cost to participants is assumed to be fixed. As for infrastructure policies, earmarked financing may accompany a sites and services or direct construction program. Otherwise, households' investment in their new properties are assumed to be obtained entirely from savings/informal financing. Because several variants of this policy type are possible, users can call for the implementation of more than one sites and services or direct construction program at the same time. Thus, a particular year's housing intervention strategy might include a direct construction program targetted to one income group as well as a sites and services program targetted to lower income households.

Table 3.3 presents the program terms that a user must specify, along with 1983 values used for our Sri Lanka simulations.

As in the previously described policies, the model allocates the available sites among eligible households according to the user's specifications, and records the resulting tenure and dwelling status changes. The solution process consists of four basic steps:

(1) Confirm that all households designated as eligible to participate in the program can indeed afford to participate. If some eligible cells cannot satisfy the affordability requirement, the model reallocates the available units of assistance among the remaining eligible cells in the household classification matrix.

TABLE 3.3

TERMS FOR SITES AND SERVICES POLICY: 1983

Number of Units	10,000
Required Household Contribution	Rs.21,800
Government Grant	0
Target Dwelling Status	1
Target Tenure	1
Cost of Structural Upgrade	0
Share of Participants Achieving Structural Upgrade After 1 Year	0
2 Years	0
3 Years	0
4 Years	0
5 Years	0
Maximum Savings/Informal Mobilization	0.50
Aggregate Amount of Loans	Rs.98,100,000
Interest Rate	10%
Market Interest Rate	17%
Repayment Period	15
Estimated Average Loan Amount	Rs.9,810
Maximum Loan Amount	Rs.10,900
Maximum Loan to Value Ratio	0.50

(2) Allocate the available sites among participating households, based on the user-specified allocation scheme.
If earmarked financing is available, allocate loans to eligible participants in the sites and services or direct construction program, using the procedures outlined in the discussion of formal financing policies.

(3) Simulate dwelling status transitions resulting from participation in the program.
All participants will, by definition, shift to units offering fully adequate infrastructure. Some program variants may also provide fully adequate structures to all participants. Alternatively, structures may be upgradeable or even inadequate, with a designated level of investment necessary to achieve full structural adequacy.

(4) In subsequent years' solutions, shift a fraction of the original sites and services program participants to fully adequate dwelling status, based on the rates provided by the user.

Simulating a Comprehensive Housing Assistance Strategy

Given the capability to implement various types of housing policy, how does the model simulate a comprehensive strategy for deploying housing resources? In this section, we discuss the types of strategies users might specify, and how the model reports policy results.

As a general rule, policies should be viewed as supplementing natural transitions. In other words, the "No Government" components of the model are always solved first, and then the incremental impacts of public policies are simulated. Policies specified by the user are implemented one-by-one in each simulation year. The model keeps track of the number of households in each cell that have received each form of assistance, including formal financing. In addition, the model records the number of households achieving fully acceptable housing through participation in each policy. This includes all participants who shift from unacceptable dwellings and/or infrastructure to fully acceptable units.

The model's annual solution algorithm will make it possible to specify an almost infinite variety of policy combinations. To illustrate, a user might define a housing assistance strategy calling for major structural reforms in the financial system. During the initial years, when these structural reforms would be taking place, reliance might be placed on direct public subsidy mechanisms, such as infrastructure upgrading or sites and services programs. Gradually, as the capacity of the financial system expanded, emphasis might shift toward programs relying on private sector formal financing for all but

the lowest income groups. Another example of the model's potential flexibility, mentioned earlier, could involve the specification of several formal financing pools or several sites and services programs, each targeted at a particular group of households.

For any package of housing assistance programs, the model generates annual tables showing of the number of households participating and the number of households achieving improvements in dwelling status. An example is provided in Table 3.4. These estimates are provided for each program and for the combination of programs in operation in any given year. In addition, counts of households achieving upgrades due to past program participation are also provided annually as shown in Table 3.5. In addition to these annual tables, the model produces a cumulative summary of total year-by-year participation in government programs, as illustrated in Table 3.6. Finally, as indicated earlier, all output tables produced for "No Government" solutions are also generated for policy simulations. Therefore, for any housing assistance strategy specified, the model reports total resource requirements, the relative contribution of formal financing, government subsidies, and savings/informal financing to housing sector resources, and year-end distributions of households by tenure and dwelling status for each income quintile.

Table 3.4

SRI LANKA -- INFRASTRUCTURE POLICY

Improved Infrastruct -- 1988

Income		Households Participating number	Households Participating percent	Households Achieving Acceptable Dws number	Households Achieving Acceptable Dws percent
low	1	1050	5.00	703	3.72
	2	2100	10.00	1407	7.44
	3	3150	15.00	2110	11.15
	4	3150	15.00	3150	16.65
	5	3150	15.00	3150	16.65
	6	3150	15.00	3150	16.65
	7	2100	10.00	2100	11.10
	8	2100	10.00	2100	11.10
	9	1050	5.00	1050	5.55
high	10	0	0.00	0	0.00
Total		21000	100.00	18921	100.00

Table 3.5

SRI LANKA -- INFRASTRUCTURE POLICY

SCHEDULED UPGRADES -- 1988
(Households achieving fully acceptable units due to past program participation)

Income		Number	Percent
low	1	173	16.67
	2	346	33.33
	3	520	50.00
	4	0	0.00
	5	0	0.00
	6	0	0.00
	7	0	0.00
	8	0	0.00
	9	0	0.00
high	10	0	0.00
total		1039	100.00

Table 3.6

SRI LANKA -- INFRASTRUCTURE POLICY

ANNUAL COUNT OF POLICY PARTICIPANTS BY INCOME

	INCOME										
	low 1	2	3	4	5	6	7	8	9	high 10	total
1984											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00
1985											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00
1986											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00
1987											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00
1988											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00
1989											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00
1990											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00
1991											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00
1992											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00
1993											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00

4. MODEL SPECIFICATIONS AND OPERATIONS

The Housing Quality Model is written in the Pascal computer programming language.[1] The compiled -- or object -- code, runs in any MS DOS environment, including Wang and IBM, that provides at least 128K bytes of memory. This object code is stored in an MS DOS file called HQSMODEL.COM, and the model is invoked by simply entering the command HQSMODEL in an MS DOS environment.

Once invoked, the Model prompts a user interactively for some input data. Specifically, the user enters the following information from the terminal:

- Simulation title;
- Number of years to be simulated;
- Type of simulation -- "No Government" or Policy;
- Revisions to initial entry cost estimates;
- Policies to be implemented, if any;
- Locations of major input data files; and
- Output tables to be printed or suppressed.

Most of the Model's input data are read from diskette files, (in ASCII text format) which the user must create before invoking the Model. Data items do not have to appear in any particular columns of the input files; only the order of the items is important. The following input data files are required for successful implementation of the Model:

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1. The program was developed using the TURBO Pascal system as implemented for MS-DOS operating systems. TURBO Pascal is distributed by Borland International, Inc.

- Base year ›ut data;
- Annual transitions data for each year in the simulation period;
- Policy terms for each policy in each year that the policy is to be implemented;
- Allocation assumptions for each policy in each year that the policy is to be implemented.

Annotated examples of these files are provided in Appendix E.

To create or modify these files, the user can invoke a "preprocessor" program -- stored as DATA.COM on the model diskette -- by entering the command DATA from an MS DOS environment. This program has been designed to minimize the effort required to create input files, and uses a series of menus, prompts and displays to assist the user. (A sample terminal session with DATA is included in Appendix E). The program also checks input for errors, generates allocation files automatically (if desired) inserts zeros as default entries, facilitates printing of revised files, and enforces systematic file-naming conventions for the input files it generates. Use of the preprocessor is not required however. Alternatively, the user can create or modify input files with any standard text editor.

In the course of a multi-year simulation, the Model creates several output data files that contain annual results for the cumulative output tables. All tables are shown on the computer screen and the user has the option of printing each of them. After these tables are generated, however, the disk files created by the Model are erased. Therefore, the only record of simulation results is contained in the year-to-year and cumulative tables that a user instructs the Model to print during the course of a simulation.

Currently, the Model is set up to operate on a single-drive micro-computer system. In other words, both the object code files a the input and output data files are stored on a single diskette. On two-drive system, however, it is straightforward to store the object code file on one diskette and all input and output data files on a second diskette. This would allow more storage space for alternative data files, as well as reducing a user's anxiety about erasing the object code file by accident.

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ANNEX A
Developing Input Data for Sri Lanka

This Annex discusses the derivation of some of the data used in the Housing Quality Model for Sri Lanka. It is limited, however, to those inputs not developed as part of the application of the housing needs methodology to the country.[1] Among the inputs developed in the housing needs application are those on trends in population and households, macro-economic conditions, average household income by sector as well as the distribution of household income, expenditures by households on housing investment, and total expected investment in housing over the 20-year plan period.

Most of the discussion in this Annex is devoted to describing the derivation of the classification of dwellings in the base year (1983) into six mutually exclusive groups, on the basis whether the unit is rated as acceptable, upgradable, or non upgradable, and infrastructure services are rated as acceptable or not acceptable. Other topics covered are the estimation of the rate at which units shift among these statuses over time, the cost per unit of reaching various dwelling quality standards, the aggregate volume of formal financing available in 1983 outside of government housing programs.

Income, Tenure, and Housing Quality

Data Sources and Definitions. The data used in this analysis were obtained from the third and fourth rounds of the Labour Force and Socio-Economic Survey of 1980/81, conducted by the Department of Census and

1. D. Manson and R. Struyk, Housing's Needs and Investment in Sri Lanka, 1983-2003, (Washington, D.C.: The Urban Institute, 1984).

Statistics of Sri Lanka. Data on tenure, income, housing expense, unit type and infrastructure were extracted for each household in the urban and rural sectors. A total of 4,655 observations were obtained from the data tape - 1,015 from the urban sector, 3,640 from the rural sector. Forty-seven households were later eliminated due to insufficient tenure information, resulting in a base of 1,001 observations for the urban sector and 3,607 for the rural sector. The weights provided on the tape were used in obtaining the final distribution of households.

For each income decile in each of the two sectors, the households are defined according to the following categories:

- tenure -- owner, unit renter, room renter
- infrastructure -- pass, fail
- structure type -- permanent, semi-permanent, improvised

These three characteristics yield 18 possible permutations -- (three types of tenure) x (two possible infrastructure labels) x (three structure types) = 18. The distribution of households across these 18 cells sums to 100 percent within each of the twenty income decile-sector categories. In assigning each household to the appropriate category, the following definitions and procedures were followed.

Income for each household is defined in accordance with the Department of Census and Statistics of Sri Lanka.[1] It is the sum of monetary as well as non-monetary income. The monetary income includes:

- wages and salaries
- profit from agriculture
- profit from other businesses
- rents, dividends, etc.
- pensions, remittances, etc.
- other periodic cash receipts.

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1. For more detail, see pp. 2, 3, 11, 13 of Labour Force and Socio-Economic Survey 1980/81 Sri Lanka Household and Expenditure.

Non-monetary income, estimated at the prevailing market prices, includes:

- goods and services provided free by the employer or received free from other sources, such as food, clothing, housing, and medical services.
- the value of home produce consumed by the household
- the estimated net rental value of owner occupied housing.

"Net rental value" is computed for owner-occupied units as rental value less the cost of maintenance and property tax payments expenditure.

After income is defined, all households are first weighted, sorted by income and then assigned to income deciles. This is done separately for urban and for rural households.

Tenure for owner occupied units are simply classed as "owner." While the model can accommodate "squatters" as well as secure owners, the distinction is not made here because of the lack of data on the incidence of squatting and the strong legal protections afforded to squatters in Sri Lanka after they have been in a location for a short period. Those who specified "rented" or "rent free" are assigned a tenure of "unit renter" if they do not share their unit with other households. If renters do share their living space with another household, however, the household is assigned "room renter" status. Households failing to specify tenure as owner or renter were deleted from the analysis. These households formed less than one percent of the unweighted sample.

As to infrastructure classes, toilet facilities as well as the source and proximity of drinking water determine whether a household passes or fails the infrastructure standard. A pass is needed for both

facilities in order to pass overall. The standards for these facilities differ by sector.

Possible responses for toilet facilities include:

- o flush toilet
- o water seal
- o bucket system
- o cess pit
- o none

Only "flush toilet" or "water seal" are acceptable facilities for urban dwellers. In rural areas, some cess pits are also acceptable, but many pits are of low quality and unsanitary. Allowing all households with cess pits to pass would mean that 72.2 percent of the rural households would be determined as having acceptable toilet facilities. It is our rough judgment that only half of the units with cess pits would pass a reasonable standard of acceptability. We assume that fewer than 50 percent of the units with pits should pass in the lower income deciles, and more than 50 percent of the units with pit latrines should pass in the higher income deciles. We arbitrarily set the passing rate at 25 percent for the (lowest) income decile and at 75 percent for the tenth decile. Since the proportion of households with cess pit facilities is nearly the same across income deciles, we constructed a linear formula which overall passes about 50 percent of the units, while allowing variation in the pass rate across income deciles. The formula allows an increase of 5.55 percent with each decile; the pass rates of cess pits are shown in Exhibit 1.[1]

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1. The formula is Pass rate = $\frac{(\text{decile} - 1/2) + 4}{18}$.

Exhibit 1
Proportion of Cess Pits Passing Toilet Acceptability Test in Rural Sector

Income Decile	% with Cess Pits	Cess Pit[1] Pass Rate
1	9.5	25.0%
2	11.3	30.6%
3	10.5	36.1%
4	10.0	41.7%
5	11.0	47.2%
6	10.9	52.8%
7	10.2	58.3%
8	10.0	63.9%
9	9.0	69.4%
10	7.7	75.0%

The water acceptability standard in the urban sector is that units pass only if they have piped water, either inside or outside of the unit. In the rural sector, protected well water within 100 yards from the unit is also acceptable.

Although the Socio-Economic Survey does not differentiate between protected and unprotected wells, another source, the Census of Population and Housing 1981, does provide some information. According to these data,[1] 68.8 percent of all wells in the rural sector are protected wells. This proportion is applied to the number of households in each decile that have a well as their main source of drinking water. The proportion of households of a given tenure group that pass the drinking water standard in one of the rural deciles is, then, the number of units with piped water plus 68.8 percent of those with a well

1. Table 19, Housing Tables, Census of Population and Housing, Sri Lanka, 1981.

within 100 yards, divided by the total number of units for that tenure group of that decile.

Computing the overall pass rate for the urban sector involves summing the units which pass both the drinking water and the toilet acceptability criteria and dividing by the total number of units. This is done for each tenure group in every income decile.

The procedure for obtaining the overall pass rate for each of these groups in the rural sector combines the application of the pit latrine pass rate and the well pass rate. From the data tape we produce tables of toilet facilities cross-tabulated with source of drinking water for each tenure group and income decile. Those responses which are definitely "pass" responses are aggregated for the table, as are those responses which definitely fail. The "cess pit" and the "well within 100 yards" are left as separate categories. The table for owner occupied units in the third income decile is reproduced below, to illustrate the procedure for obtaining the overall pass rate. The proportion of cess pits allowed to "pass" in the third income decile was set at 36.1 percent (See Exhibit 1). The proportion of wells which are protected is 68.8 percent. The estimated number of units which pass both the toilet and drinking water acceptability standards is, then 1642 + (.688) x 10453 + (.361) x 1233 + (.688) x (.361) x 77,341 = 28,487.8. The overall infrastructure pass rate is therefore 28,488 divided by the total number of units which are owner occupied in the third income decile. 28,488 - 190,969 = 14.92 percent.

Because the Socio-Economic Survey does not contain information on dwelling unit quality, the distribution of dwelling units among

Exhibit 2
Identifying Infrastructure Acceptability
(rural homeowners in third income decile)

Toilet Facilities	Water Facilities: Pass	Close Well	Fail
Pass	1,642	10,453	5,494
Cess Pit	1,233	77,341	19,710
Fail	3,555	47,466	24,075
		Total =	190,969

structure types utilizes data from Sri Lanka's Census of Population and Housing, 1981. Counts of housing units defined as "permanent, "semi-permanent" or "improvised" (based on the materials with which they are constructed) are cross-tabulated by main source of drinking water in Table 19 of the Census Report[1], and by toilet facility in Table 21. The tables present figures for urban and rural areas separately.

The distribution of structure type for urban units passing the drinking water standard involves summing the units with piped water for each structure type, then expressing these sums as percentages of all units with piped water.

A portion of table 19 is reproduced as Exhibit 3 to help illustrate this procedure. The total number of permanent structures with piped water is 113,197 + 64,160 = 177,357. Similarly, for semi-permanent units, the number is 9281 + 36,597 = 45,878; and the figure for improvised structures is 1772 + 12,020 = 13,792. The distribution by

1. Census of Population and Housing Sri Lanka - 1981 Housing Tables, Department of Census and Statistics Ministry of Plan Implementation, June 1982, pp. 66-68.

Exhibit 3
Main Source of Drinking Water

Sector and type of Housing Units	Total	Piped Water	
		Within Premises	Outside Premises
Urban	509459	124247	112779
Permanent	346623	113197	64160
Semi-permanent	124013	9281	36597
Improvised	38820	1772	12020

Exhibit 4
Urban Households Passing the
Drinking Water Standard

	With Piped Water	Percent Distribution
Permanent	177,357	74.8%
Semi-permanent	45,878	19.4%
Improvised	13,792	5.8%
Total	237,027	100.0%

structure type for housing units with piped water is then obtained by dividing each of these numbers by the total number of units which have piped water (177,357/237,027=.748). This yields the percentages shown in Exhibit 4.

The distribution in Exhibit 4 is a conditional distribution; given that we know a household in the urban sector has piped water, there is a 74.8 percent chance that the unit is a permanent structure.

The procedure for the rural sector is similar, though not so straightforward. In this sector protected wells within 100 yards are acceptable. Since the Census does not distinguish distance to wells, we use data from the Socio-Economic Survey to obtain the proportion of households with wells which were within 100 yards. This proportion, 71.8 percent, is applied to the number of households using protected wells for each structure type. Again, the number of units passing is summed by structure type, and then each sum is divided by the total number of passing units in the rural sector.

Distributions are obtained in a similar way for those units passing the toilet acceptability standard. In the urban sector, flush toilets or water seal facilities are acceptable. In the rural sector, since it had been decided to allow only 50 percent of the units with cess pits to pass, the number of such units in each structure type category is reduced by 50 percent. The distributions of structure type for households passing the toilet standard are presented in Exhibit 5.

The distribution of structure types for units passing both acceptability standards is not obtainable from published census tables;

Exhibit 5
Distribution of Units Passing Toilet Standard[1]

Structure	Urban	Rural
Permanent	.8836	.5735
Semi-permanent	.1046	.4068
Improvised	.0118	.0198

therefore the distribution of the more restrictive of the two standards is chosen. In most income deciles for both sectors, the proportions of units passing the toilet standard are lower than the proportions passing the water standard. The distribution of structure type for those units which pass the toilet standard is therefore used as the distribution of structure type for those units passing the overall infrastructure test. The distribution of structure type for all housing units is also computed for each sector from the census tables. The results are presented in Exhibit 6.

Final Computations. From the data tape for the Socio-Economic Survey, we obtain for each of the 20 sector-income divisions:

1. tenure distribution
2. proportion passing overall standard, given tenure.

From the census tables we have, by sector:

1. distribution of structure type, given a "pass" on toilet facilities
2. distribution of structure type, given a "pass" on water facilities
3. distribution of structure type overall.

1. These distributions were adopted for the "overall" pass distribution. From Table 21, Census of Population and Housing 1981, Republic of Sri Lanka.

Exhibit 6
Distribution of Structure Type By Sector[1]

Structure	Urban	Rural
Permanent	.6804	.3725
Semi-permanent	.2434	.5606
Improvised	.0762	.0669

For simplicity and lack of better data, the conditional distributions involving structure and infrastructure acceptability are applied to all income deciles and tenure groups (see Exhibit 5). For example, the census table shows that of the units in the urban sector which pass the toilet acceptability criteria, 88 percent are permanent structures. We assume that this proportion applies regardless of tenure or income. The simple distribution of structure types for both sectors are also applied to each decile and tenure group (see Exhibit 6).

To illustrate how the final distribution is obtained in each of the 20 income-sector divisions, we present a particular example for one tenure group with one structure type -- owners with permanent structures in the second (lowest) rural income decile. The distribution across the other cells utilizes the same procedure.

From the data tape, we know that 86.91 percent of the households in this decile are owners. We also know that 13.73 percent of the owners in this decile have passed the overall infrastructure standard. The census tables show that of the rural units passing the toilet standard, 57.35 percent are permanent structures, 40.68 percent are semi-

1. From Table 21, Census of Population and Housing 1981, Republic of Sri Lanka.

permanent, and 1.98 percent are improvised structures (see Exhibit 5). We have chosen to use the distribution of structure type for those passing the toilet acceptability criterion for those passing the overall infrastructure standard. Thus, we estimate that 57.35 percent of the 13.73 percent of owner-occupied units are units which pass the overall infrastructure standard, are owner occupied, and are of permanent construction. Since 86.91 percent of the households in this decile are owner occupants, 6.8 percent (.5735 X .1373 X .8691 = .0684) of all the units are owner-occupied, permanent structures which have passed the overall infrastructure test.

We now have to compute the percentage of all units that are owner-occupied and made of permanent materials so we can determine the portion of such units failing the infrastructure standard. Data from the census tables yield an estimate of the distribution of structure types in the rural sector (see Exhibit 6). About 37.2 percent of the structures in this decile are permanent; 56.1 percent are semi-permanent, and 6.7 percent are improvised. Since we apply this structure distribution regardless of tenure, an estimated 32.3 percent (.372 X .8691 = .3233) of the units are owner-occupied and of permanent construction. We have already estimated that 6.8 percent of the units were owner-occupied permanent structures passing the infrastructure test. Thus 25.5 percent (32.3% - 6.8% = 25.5%) of the housing units are owner-occupied permanent structures which do not pass the overall acceptability standard for infrastructure. Exhibit 7 presents the final quality distributions for 1981. These are assumed not to have changed between 1981 and 1983.

EXHIBIT 7

FINAL DISTRIBUTION OF HOUSEHOLDS

RURAL

Decile 1

STRUCTURE	INFRASTRUCTURE	TENURE Owner	Unit Renter	Room Renter	Owner	Unit Renter	Room Renter
Permanent	Pass	5.043	3.089	6.473	5.732	0.876	0.159
	Fail	25.175	20.007	6.251	27.363	2.391	0.728
Semi-permanent	Pass	0.597	0.306	0.706	4.066	0.621	0.113
	Fail	10.213	7.897	4.531	45.742	4.295	1.222
Improvised	Pass	0.067	0.041	0.086	0.198	0.030	0.005
	Fail	3.317	2.545	1.563	5.746	0.556	0.154
Total		44.412	33.946	21.640	88.848	8.770	2.380

Decile 2

STRUCTURE	INFRASTRUCTURE	Owner	Unit Renter	Room Renter	Owner	Unit Renter	Room Renter
Permanent	Pass	5.367	1.494	3.896	6.843	1.015	0.236
	Fail	23.656	16.618	15.007	25.530	2.953	0.673
Semi-permanent	Pass	0.635	0.177	0.461	4.854	0.720	0.167
	Fail	9.747	7.018	6.301	43.867	5.251	1.201
Improvised	Pass	0.072	0.020	0.052	0.236	0.035	0.008
	Fail	3.179	2.233	2.065	5.578	0.677	0.155
Total		42.657	29.559	27.782	86.908	10.650	2.440

Decile 3

STRUCTURE	INFRASTRUCTURE	Owner	Unit Renter	Room Renter	Owner	Unit Renter	Room Renter
Permanent	Pass	9.431	8.837	5.180	7.226	1.890	0.239
	Fail	25.300	13.371	5.925	24.231	3.333	0.331
Semi-permanent	Pass	1.116	1.046	0.613	5.126	1.340	0.169
	Fail	11.306	6.899	3.360	42.216	6.519	0.688
Improvised	Pass	0.126	0.118	0.069	0.249	0.065	0.008
	Fail	3.764	2.369	1.175	5.400	0.873	0.094
Total		51.046	32.640	16.322	84.448	14.020	1.530

Decile 4

STRUCTURE	INFRASTRUCTURE	Owner	Unit Renter	Room Renter	Owner	Unit Renter	Room Renter
Permanent	Pass	9.642	5.591	2.597	7.973	1.499	0.609
	Fail	28.666	12.910	8.426	24.679	2.211	0.277
Semi-permanent	Pass	1.141	0.662	0.307	5.656	1.064	0.432
	Fail	12.634	5.957	3.632	43.466	4.520	0.902
Improvised	Pass	0.129	0.075	0.035	0.275	0.052	0.021
	Fail	4.184	1.997	1.206	5.589	0.615	0.136
Total		56.596	27.192	16.200	87.658	9.960	2.380

EXHIBIT 7
(Continued)

Decile 5

STRUCTURE	INFRASTRUCTURE	Owner	Unit Renter	Room Renter	Owner	Unit Renter	Room Renter
Permanent	Pass	9.623	8.804	4.615	11.705	1.622	0.305
	Fail	23.740	14.247	7.009	21.078	1.754	0.585
Semi-permanent	Pass	1.139	1.042	0.546	8.303	1.293	0.216
	Fail	10.796	7.204	3.612	41.035	4.089	1.123
Improvised	Pass	0.129	0.118	0.062	0.404	0.063	0.011
	Fail	3.608	2.464	1.240	5.484	0.579	0.149
Total		49.035	33.879	17.084			

Decile 6

STRUCTURE	INFRASTRUCTURE	Owner	Unit Renter	Room Renter	Owner	Unit Renter	Room Renter
Permanent	Pass	10.335	11.090	5.392	13.384	1.070	0.383
	Fail	24.190	15.210	1.815	20.826	1.455	0.131
Semi-permanent	Pass	1.223	1.313	0.638	9.493	0.759	0.272
	Fail	11.127	8.096	1.940	41.991	3.042	0.502
Improvised	Pass	0.138	0.148	0.072	0.462	0.037	0.013
	Fail	3.729	2.797	0.735	5.682	0.417	0.079
Total		50.742	38.655	10.592	91.838	6.780	1.380

Decile 7

STRUCTURE	INFRASTRUCTURE	Owner	Unit Renter	Room Renter	Owner	Unit Renter	Room Renter
Permanent	Pass	11.595	13.183	1.306	14.763	2.034	0.151
	Fail	31.621	6.558	3.775	18.682	1.572	0.047
Semi-permanent	Pass	1.373	1.561	0.155	10.472	1.443	0.107
	Fail	14.068	5.502	1.663	39.863	3.984	0.190
Improvised	Pass	0.155	0.176	0.017	0.510	0.070	0.005
	Fail	4.685	2.035	0.552	5.497	0.577	0.036
Total		63.510	29.014	7.467	89.788	9.680	0.530

Decile 8

STRUCTURE	INFRASTRUCTURE	Owner	Unit Renter	Room Renter	Owner	Unit Renter	Room Renter
Permanent	Pass	17.956	14.693	0.997	17.891	1.106	0.285
	Fail	23.205	10.421	0.766	16.166	1.539	0.263
Semi-permanent	Pass	2.126	1.739	0.118	12.690	0.784	0.202
	Fail	12.599	7.245	0.513	38.564	3.196	0.622
Improvised	Pass	0.240	0.196	0.013	0.618	0.035	0.010
	Fail	4.376	2.617	0.184	5.499	0.437	0.069
Total		60.496	36.912	2.591	91.428	7.100	1.470

EXHIBIT 7
(Continued)

Decile 9

STRUCTURE	INFRASTRUCTURE	Owner	Unit Renter	Room Renter	Owner	Unit Renter	Room Renter
Permanent	Pass	29.461	12.903	3.915	20.139	0.920	0.110
	Fail	20.364	0.374	1.021	14.484	1.419	0.177
Semi-permanent	Pass	3.488	1.527	0.463	14.285	0.652	0.078
	Fail	14.337	3.222	1.362	37.821	2.868	0.354
Improvised	Pass	0.393	0.172	0.052	0.695	0.032	0.004
	Fail	5.187	1.315	0.500	5.523	0.388	0.048
Total		73.229	19.515	7.254	92.948	6.280	0.770

Decile 10

STRUCTURE	INFRASTRUCTURE	Owner	Unit Renter	Room Renter	Owner	Unit Renter	Room Renter
Permanent	Pass	54.289	6.053	0.000	25.560	1.956	0.085
	Fail	7.687	0.009	0.000	9.317	0.212	0.120
Semi-permanent	Pass	6.427	0.717	0.000	18.130	1.385	0.060
	Fail	15.745	1.452	0.000	34.358	1.875	0.245
Improvised	Pass	0.725	0.081	0.000	0.882	0.068	0.003
	Fail	6.216	0.598	0.000	5.381	0.322	0.034
Total		91.088	8.910	0.000	93.626	5.820	0.550

Dwelling Unit Costs

The model requires two types of cost information. First, it needs the "minimum cost" of a unit in each of the six dwelling quality categories. (Costs may differ between urban and rural areas.) Second, the model requires that the cost of units developed under government programs be specified. Derivation of these two sets of figures is now described.

Minimum costs. The rules for computing these costs are outlined in the tabulation shown below. Where the rule is "entry level," it refers to the value of units in this quality category occupied by households in the lowest income decile having a significant representation among all households with units in the quality class. "Government cost" refers to the cost experienced by the government as of 1983 in developing units meeting this standard; these figures are from the report on housing needs analysis (op. cit., pp. 50, A-4, 5).

DWELLING QUALITY STATUS			RULE	
			cost	
unit	**infrastructure**	**basis**	**urban**	**rural**
A	A	gov't cost	RS.29,000	RS.26,000
A	I	entry level	varies	
I,U	A	gov't cost	14,000	8,500
I,U	I	entry level	varies	
I,N	A	entry level	varies	
I,N	I	entry level	varies	

where A = acceptable, I = inadequate, U = upgradable, and N= not upgradable.

Government programs. Two types of government housing programs are included in these simulations for urban areas: a sites and services

program which follows the general description of the urban part of the Million Houses program, and an infrastructure upgrading program which simply embodies the large scale improvements in water and sanitation facilities which are underway through agencies other than NHDA.

Information on the sites and services program comes from the 1985 AID Project Memorandum (pp. 9-10), which indicates a unit cost of about Rs.20,000. To finance a unit, a Rs.10,000 loan will be available to the purchaser and the purchaser is expected to provide the rest of the funds from savings or informal borrowing. In 1983 prices, the unit cost is equivalent to Rs.18,180.

The very large on-going projects in the water supply and sanitation sector are described in the World Bank's 1984 sector report. From the figures provided in the report on individual projects, we allocated the projects between those serving urban and rural areas. A rough average cost figure was also computed as Rs.5,000 per unit for those obtaining adequate water supply and sanitary facilities. (We have assumed that all services provided meet or exceed the standards of adequacy mentioned in the previous section.) Although the projects listed in the sector report were almost all scheduled for completion by 1986, we have assumed that the projects are completed over the full decade of the 1980s, in light of the delays in implementation that are being experienced. For urban areas this implies about 35,000 units per year obtain adequate water and sanitation services over the decade. The substantial degree of uncertainty surrounding this figure is emphasized. It assumes that units obtaining adequate sanitation also have adequate water supply. Also, note that about 2.5 times this number of units is scheduled to

obtain improved water services over the period. The comparable figures for rural areas are 15,000 units per year and 2.1 more units obtaining improved water services than improved sanitation services.

Formal Housing Finance

To calibrate the "no government" version of the model one needs to have an estimate of the volume of formal housing finance in the system in the base year, in this case 1983. In 1983 the SMIB, a governmental parastatal was for all practical purposes the only source of formal financing not associated with a housing program being directly implemented by the government. The 1985 Project Memorandum reports that the number of loans made by the SMIB increased sharply from 700 to 3,000 between 1980 and 1984; in 1984 the amount of funds lent was equivalent to $6 million. For these calculations we have assumed that 2,500 loans were made in 1983, with a value of Rs. 125 million, or Rs. 50,000 average per loan.

As to the terms on which these loans are made, the following rules have been used. Maximum loan-to-value ratio is 0.7; interest rate is 16 percent; term is 15 years. There are no restrictions on who can borrow in terms of tenure or housing quality at the time the loan is applied for, but all units on which the SMIB makes mortgage loans must be owner-occupied and meet the unit and infrastructure service acceptability standards outline earlier. Those obtaining loans are assumed to be upper income households, i.e., in the sixth through 10th income deciles, with most borrowers concentrated in the highest two deciles.

Dwelling Transitions

One input into the model is the rate at which existing units shift between quality classes because of spontaneous (non government induced) investment by property owners. The model considers only net transitions from lower housing quality categories to higher categories. In Sri Lanka for unit quality this means from a unit made of less than permanent materials to one made of permanent materials, and for infrastructure it means a unit moving from lacking water and sanitation services consistent with the definition given earlier to having such services.

We have relied on the analysis by Gunatilleke (1985) of data from the 1971 and 1981 censuses to obtain the transition rates. Since the census data are for all units, including those whose improvement was due to government intervention, the rates calculated may be biased upwards. We believe that this bias will be small, however, because government housing programs were highly focused on the construction of new units. Improvement of water supply in rural areas may have been more affected but the major programs did not have much impact until after the time of the 1981 census.

In any event Exhibit 8 shows the rates calculated using the figures provided by Gunatilleke.[1] Interestingly, the rate of improvement in rural areas exceeds that in urban areas.

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1. See N. Gunatilleke, 1984.

New Rental Units

The model requires that the number of new rental units constructed each period be supplied as an exogenous data input. Sri Lanka has had tough rent control laws as well as laws limiting the number of rental units a household can own (rental housing cannot be owned and operated by businesses) since the mid-1970s. This has had the expected negative effect on the development of new rental properties. In urban areas there was actually a net decrease in the number of rental units by 14,000 between 1971 and 1981. In rural areas on the other hand, rental units increased by 55,300, presumably reflecting less stringent enforcement of the laws in the countryside. In calibrating the model we have assumed no new rental units are being built in urban areas and that in rural areas new rental units equivalent to about 2.8 percent of the base year rental stock are being built annually.

Exhibit 8
Rate at Which Substandard Units are Improved
to Meet Acceptability Criteria
(percent per year)

	Average Annual Percentage Change	
	Urban	Rural
Units to standard quality as percent of standard units in 1971	0.94	2.19
Units with standard infrastructure as percent of those with standard infrastructure:		
of permanent units [a]	0.94	2.19
of semi-permanent or permanent units	-	1.58

a. Assumes all permanent units added to stock (either by new construction or upgrading) and adequate infrastructure.

ANNEX B

HOUSEHOLDS' RESPONSE TO HOUSING OPPORTUNITIES

In order to implement the Housing Quality Model, we need estimates of how households respond when presented with housing opportunities. "Opportunities," in this context, include access to formal sector housing finance, as well as chances to participate in government housing assistance programs. The "response" of primary interest is a shift from substandard housing to acceptable housing. Conventional econometric estimates of the income and price elasticities of housing demand are not particularly helpful for this purpose because they are based on cross-sectional samples of households, some of which are confronted by housing opportunities and many of which are not. Hence, the estimated elasticities are, in effect, the weighted average of the actual behavior of households with no opportunity to improve their housing and households enjoying such opportunities.[1]

Knowing how households have responded when opportunities have been presented is essential. These response functions play an integral role in the Housing Quality Model, and are needed for a meaningful implementation of the model. For implementation of the model in different developing countries, it will be necessary to obtain country-specific values, probably on the basis of informed judgments from local experts. However, when discussing the magnitude of such responses with host country experts, our initial estimates will provide an invaluable point of departure.

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1. Mayo (1985) examines the economics of this proposition rigorously, treating the lack of opportunities in effect as market imperfections.

This section reviews studies we have been able to locate that document the degree to which households have improved the quality of their housing in response to various housing opportunities. Table B.1 lists the studies identified and summarizes the type of response documented in each. (Full references for these studies are provided in the bibliography for this report.) Six "opportunities" are listed as the headings of the first set of columns, while the second set of columns deals with two types of general market activity of particular interest: the rate of shifts between various tenure classes, and the extent of market-wide upgrading in either dwelling quality or infrastructure quality occurring over time.

The balance of this discussion summarizes the findings from these studies. It is organized by the type of opportunity or transition, beginning with access to obtaining mortgage loans from the formal financial sector.

Formal Housing Finance

Struyk-Turner provide the analysis most germane for the Housing Quality Simulation Model. This paper analyzes the relationship between the receipt of formal housing finance and the quality of housing occupied by homeowners in urban areas in Korea and the Philippines using a three-stage model. The first stage estimates the likelihood that a household will obtain formal housing finance (vs. informal or no financing) for the purchase of a home. The second stage estimates the size of the formal loan obtained, the size of the informal loan obtained for those obtaining informal financing (if any), and the value of the

Table B.1

Summary of Studies on Effects of Policy Interventions and Overall Market Activity on Housing Quality

Study[a]	Impacts on Housing Quality of: Formal Finance	Sites/ Services	Slum Upgrading	Infra-structure Only	Improved Security	Direct Construction	General Market Activity: Tenure Transition	Upgrading Over Time
1. Strassman-Cartagena				X				
2. Strassman-Lima and other places				X				X
3. Keare and Parris		X	X					
4. Bamberger et al.-Zambia		X						
5. Bamberger et al.-El Salvador		X						X
6. Mayo								X
7. Jimenez-Tondo			X					
8. Jimenez and Mayo					X			
9. Struyk and Lynn			X		X		X	
10. Struyk and Turner	X							X
11. Struyk and Wessel	X	X	X			X		
12. Gilbert							X	

a. Full citations for these studies are included in the references for this report.

unit purchased, using simultaneous techniques. The final stage estimates the ultimate impact on dwelling quality of the value of the unit -- which in turn depends on the size of the formal loan obtained and the likelihood of receiving such a loan. Of particular interest here is the fact that housing quality is defined discretely. Specifically, units are rated as passing dwelling quality, infrastructure quality, and crowding criteria, and each unit is then classified into one of eight mutually exclusive categories (on the basis of these three, pass-fail standards). The probability of a home purchaser living in each category of units is estimated as a function of a number of variables including income and the value of the unit purchased.

The Struyk-Turner analysis concludes by tracing the effects of obtaining formal financing to determine the impact on a home purchaser's chance of obtaining a dwelling that meets all three acceptability standards. For a moderate income first-time homebuyer, the probabilities of obtaining a fully acceptable unit are as follows:

type of finance	**Philippines**	**Korea**
formal	.73	.70
none	.42	.64

The difference between the no financing and the formal financing probabilities reflects the impact on identical households of obtaining housing finance. The large differences between the Philippines and Korea appear to be due to the very significant differences in the availability and allocation of formal housing finance in the two countries, as well as differences in the operation of their housing markets.

Assuming that the Philippines estimate will generally be more applicable, we conclude that on the order of 70 percent of the households obtaining formal financing will occupy a unit meeting the type of standards employed in the Struyk-Turner analysis. Moreover these households are about 70 percent more likely to achieve adequate housing than those not obtaining any financing [(.73-.42)/.42].[1]

The second study of particular interest is that by Struyk and Wessel, which examined the variation in housing quality with tenure, income, and participation in a variety of government housing programs in Davao and Manila in the Philippines. This study, like the Struyk-Turner analysis, employed explicit standards to rate units as passing or failing minimum quality criteria. Units were rated separately for dwelling and infrastructure quality, and different standards were used for Manila and for Davao, in light of differences in overall quality and in the type of infrastructure appropriate for urban areas with differing population densities.[2] The results show that receiving formal housing finance has a very significant effect on dwelling quality. Specifically, the results show that, compared to squatter households of

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1. Struyk-Turner also analyze the effect of obtaining financing from informal sources exclusive of intrafamily borrowing. In their analysis intrafamily borrowing is included in the "no financing" group and is treated as savings.

2. The standards used by Struyk-Wessel were the same as those used for Manila in the analysis by Struyk-Turner just described.

Three programs are included in this group, two operated by social security groups and one government housing program which constructed high quality units and then sold them to eligible households (at substantial subsidies). It should be noted that in all three the "sponsoring agency" exercised considerable control over dwelling standards; and this may have effected the quality of housing obtained. On the other hand, formal financial institutions in general will require that fairly stringent building standards be met before they will be willing to make a long-term loan on the structure.

equivalent incomes, those receiving formal finance are 50 percentage points more likely to pass the dwelling quality standard, 84 percentage points more likely to pass the infrastructure standard, and 77 percentage points more likely to pass both standards. Since a few percent of all squatter households pass the infrastructure standards and almost 40 percent pass the dwelling standards, these results indicate that those receiving formal finance are almost certain to occupy units meeting minimum quality standards.

Together these two studies indicate that households receiving formal housing finance have a very high probability of occupying units meeting or exceeding minimum physical standards.

Sites and Services Projects

The evidence available on housing quality improvements among participants in sites and services projects comes almost exclusively from a series of evaluations done by the World Bank of projects it financed. The most thorough of these is a longitudinal study by Bamberger and others of projects in El Salvador. Some supporting evidence is provided by a less rigorous study done of projects in Zambia.

The procedure employed by Bamberger and his colleagues in El Salvador was to use data from a baseline survey to estimate a hedonic function for properties in control neighborhoods. The hedonic function is a regression model explaining the variation in property values using physical attributes of the unit as explanatory variables. After the development of sites and services projects, properties in these projects, as well as those in the control neighborhoods were again

surveyed to record their physical attributes. These new attributes were then substituted into the original hedonic functions to obtain new estimates of the value of the properties. The price weights -- the estimated coefficients from the original hedonic function -- are held constant in this process. Thus, change in estimated property values can be interpreted as changes in the quantity of services provided by the unit. In other words, the effects of price inflation are factored out.

The results of this exercise for Santa Ana are summarized in Table B.2. The figures in the table highlight several points. First, if one looks at the row labeled "1980 score" for sites and services participants, it is clear that participants universally obtained the maximum score for infrastructure variables; this contrasts with lower scores in the base year (1976). Second, the overall change in the level of housing services enjoyed by participants is +57. This figure can be compared with the amount of change in the control areas, which averaged about half as much. This suggests that a good deal of housing improvement occured even in the absence of the sites and services projects, but that participants did enjoy a higher average level of improvement. Note that the biggest improvements experienced by <u>all</u> households were generally not to their structures, over which households have direct control, but to their infrastructure services. This indicates that in the colonias and tugurious, government agencies had been active over the period upgrading these services.

Bamberger and his colleagues undertook less rigorous monitoring of projects in Zambia The comparatively limited information available supports the pattern just described in which the largest gains to

Table B.2
CHANGES IN HOUSING QUALITY OF PROJECT PARTICIPANTS IN SANTA ANA
1976-1980 AND THEIR COMPARISON WITH CHANGES
IN CONTROL GROUP HOUSING

(In Percent)

	Roof	Walls	Floor	Water	Sanitation	Light	Weighted Average Change	Weighted Average 1980 Score
Weights*	3.875	.753	1.365	2.759	3.465	2.904		
Participants								
1976 Score	99	53	80	49	45	94		
1980 Score	100	99	48	100	100	100		240.0
Change	+1	+46	-32	+51	+55	+6	+57.2	
Control Group Change								
Mesones	+1	+4	-23	-3	+11	+3	+2.3	177.6
Colonias	+5	0	-16	+22	+24	+9	+27.9	207.1
Tugurios	+20	+20	+1	+17	+25	-2	+36.9	97.6

Note: Data on participants obtained from the percentage of families who previously lived in mesones. There is no statistically significant difference between their rate of change and that for all participants.

* Weights are derived from hedonic indices.

Source: Bamberger et al., Evaluation of Sites and Services: Evidence from El Salvador, Table 4.3.

participants were in infrastructure services rather than in dwelling services.[1] Keare and Parris provide an overview of these results in their publication.

Overall, it appears safe to conclude that sites and services projects can be counted upon to raise the infrastructure services of participants to the standard employed in the project. Progress on unit quality is much more uneven and depends on the length of time it is monitored after households occupy their sites, the depth of the subsidies involved, and the extent to which some structure is provided as part of the initial "package."[2]

Slum Upgrading

The most thorough analysis of the change in housing quality accompanying a slum upgrading project has been done by Jimenez for the Tondo project in Manila. This project involved establishing a regular street layout (reblocking), and the provision of water and sanitary services as well as streets, schools, clinics, and the like. Jimenez used the same type of "before and after" hedonic index approach as followed by Bamberger in analyzing sites and services projects. The second wave of data was gathered a few months after completion of the reblocking process.

Jimenez found that the quantity of services provided by dwellings in the target area increased by 30 to 44 percent over this short period. This translates into households investments amounting to

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1. See Table 10.7 thru 10.9 of the report on Zambia by Bamberger et al.

2. See Mayo (1985) for more on the sensitivity of outcome to design standards and subsidies.

about six months of income over the period. Interestingly, the majority of the increase in services is not accounted for by the provision of water and sanitation services. Hence, most of the improvement is attributable to dwelling improvements made in addition to the new infrastructure services, and paid for directly by the households involved.[1] This six-month income equivalent figure provides a rule-of-thumb estimate of the level of resources a household might be expected generate from savings and intra-family and informal borrowing when presented with such a housing opportunity. Additionally, the value seems broadly consistent with other scattered information on this point.[2,3]

A secondary effect of both sites and services and slum upgrading programs has been the development of rental housing -- rented

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1. The land and infrastructure investment were financed with market rate mortgage loans made by the government agency that developed the project.

2. Jimenez also estimated the elasticity of improvements with respect to income and obtained a value of 0.8. This value seems quite low until one realizes that all of those included in the sample were faced with the same opportunity. The average level of investment was high; so the variation in income was associated with relatively little of the total investment undertaken.

3. Struyk-Wessel in their analysis of the effect of slum upgrading programs in Manila on dwelling and infrastructure quality find somewhat different but not necessarily contradictory results. The sample data they employed were for a cross-sectional sample of dwellings designed to be representative of all units in Manila. Some of the sample neighborhoods included were sites of upgrading projects -- some finished, some just being begun, some in mid-stream. Respondents living in areas with such a program active or completed responded that they were "involved" with such a program. The analysis is unable to distinguish among the various degrees of progress. Hence, the results obtained are somewhat difficult to interpret. It is safe to conclude, however, that they do give the lower-bound estimates of the effects of the upgrading programs. Struyk-Wessel find that compared to squatter homeowners, those in upgrading project areas are 14 percentage points more likely to pass dwelling quality standards, 16 points more likely to pass infrastructure standards, and 18 points more likely to pass both standards.

rooms to be more accurate -- in the new or upgraded units.[1] Struyk and Lynn discuss a possible pattern in which low-income households invest heavily in their units to the point at which they have enough space of minimum quality that they can rent a room that is then instrumental in generating additional funds for investment in housing as well as other durables. This study found that two of five homeowners in the Tondo and similar neighborhoods in Manila have renters -- either paying rent or living in the unit "rent free," but probably is making in-kind contributions of some sort. There appear to be differences between the upgrading patterns of households who do and do not have renters present, but Struyk and Lynn are unable to provide a clear explanation for these differences.

This general pattern of a higher "equilibrium housing stock" for owners with rented rooms is supported by Hamer's analysis for Bogata (1985, Table 2). Bamberger also notes the importance of rental income in the Zambia sites and services project. He estimates that 23 percent of the income of households in the lowest income quintile comes from this source.[2]

The general point is that rented rooms can be a significant, and in some instances appropriate, element in the housing stock.[3]

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1. Alan Gilbert has noted the frequency of rented rooms in South America. He states, for example, that 55 percent of renters in Bogota share their unit with the owner of the property. Looking at the same situation from another perspective, Hamer (1981, pp. 136-7) report that one-quarter of homeowners in Bogota and 18 percent in Cali rent space within their homes to other families.

2. Keare and Parris review the findings from the World Bank's projects on this point.

3. Hamer (1985) reports that in Bogota 20 percent of households rent rooms or otherwise shared a unit with one or more families. He also makes a case as to why this is a reasonable solution for some of these households.

Upgrading and sites and services projects can generate substantial increments in the supply of small and below standard rental accommodations. An increased availability of such units may act as a substitute for increased development of squatter housing, and this trade-off needs to be considered in the Housing Quality Simulation Model.

Provision of Infrastructure

While urban households are able to upgrade their dwelling units through their own resources, they are sharply limited in the amount of infrastructure improvement they can accomplish without the public cooperation. At some point, the willingness of households to continue to improve their dwellings may be attenuated if complementary infrastructure improvements are not forthcoming. Following this logic, it has been commonly hypothesized that homeowners will respond to the provision of infrastructure services by upgrading their units. The response of homeowners in slum upgrading project areas offers a particular case of this more general phenomenon.

Paul Strassman has pursued this hypothesis further than other analysts. In his work on upgrading in Cartegena he studied the relationship between the presence of water and sanitation services and the extent of improvements undertaken. Improvements in this case were measured by a count of improvements made or the number of types of improvements made by the homeowner. In the analysis most closely directed at documenting this relationship, independent variables

measuring the presence of indoor piped water and connection to a public sewerage system were not statistically significant at reasonable levels. It is difficult to know how to interpret this finding, since Strassman's analysis does not sort out the timing of the infrastructure improvements and dwelling upgrading activities. Hence, the results could easily be confounded. For example, if high dwelling and water/sanitation service quality came as a package, then those households having high water/sanitation services would have little incentive to upgrade their units further.

In a similar analysis for Lima, Strassman does establish a significant relationship between the likelihood of a household undertaking a large number of improvements and the connection of the unit to a sewer system. Strassman also notes that others have obtained similar results in other countries.

Hamer (1985) provides additional information on the timing of housing investments relative to infrastructure improvements in Bogota. He reports that larger investments were made contemporaneously with infrastructure improvements, with many of the latter being accomplished through private initiative.

It is important to note that the value placed on obtaining particular levels of infrastructure services (e.g. an improved pit latrine vs. flush toilet) in each market is sensitive to the existing distribution of services. Where no sanitary services or bucket-type toilets are common, improved pit latrines will be valued and flush toilets even more so. Where pit latrines and public toilets are common, these may be little valued but flush toilets in the unit will command a

premium.[1] Both Cartegena and Lima have reasonably high levels of initial infrastructure services. Hence, the lack of significance of water on tap in an analysis involving all units is not surprising.

All of this taken together indicates that while upgrading of dwellings in response to the provision of infrastructure can be expected, the degree of upgrading and the response to the provision of particular improvements can be highly variable.[2] This variation will occur not only across countries, but among cities within the same country and even within the same city depending on the initial levels of such services in particular neighborhoods. This implies that these response parameters will probably have to be determined on a case-by-case basis.

Improved Tenure Security

Numerous policy analysts have observed that increasing the security of tenure for squatter households has a positive effect on the willingness of these households to invest in their units. Jimenez and Mayo have estimated the effect on property values of secure tenure in Manila and Davao. They find that secure tenure increases property values of owner occupied units by 23 percent in Manila and 58 percent in Davao on average, after controlling for other factors.[3]

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1. This pattern is evident when comparing similar hedonic indexes and willingness-to-pay analyses done for different countries and even cities within the same country. See, for example, Follain and Jimenez (1983).

2. Strassman notes this pattern at the conclusion of his paper on Lima.

3. The Manila figure is from a more recent paper by Friedman, Jimenez, and Mayo (1985).

There is also more direct evidence on the impact of secure tenure on housing investment. Struyk and Lynn, in an analysis of whether homeowners in Tondo and control neighborhoods had undertaken certain kinds of improvements, found that, holding other factors constant, the perception on the part of a household that its tenure security had increased over a two-year observation period increased the likelihood of undertaking improvements by between 12 and 27 percentage points.[1] In addition, the analysis by Struyk and Wessel of the likelihood of housing units in Manila and Davao passing minimum dwelling quality standards bears on this point. They found the following percentage point increases in the likelihood of passing the standards associated with secure title:

city	dwelling	infrastructure	both
Manila	39	48	44
Davao	9	10	6

Somewhat surprisingly, the effect on dwelling and infrastructural pass rates is about the same. However, this may reflect a perception by households that their tenure status is more secure when infrastructure services are extended to their neighborhoods by public agencies.

There is clear evidence that increasing tenure security -- or even the perception of it -- does have a significant impact on housing investment. The available evidence from the Philippines suggests that

1. The dependent variable took on the value of one if any of the following improvements had been accomplished: strength of the materials out of which the unit was built had been strengthened (for example, for the walls to be improved from wood to masonary); the quality of the toilet facilities had been upgraded; and, a floor had been added to the unit. Otherwise, the variable had the value of zero.

at a minimum, the effect on the probability of occupying a minimally standard unit would rise by 0.1 and perhaps as much as 0.4.

Tenure Transitions

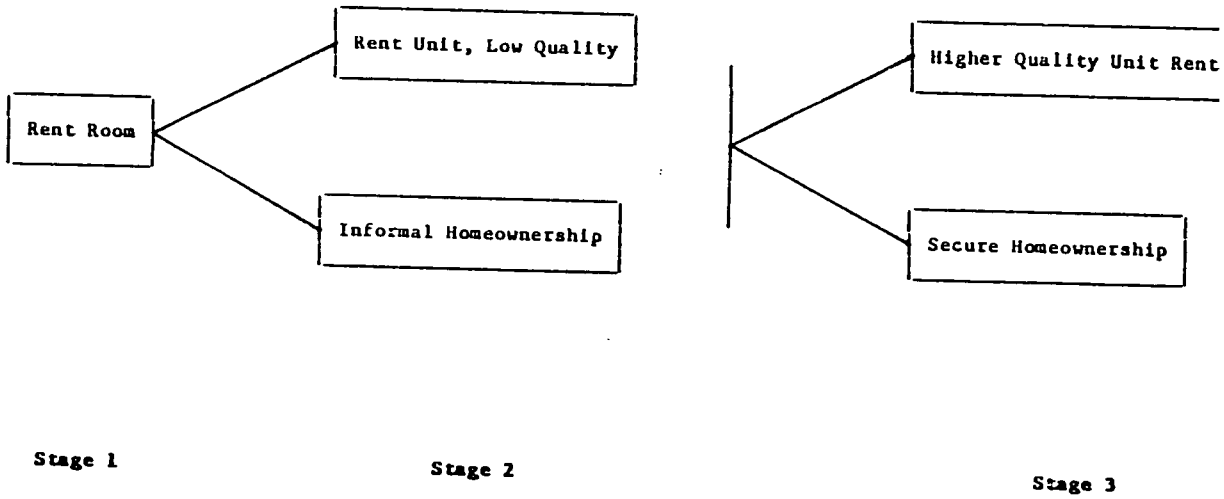
At this point, we leave the discussion of the impact on housing quality of various housing opportunities, and turn to an examination of two more general types of change ongoing in housing markets. One is the extent to which households shift among tenure classes. The other, discussed in the next section, is the rate of overall upgrading that seems to be happening in the cities of developing countries, much of it quite independent of government intervention in the housing sector.

Our principal interest in examining the rates at which households transfer among tenure statuses is that housing quality appears to vary systematically with tenure.[1] In particular, one observes a consistent, if rough, ranking of housing quality by tenure status. Beginning with the lowest quality and going to the highest the ranking is: room renters, homeowners without secure title (legal or implied), unit renters, homeowners with secured title. Figure B.1 depicts what might be thought of as reasonably standard "paths" to higher quality housing for lower- and middle-income households. These paths have been discussed by Gilbert and by Struyk and Lynn. It seems that households are very likely to make the transition from room renters to some other status but that shifting from this new position, as either a squatter or unit renter, to higher quality units is much more difficult. Gilbert's analysis of renter households is particularly germane in this regard. He shows that position in the life cycle (and

1. For evidence on this point for the Philippines, see Struyk-Wessel.

Figure B.1

Stylized Tenure Transition Paths for Lower Income Households



associated household income level) is very important in determining further movement. Gilbert also finds that, while some households succeed in moving along the path, many lower income households -- even the majority -- do not. Finally, Gilbert indicates that transitions tend to be one way, i.e. few households travel these paths in the reverse direction.

Evidence on the rate at which households make tenure transitions is extremely sparse. To illustrate, while we do have data from several countries on the share of homeowners moving into a unit in a year who were previously renters, we have not been able to infer in only one case the percentage of renters who became homeowners annually. In Bogota, about 6.7 percent of renters shifted annually to being homeowners in the early 1970s.[1] It is unclear, however, whether homeowners obtained secure tenure or not. To put this rate in perspective, note that annually about 23 percent of households in Bogota relocate.

Even more difficult to find are data on the transitions from room-renter status to that of unit renter or informal homeowner. Given this lack of data, we do not treat tenure transitions separately but rather infer them from the tenure distributions of households occupying units in different quality groups. In general, these transitions will have to be determined on a case-by-case basis.

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1. Author's calculations from data in Hamer (1981), Tables II-8 and IV-6.

Upgrading Over Time

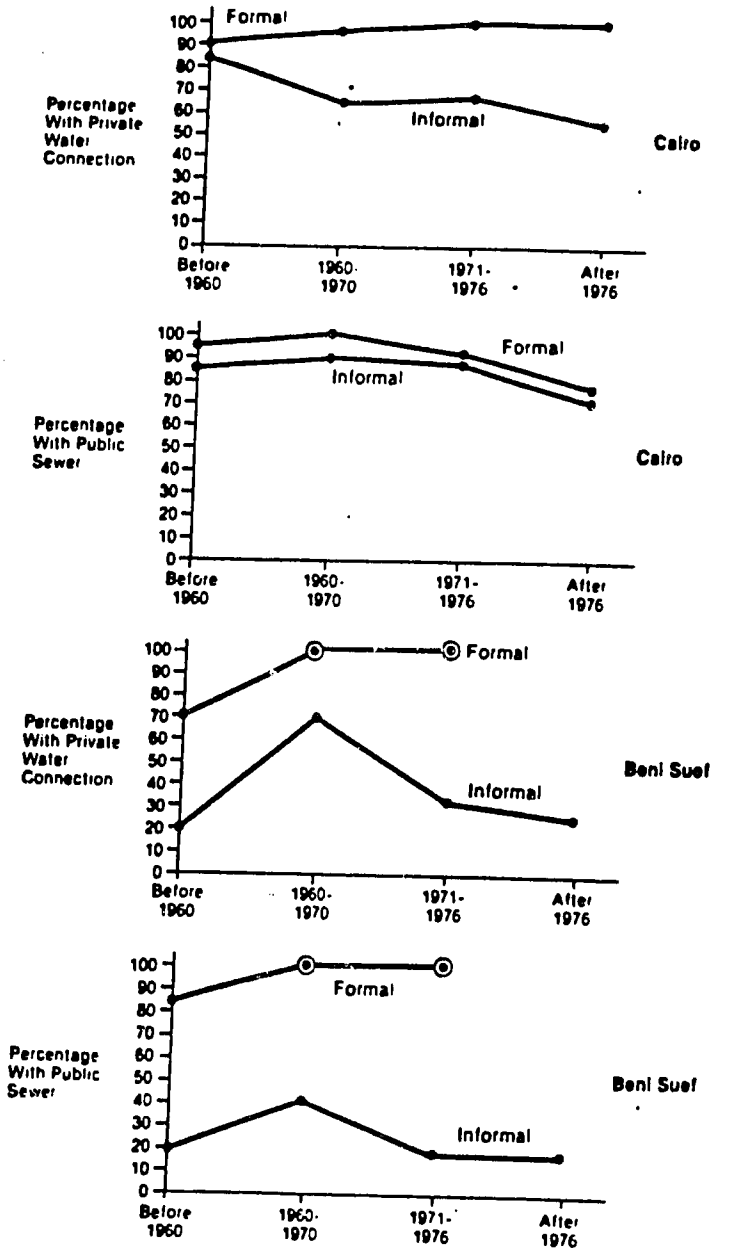
Ideally, we would like to know the rate at which housing (both units and related infrastructure) is being improved without explicit government intervention in the housing sector. Naturally, this rate will be sensitive to the rate of overall economic growth, the extent of government activity related to housing, such as providing water and sanitation infrastructure, and the availability of housing finance. Figures on the rates we seek seem to be non-existent. Thus, we have to settle for fragmentary evidence on gross rates of improvement which include the effects of government interventions.

Figure B.2, which is reproduced from Mayo's analysis of informal housing in Egypt, gives a good introduction. It shows the change over time in the percentage of units having infrastructure connections by the year the units were built. In Cairo, the longer the units have existed, the greater the probability of having these services. In Beni Suef, by contrast, there appears to have been some initiatives to provide such services in the 1960s which were not sustained thereafter; thus the pattern is highly irregular over time. Also note the much higher overall level of services to the informal sector in Cairo compared to Beni Suef.

Strassman's work for Cartagena documents widespread upgrading of units over a period of occupancy of up to ten years. The majority of improvements are made in the first two years of occupancy and nearly all are accomplished in the first five years. This pattern is consistent with the pattern of initial investment by new occupants observed even in industrial countries. Additionally, however, it is consistent with a pattern in which, because of limited mortgage financing, households can

Figure B.2

Relationship Between Time of Construction and Infrastructure Connections in Cairo and Beni Suef



◉ Fewer Than 5 Observations

Source: S. Mayo et al., Informal Housing in Egypt, Figure 5.5.

purchase less housing outright initially, but arrive at the same quantity of services after several years of heavy investment financed from current income and informal borrowing.

This is not to suggest, however, that homeowners will consistently reach a common minimum standard of housing over extended periods. In the analysis by Struyk and Turner on the likelihood of obtaining units passing minimum standards in Korea and the Philippines, they found clear that: (a) the probability of eventually passing the minimum standards was quite dependent on the value of the initial unit at the time of occupancy; and (b) there are important cohort effects, with newer units having a greater likelihood of passing. This cohort effect may reflect the increasing quality of new units caused by demand, government regulations, or formal financial institution underwriting standards.

While all of the foregoing is relevant to this discussion, it tells us precious little about actual transition rates overall and even less for households in different income groups. Still, some information has been found on the rate of transitions of units by quality of building materials for Sri Lanka, and presumably similar data exist for other countries. These figures, which are for gross rates, are shown in Table B.3. They indicate that units equivalent to about one percent of the base year stock of acceptable units in urban areas and 2 percent in rural areas are added to the acceptable stock from the base year unacceptable stock. Other data suggest that infrastructure services improved at about the same rate in urban areas but almost not at all in

Table B.3

Changes in the Number of "Permanent Dwellings" in the Housing Stock in Sri Lanka, 1971-81
(thousands of units)

	Urban	Rural
1971 stock	264.8	492.7
1981 stock	346.6	726.4
Stock change, 1971-1981	81.8	283.7
New construction, 1971-1981	56.9	175.9
1971 stock still present in 1981	287.7	600.5
Addition (+) or depletion (-) of 1971 stock by 1981	24.9	107.8
Average annual rate of addition or depletion (percent)	0.94	2.19

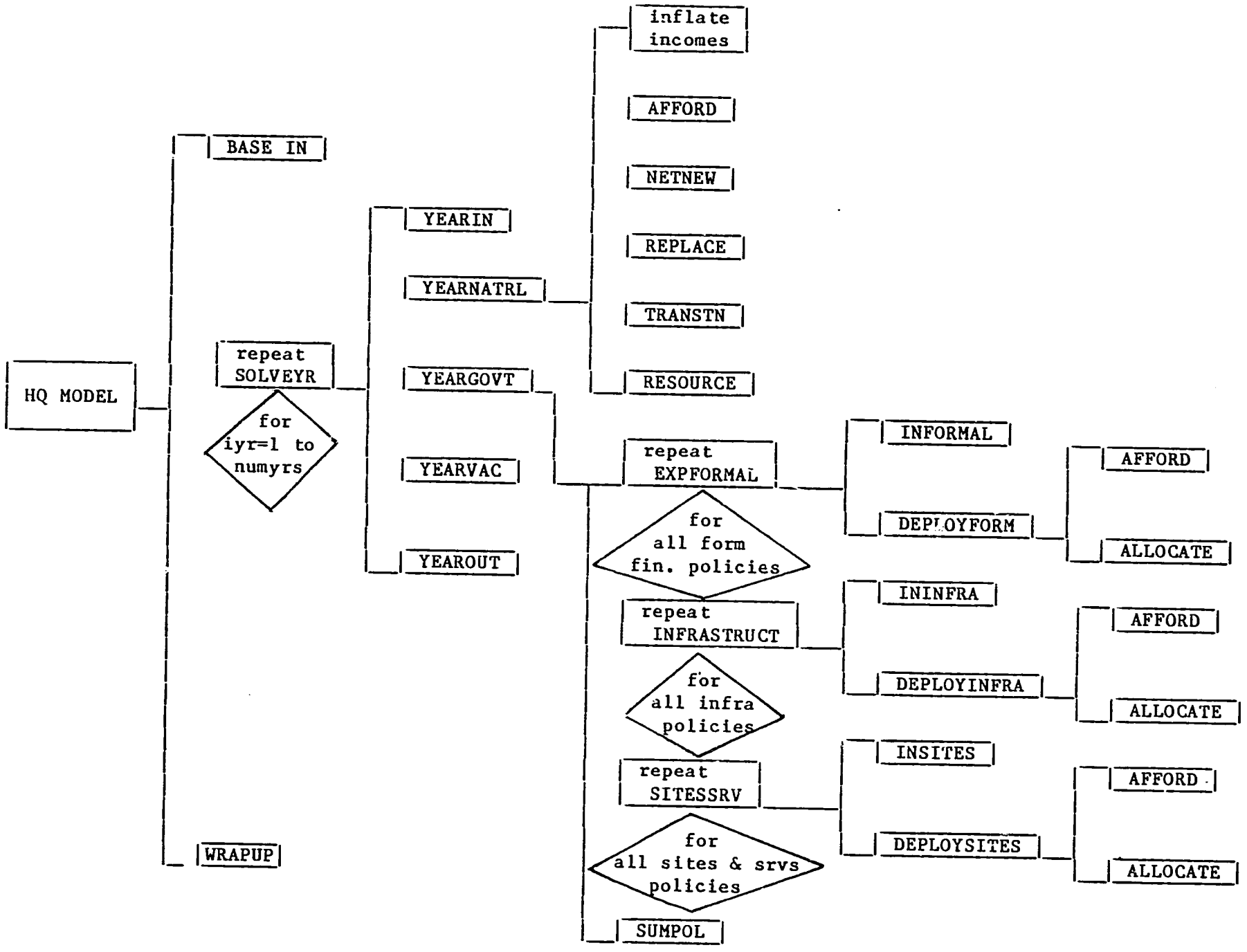
Source: Gunatilleke (1984), Tables 2 and 3.

rural areas over the 1971-1981 observation period.[1] Hence, the rate of transition for units existing in 1971 to acceptable quality in terms of both unit and infrastructure attributes is probably about 1 percent per year in urban areas but 0.2-0.3 percent in rural areas.

1. Gunatilleke (1984), Table 7.

ANNEX C

HOUSING QUALITY MODEL ORGANIZATIONAL DIAGRAM


HQ MODEL
BASE IN
repeat SOLVEYR
for iyr=1 to numyrs
YEARIN
YEARNATRL
YEARGOVT
YEARVAC
YEAROUT
inflate incomes
AFFORD
NETNEW
REPLACE
TRANSTN
RESOURCE
repeat EXPFORMAL
for all form fin. policies
INFORMAL
DEPLOYFORM
AFFORD
ALLOCATE
repeat INFRASTRUCT
for all infra policies
ININFRA
DEPLOYINFRA
AFFORD
ALLOCATE
repeat SITESSRV
for all sites & srvs policies
INSITES
DEPLOYSITES
AFFORD
ALLOCATE
SUMPOL
WRAPUP

HQMODEL:	Main control routine
BASEIN:	Reads base year input data from diskette file.
SOLVEYR:	Controls steps for each solution year.
WRAPUP:	Produces cumulative output tables for multi-year solutions.
YEARIN:	Reads a year of transition data from diskette file.
YEARNATRL:	Controls steps for "no government" components.
YEARGOVT:	Controls steps for policy simulations, if any.
YEARVAC:	Retains vacant units for subsequent years.
YEAROUT:	Produces output tables for single year.
AFFORD:	(Called from YEARNATRL) Calculates capitalized value of income available for housing investment and entry cost levels.
NETNEW:	Adds net newcomers to the housing sector.
REPLACE:	Replaces units withdrawn from the housing stock.
TRANSTNS:	Shifts existing dwelling units between status categories.
RESOURCE:	Sums new dwelling and investment resource requirements.
EXPFORMAL:	Controls simulation of expanded formal finance policies.
INFRASTRUCT:	Controls simulation of infrastructure policies.
SITESSRV:	Controls simulation of sites and services policies.
SUMPOL:	Produces policy output tables for a single year.
INFORMAL:	Reads formal finance policy data from diskette file.
DEPLOYFORM:	Controls deployment of formal loans.
ININFRA:	Reads infrastructure policy data from diskette file.
DEPLOYINFRA:	Controls deployment of infrastructure assistance.
INSITES:	Reads sites and services policy data from diskette file.
DEPLOYSITES:	Controls deployment of sites and services units.
AFFORD:	Calculates maximum affordability levels for policy participants, and reallocates assistance if necessary.
ALLOCATE:	Allocates policy assistance, shifting households and incrementing resource requirements.

ANNEX D

HOUSING QUALITY MODEL OUTPUT TABLES

SRI LANKA -- INFRASTRUCTURE POLICY

Improved Infrastruct -- 1988

Income		Households Participating number	Households Participating percent	Households Achieving Acceptable Dws number	Households Achieving Acceptable Dws percent
low	1	1050	5.00	703	3.72
	2	2100	10.00	1407	7.44
	3	3150	15.00	2110	11.15
	4	3150	15.00	3150	16.65
	5	3150	15.00	3150	16.65
	6	3150	15.00	3150	16.65
	7	2100	10.00	2100	11.10
	8	2100	10.00	2100	11.10
	9	1050	5.00	1050	5.55
high	10	0	0.00	0	0.00
Total		21000	100.00	18921	100.00

SRI LANKA -- INFRASTRUCTURE POLICY

SCHEDULED UPGRADES -- 1988
(Households achieving fully acceptable units due to past program participation)

Income		Number	Percent
low	1	173	16.67
	2	346	33.33
	3	520	50.00
	4	0	0.00
	5	0	0.00
	6	0	0.00
	7	0	0.00
	8	0	0.00
	9	0	0.00
high	10	0	0.00
total		1039	100.00

SRI LANKA -- INFRASTRUCTURE POLICY

TOTAL RESOURCE REQUIREMENTS (in millions) -- 1988

For the Sector	843.04
Formal Financing	95.00
Savings/Informal	713.75
Govt. Subsidies	34.29
For Owner-Occupants	720.22
Formal Financing	95.00
Savings/Informal	603.96
Govt. Subsidies	21.26
For Unit Landlords	122.82
Formal Financing	0.00
Savings/Informal	122.82
Govt. Subsidies	0.00

SRI LANKA -- INFRASTRUCTURE POLICY

SAVINGS/INFORMAL FINANCING AS % OF INCOME -- 1988
OWNERS WITH CLEAR TITLE

	DWELLING STATUS					
INCOME	perm-pass	perm-fail	semi-pass	semi-fail	imprv-pass	imprv-fa
low 1	1.24	0.95	0.66	2.22	1.96	1.0
2	0.67	1.00	0.39	2.49	1.26	1.0
3	0.66	0.93	0.36	2.29	1.16	0.9
4	0.63	0.96	1.49	2.50	0.96	0.9
5	0.56	0.81	1.29	1.92	0.82	0.8
6	0.51	0.82	1.12	1.76	0.82	0.8
7	0.49	1.00	1.34	1.91	0.98	0.7
8	0.20	0.95	1.44	1.34	0.98	0.6
9	0.33	1.21	2.32	1.15	0.82	0.4
high 10	1.06	0.89	2.81	0.59	0.37	0.1

SRI LANKA -- INFRASTRUCTURE POLICY

NET NEW DWELLING UNITS CONSTRUCTED -- 1988

TENURE	DWELLING STATUS perm-pass	perm-fail	semi-pass	semi-fail	imprv-pass	imprv-fail
secure owners	4289	5601	476	2811	51	1036
squatters	0	0	0	0	0	0
unit renters	741	439	82	202	6	114
total	5030	6040	558	3013	57	1151

SRI LANKA -- INFRASTRUCTURE POLICY

DWELLING UNITS VACANT -- 1988

DWELLING STATUS perm-pass	perm-fail	semi-pass	semi-fail	imprv-pass	imprv-fail
0	-0	0	-0	0	0

SRI LANKA -- INFRASTRUCTURE POLICY

ROOM RENTERS BY DWELLING STATUS -- 1988

	DWELLING STATUS perm-pass	perm-fail	semi-pass	semi-fail	imprv-pass	imprv-fail
number	25188	37258	2728	16985	321	6455
percent	28.32	41.89	3.07	19.10	0.36	7.26

SRI LANKA -- INFRASTRUCTURE POLICY

ROOM RENTERS BY INCOME CLASS -- 1988

	INCOME CLASS low 1	2	3	4	5	6	7	8	9	high 10
number	15241	19388	11460	11262	12026	7542	5206	1836	4977	0
percent	17.14	21.80	12.89	12.66	13.52	8.48	5.85	2.06	5.60	0.00

SRI LANKA -- INFRASTRUCTURE POLICY

HOUSEHOLDS BY INCOME AND TENURE -- 1988
(count,row percent,col percent)

INCOME	TENURE secure owners	squatters	unit renters	room renters	total
low 1	31271	0	20524	15241	67035
	46.65	0.00	30.62	22.74	
	7.70	0.00	11.70	17.14	
2	29775	0	17873	19388	67036
	44.42	0.00	26.66	28.92	
	7.33	0.00	10.19	21.80	
3	35847	0	19735	11460	67041
	53.47	0.00	29.44	17.09	
	8.83	0.00	11.25	12.89	
4	39328	0	16441	11262	67030
	58.67	0.00	24.53	16.80	
	9.69	0.00	9.37	12.66	
5	34526	0	20484	12026	67036
	51.50	0.00	30.56	17.94	
	8.51	0.00	11.67	13.52	
6	36117	0	23371	7542	67030
	53.88	0.00	34.87	11.25	
	8.90	0.00	13.32	8.48	
7	44288	0	17543	5206	67037
	66.07	0.00	26.17	7.77	
	10.91	0.00	10.00	5.85	
8	42883	0	22317	1836	67036
	63.97	0.00	33.29	2.74	
	10.56	0.00	12.72	2.06	
9	50260	0	11798	4977	67035
	74.98	0.00	17.60	7.42	
	12.38	0.00	6.72	5.60	
high 10	61649	0	5387	0	67036
	91.96	0.00	8.04	0.00	
	15.19	0.00	3.07	0.00	
total	405943	0	175472	88936	

100

SRI LANKA -- INFRASTRUCTURE POLICY

HOUSEHOLDS BY INCOME AND DWELLING STATUS -- 1988
(count,row percent,col percent)

	DWELLING STATUS						
INCOME	perm-pass	perm-fail	semi-pass	semi-fail	imprv-pass	imprv-fail	total
low 1	14991	32628	2430	11879	133	4975	67035
	22.36	48.67	3.62	17.72	0.20	7.42	
	5.09	15.98	8.46	12.90	5.27	10.24	
2	16435	31669	3399	10424	99	5010	67036
	24.52	47.24	5.07	15.55	0.15	7.47	
	5.58	15.51	11.84	11.32	3.92	10.32	
3	28507	20086	5519	7820	208	4901	67041
	42.52	29.96	8.23	11.66	0.31	7.31	
	9.69	9.84	19.22	8.50	8.28	10.09	
4	28605	23723	1382	8212	159	4949	67030
	42.67	35.39	2.06	12.25	0.24	7.38	
	9.72	11.62	4.81	8.92	6.33	10.19	
5	31999	20333	1750	7845	206	4903	67036
	47.73	30.33	2.61	11.70	0.31	7.31	
	10.87	9.96	6.10	8.52	8.18	10.10	
6	34503	17825	2022	7572	239	4869	67030
	51.47	26.59	3.02	11.30	0.36	7.26	
	11.72	8.73	7.04	8.23	9.50	10.02	
7	28328	22271	1919	9411	226	4882	67037
	42.26	33.22	2.86	14.04	0.34	7.28	
	9.62	10.91	6.68	10.22	8.99	10.05	
8	33582	17017	2491	8837	298	4810	67036
	50.10	25.39	3.72	13.18	0.44	7.18	
	11.41	8.33	8.68	9.60	11.83	9.90	
9	36557	12309	3383	9677	409	4698	67035
	54.53	18.36	5.05	14.44	0.61	7.01	
	12.42	6.03	11.78	10.51	16.27	9.67	
high 10	40819	6315	4419	10375	540	4569	67036
	60.89	9.42	6.59	15.48	0.81	6.82	
	13.87	3.09	15.39	11.27	21.44	9.41	
total	294324	204177	28715	92054	2517	48566	

SRI LANKA -- INFRASTRUCTURE POLICY

ANNUAL RESOURCE REQUIREMENTS (in millions)

	Total Sector	Owner-Occupants	Unit Landlords
1984			
Total	723.24	617.64	105.61
Formal Financing	95.00	95.00	0.00
Savings/Informal	597.06	503.30	105.61
Govt. Subsidies	31.18	19.33	0.00
1985			
Total	752.60	642.83	109.78
Formal Financing	95.00	95.00	0.00
Savings/Informal	625.68	528.03	109.78
Govt. Subsidies	31.92	19.79	0.00
1986			
Total	781.56	667.64	113.92
Formal Financing	95.00	95.00	0.00
Savings/Informal	653.86	552.37	113.92
Govt. Subsidies	32.70	20.27	0.00
1987			
Total	812.03	693.64	118.39
Formal Financing	95.00	95.00	0.00
Savings/Informal	683.56	577.88	118.39
Govt. Subsidies	33.47	20.75	0.00
1988			
Total	843.04	720.22	122.82
Formal Financing	95.00	95.00	0.00
Savings/Informal	713.75	603.96	122.82
Govt. Subsidies	34.29	21.26	0.00
1989			
Total	887.46	759.87	127.59
Formal Financing	95.00	95.00	0.00
Savings/Informal	757.35	643.10	127.59
Govt. Subsidies	35.11	21.77	0.00
1990			
Total	922.17	789.41	132.75
Formal Financing	95.00	95.00	0.00
Savings/Informal	791.21	672.12	132.75
Govt. Subsidies	35.95	22.29	0.00
1991			
Total	957.04	819.36	137.68
Formal Financing	95.00	95.00	0.00
Savings/Informal	825.23	701.54	137.68
Govt. Subsidies	36.81	22.82	0.00
1992			
Total	993.90	850.83	143.07
Formal Financing	95.00	95.00	0.00
Savings/Informal	861.20	732.46	143.07
Govt. Subsidies	37.69	23.37	0.00
1993			
Total	1032.19	883.52	148.67
Formal Financing	95.00	95.00	0.00
Savings/Informal	898.59	764.59	148.67
Govt. Subsidies	38.60	23.93	0.00

SRI LANKA -- INFRASTRUCTURE POLICY

NET NEW DWELLING UNITS CONSTRUCTED ANNUALLY

	DWELLING STATUS						
	perm-pass	perm-fail	semi-pass	semi-fail	imprv-pass	imprv-fail	total
1984	4178	6342	495	3269	56	1122	15463
1985	4387	6267	515	3205	56	1130	15559
1986	4600	6191	531	3141	56	1137	15656
1987	4814	6116	545	3077	57	1144	15752
1988	5030	6040	558	3013	57	1151	15849
1989	5321	6080	577	3007	58	1178	16222
1990	5542	6006	586	2944	59	1185	16321
1991	5763	5931	595	2880	59	1192	16421
1992	5953	5857	604	2817	60	1200	16520
1993	6204	5783	612	2754	60	1207	16619

SRI LANKA -- INFRASTRUCTURE POLICY

ANNUAL COUNT OF ROOM RENTERS BY DWELLING STATUS

	DWELLING STATUS						
	perm-pass	perm-fail	semi-pass	semi-fail	imprv-pass	imprv-fail	total
1984							
count	21663	32601	2513	16374	286	5748	79184
percent	27.36	41.17	3.17	20.68	0.36	7.26	
1985							
count	22544	33765	2567	16527	295	5925	81622
percent	27.62	41.37	3.14	20.25	0.36	7.26	
1986							
count	23426	34929	2621	16679	304	6102	84060
percent	27.87	41.55	3.12	19.84	0.36	7.26	
1987							
count	24307	36094	2674	16832	312	6279	86498
percent	28.10	41.73	3.09	19.46	0.36	7.26	
1988							
count	25188	37258	2728	16985	321	6455	88936
percent	28.32	41.89	3.07	19.10	0.36	7.26	
1989							
count	26087	38447	2784	17151	330	6637	91437
percent	28.53	42.05	3.04	18.76	0.36	7.26	
1990							
count	26986	39637	2840	17318	339	6818	93938
percent	28.73	42.19	3.02	18.44	0.36	7.26	
1991							
count	27884	40827	2896	17484	349	7000	96439
percent	28.91	42.33	3.00	18.13	0.36	7.26	
1992							
count	28783	42017	2952	17650	358	7181	98940
percent	29.09	42.47	2.98	17.84	0.36	7.26	
1993							
count	29682	43207	3008	17816	367	7363	101442
percent	29.26	42.59	2.96	17.56	0.36	7.26	

SRI LANKA -- INFRASTRUCTURE POLICY

ANNUAL COUNT OF POLICY PARTICIPANTS BY INCOME

	INCOME										
	low 1	2	3	4	5	6	7	8	9	high 10	total
1984											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00
1985											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00
1986											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00
1987											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00
1988											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00
1989											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00
1990											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00
1991											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00
1992											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00
1993											
count	1050	2100	3150	3150	3150	3150	2100	2100	1050	0	21000
percent	5.00	10.00	15.00	15.00	15.00	15.00	10.00	10.00	5.00	0.00	100.00

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. ANNEX E
HOUSING QUALITY MODEL INPUT FILES

Base Input Data File

income by decile

6467 10073 10881 13219 15807 18933 24770 31270 46370 10297
0.144 0.144 0.136 0.136 0.116 0.116 0.140 0.140 0.195 0.195 — sha
60462 60462 60462 60462 60462 60462 60462 60462 60462 60462 – # households by decile

sing. inv

Distribution of Households:

5.043	0	3.089	6.473	Decile 1 (low)
25.175	0	20.007	8.251	
0.597	0	0.366	0.766	
10.213	0	7.897	4.501	
0.067	0	0.041	0.086	
3.317	0	2.545	1.563	
5.367	0	1.494	3.896	2
23.656	0	18.618	15.007	
0.635	0	0.177	0.461	
9.747	0	7.018	6.301	
0.072	0	0.020	0.052	
3.179	0	2.233	2.065	
9.431	0	8.837	5.180	3
25.300	0	13.371	5.925	
1.116	0	1.046	0.613	
11.308	0	6.899	3.360	
0.126	0	0.118	0.069	
3.764	0	2.369	1.175	
9.642	0	5.591	2.597	4
28.866	0	12.910	8.426	
1.141	0	0.662	0.307	
12.634	0	5.957	3 636	
0.129	0	0.075	0.035	
4.184	0	1.997	1.200	
9.623	0	8.804	4.615	5
23.740	0	14.247	7.009	
1.139	0	1.042	0.546	
10.796	0	7.204	3.612	
0.129	0	0.118	0.062	
3.608	0	2.464	1.240	
10.335	0	11.090	5.392	6
24.190	0	15.210	1.815	
1.223	0	1.313	0.638	
11.127	0	8.096	1.940	
0.138	0	0.148	0.072	
3.729	0	2.797	0.735	
11.595	0	13.183	1.306	7
31.621	0	6.558	3.775	
1.373	0	1.561	0.155	
14.088	0	5.502	1.663	
0.155	0	0.176	0.017	
4.685	0	2.035	0.552	
17.956	0	14.693	0.997	8
23.205	0	10.421	0.766	
2.126	0	1.739	0.118	
12.599	0	7.245	0.513	
0.240	0	0.196	0.013	
4.370	0	2.617	0.184	

29.461	0	12.903	3.915	Decile 9
20.364	0	0.374	1.021	
3.488	0	1.527	0.463	
14.337	0	3.222	1.302	
0.393	0	0.172	0.052	
5.187	0	1.315	0.500	
54.289	0	6.053	0.000	10 (high)
7.687	0	0.009	0.000	
6.427	0	0.717	0.000	
15.745	0	1.452	0.000	
0.725	0	0.081	0.000	
6.216	0	0.598	0.000	

Annual Transitions Data File

0.0285 0.0285 0.0285 0.0285 0.0285 0.0285 0.0285 0.0285 0.0285 0.0285 income growth rate by decile

0.17 interest rate

1315 1315 1315 1315 1315 1315 1315 1315 1315 1315 = new households by decile

0.672	0	0	0.328	decile 1	
0.606	0	0	0.394	2	
0.758	0	0	0.242	3	
0.777	0	0	0.223	4	
0.742	0	0	0.258	5	
0.827	0	0	0.173	6	
0.895	0	0	0.105	7	
0.959	0	0	0.041	8	
0.910	0	0	0.090	9	
1.000	0	0	0	10	
0	0	0	0	0	0
0.0043	0	0.	0	0	0
0.0043	0.0164	0	0	0	0
0.0043	0.0164	0.0016	0	0	0
0	0	0	0	0	0
0	0	0	0	0	0

tenure distribution of new households

existing dwelling transition rates

0.009 replacement rate

35000000 volume of formal financing

Formal Finance Policy Terms File

37888000	Aggregate Volume
0.17	Interest Rate
0.17	Market Interest Rate
15	Repayment Period
11264	Expected Average Loan
0.5	Savings/Informal Mobilization
1	Target Dwelling Status
22323	Minimum Cost of Target Dwelling
15626	Maximum Loan
0.70	Maximum Loan to Value Ratio

Infrastructure Policy Terms File

21000	Number of Households
3072	Household Contribution
1485	Grant
5120	Cost of Structural Upgrade
0.20 0.10 0.10 0.10 0.10	Subsequent Year Upgrade Rates
0.75	Savings/Informal Mobilization Rate

Sites & Services Policy Terms File

10000	Number of Households
22323	Household Contribution
0	Grant
1 1	Target Dwelling & Tenure Status
0	Cost of Structural Upgrade
0 0 0 0 0	Subsequent Year Upgrade Rates
0.5	Savings/Informal
100454400	Aggregate Volume of Loans
0.10	Interest Rate
0.17	Market Rate
15	Repayment Period
10045	Expected Average Loan
11162	Max Loan
0.50	Max Loan to Value Ratio

Formal Finance Policy Allocation File

0	0	0	0	0	0		Decile 1
0	0	0	0	0	0		
0	0	0	0	0	0		
0	0	0	0	0	0		
0	0	0	0	0	0		2
0	0	0	0	0	0		
0	0	0	0	0	0		
0	0	0	0	0	0		
0	0	0	0	0	0		3
0	0	0	0	0	0		
0	0	0	0	0	0		
0	0	0	0	0	0		
0.025	0.063	0.002	0.025	0	0.010		4
0	0	0	0	0	0		
0.023	0.035	0.002	0.018	0	0.005		
0.013	0.017	0	0.010	0	0.002		
0.025	0.063	0.002	0.025	0	0.010		5
0	0	0	0	0	0		
0.023	0.035	0.002	0.018	0	0.005		
0.013	0.017	0	0.010	0	0.002		
0.025	0.063	0.002	0.025	0	0.010		6
0	0	0	0	0	0		
0.023	0.035	0.002	0.018	0	0.005		
0.013	0.017	0	0.010	0	0.00		
0.025	0.063	0.002	0.025	0	0.010		7
0	0	0	0	0	0		
0.023	0.035	0.002	0.018	0	0.005		
0.013	0.017	0	0.010	0	0.00		
0	0	0	0	0	0		8
0	0	0	0	0	0		
0	0	0	0	0	0		
0	0	0	0	0	0		
0	0	0	0	0	0		9
0	0	0	0	0	0		
0	0	0	0	0	0		
0	0	0	0	0	0		
0	0	0	0	0	0		10
0	0	0	0	0	0		
0	0	0	0	0	0		
0	0	0	0	0	0		

Infrastructure Policy Allocation File

0	0.021	0	0.010	0	0	Decile 1
0	0	0	0	0	0	
0	0.0125	0	0.0065	0	0	
0	0	0	0	0	0	
0	0.042	0	0.020	0	0	2
0	0	0	0	0	0	
0	0.025	0	0.013	0	0	
0	0	0	0	0	0	
0	0.063	0	0.030	0	0	3
0	0	0	0	0	0	
0	0.0375	0	0.0195	0	0	
0	0	0	0	0	0	
0	0.063	0	0.030	0	0	4
0	0	0	0	0	0	
0	0.0375	0	0.0195	0	0	
0	0	0	0	0	0	
0	0.063	0	0.030	0	0	5
0	0	0	0	0	0	
0	0.0375	0	0.0195	0	0	
0	0	0	0	0	0	
0	0.063	0	0.030	0	0	6
0	0	0	0	0	0	
0	0.0375	0	0.0195	0	0	
0	0	0	0	0	0	
0	0.042	0	0.020	0	0	7
0	0	0	0	0	0	
0	0.025	0	0.013	0	0	
0	0	0	0	0	0	
0	0.042	0	0.020	0	0	8
0	0	0	0	0	0	
0	0.025	0	0.013	0	0	
0	0	0	0	0	0	
0	0.021	0	0.010	0	0	9
0	0	0	0	0	0	
0	0.0125	0	0.0065	0	0	
0	0	0	0	0	0	
0	0	0	0	0	0	10
0	0	0	0	0	0	
0	0	0	0	0	0	
0	0	0	0	0	0	

Sites & Services Policy Allocation File

0	0	0	0	0	0	Decile 1
0	0	0	0	0	0	
0	0	0	0	0	0	
0	0	0	0	0	0	
0	0.062	0.003	0.029	0	0.009	2
0	0	0	0	0	0	
0	0.037	0.003	0.019	0	0.006	
0	0.018	0.002	0.009	0	0.003	
0	0.062	0.003	0.029	0	0.009	3
0	0	0	0	0	0	
0	0.037	0.003	0.019	0	0.006	
0	0.018	0.002	0.009	0	0.003	
0	0.062	0.003	0.029	0	0.009	4
0	0	0	0	0	0	
0	0.037	0.003	0.019	0	0.006	
0	0.018	0.002	0.009	0	0.003	
0	0.062	0.003	0.029	0	0.009	5
0	0	0	0	0	0	
0	0.037	0.003	0.019	0	0.006	
0	0.018	0.002	0.009	0	0.003	
0	0.062	0.003	0.029	0	0.009	6
0	0	0	0	0	0	
0	0.037	0.003	0.019	0	0.006	
0	0.018	0.002	0.009	0	0.003	
0	0	0	0	0	0	7
0	0	0	0	0	0	
0	0	0	0	0	0	
0	0	0	0	0	0	
0	0	0	0	0	0	8
0	0	0	0	0	0	
0	0	0	0	0	0	
0	0	0	0	0	0	
0	0	0	0	0	0	9
0	0	0	0	0	0	
0	0	0	0	0	0	
0	0	0	0	0	0	
0	0	0	0	0	0	10
0	0	0	0	0	0	

. DATA PRE-PROCESSOR

The following sample terminal session with program DATA illustrates one of its applications: the editing of a pre-existing input file. First, the user is presented a menu of ten alternatives. The first eight of these will edit or create the eight types of input files required for the simulation program. The ninth option allows reading and writing of input files to the "B" disk drive, and the tenth, or "0" option terminates the program. In the present example, the user selects option 2, to edit or create an Annual Transitions Data File.

Next, the user is asked to supply a "Year of Transition Data File to be Edited," and an "extension" for the file to be created or modified. Since, in our example, the user desires to modify the existing file YEAR1.001, the two questions are answered with "1" and "001" respectively. The program then looks for the file YEAR1.001 in disk drive "A," finds the file, and reads its contents into memory for editing. If file YEAR1.001 had not existed, the program would have created and initialized a new file of that name.

Annual Transition Files consist of six components, so the program next asks the user to specify which of those components is to be modified. The user answers with a "2" for "Number of New Households by Decile". The program then presents the current values for that item, and facilitates modification of those values. Upon confirmation that the new values are current, the program allows the user to modify other components of the file, save the new version as YEAR1.002, return to the main menu, and exit. A copy of YEAR1.002 is attached to show the resulting ASCII file.

SAMPLE TERMINAL SESSION WITH PRE-PROCESSOR PROGRAM
(USER RESPONSES ARE CIRCLED)

```
      HOUSING QUALITY SIMULATION MODEL
    DATA ENTRY AND PREPROCESSOR PROGRAM

Please select one of the following:

1) Edit Base Input Data File
2) Edit Annual Transitions Data File
3) Edit Formal Finance Policy Terms File
4) Edit Infrastructure Policy Terms File
5) Edit Sites and Services Policy Terms File
6) Edit Formal Policy Allocation File
7) Edit Infrastructure Policy Allocation File
8) Edit Sites and Services Policy Allocation File
9) Change default input file drive from: A
0) Exit preprocessor program

Please enter your choice: 2


Enter year of Transition Data File to be edited
For example, enter "1" for first year's transition
1
Enter extension of Annual Transitions Data File file to be edited: 001
```

Components of file A:YEAR1.001:

1) Income Growth by Decile
2) Number of New Households by Decile
3) Tenure Distribution of New Households
4) Existing Dwelling Transition Rates
5) Replacement Rate
6) Volume of Formal Financing

Enter choice of component to modify or "0" to exit
2
Do you want to assign a common value to all deciles?
n

Components of file A:YEAR1.001:

1) Income Growth by Decile
2) Number of New Households by Decile
3) Tenure Distribution of New Households
4) Existing Dwelling Transition Rates
5) Replacement Rate
6) Volume of Formal Financing

Enter choice of component to modify or "0" to exit

2

Do you want to assign a common value to all deciles?

n

----- Number of New Households per Decile ---

Before revision:

Decile 1:	1315.000
Decile 2:	1315.000
Decile 3:	1315.000
Decile 4:	1315.000
Decile 5:	1315.000
Decile 6:	1315.000
Decile 7:	1315.000
Decile 8:	1315.000
Decile 9:	1315.000
Decile 10:	1315.000

Do you want to change these values? (y/n) Y
Enter new values or press [RETURN] to keep old values

Decile 1:	1315.000
Decile 2:	1315.000
Decile 3:	1315.000
Decile 4:	1200
Decile 5:	1315.000
Decile 6:	1315.000
Decile 7:	1315.000
Decile 8:	1315.000
Decile 9:	1315.000
Decile 10:	1315.000

After revisions:

---------- Number of New Households per Decile ----------

Decile 1:	1315.000
Decile 2:	1315.000
Decile 3:	1315.000
Decile 4:	1200.000
Decile 5:	1315.000
Decile 6:	1315.000
Decile 7:	1315.000
Decile 8:	1315.000
Decile 9:	1315.000
Decile 10:	1315.000

Are new values correct? (y/n) Y

Components of file A:YEAR1.001:

1) Income Growth by Decile
2) Number of New Households by Decile
3) Tenure Distribution of New Households
4) Existing Dwelling Transition Rates
5) Replacement Rate
6) Volume of Formal Financing

Enter choice of component to modify or "0" to exit
3

Before revisions:

Tenure Distribution of New Households

	Sec-Own	Squatter	Unit-Rnt	Room-Rnt
Decile 1:	0.672	0.000	0.000	0.328
Decile 2:	0.606	0.000	0.000	0.394
Decile 3:	0.758	0.000	0.000	0.242
Decile 4:	0.777	0.000	0.000	0.223
Decile 5:	0.742	0.000	0.000	0.258
Decile 6:	0.827	0.000	0.000	0.173
Decile 7:	0.895	0.000	0.000	0.105
Decile 8:	0.959	0.000	0.000	0.041
Decile 9:	0.910	0.000	0.000	0.090
Decile 10:	1.000	0.000	0.000	0.000

Do you want to modify data? Y

	Sec-Own	Squatter	Unit-Rnt	Room-Rnt
Decile 1:	0.672	0.000	0.000	0.328
Decile 2:	0.606	0.000	0.000	0.394
Decile 3:	0.758	0.000	0.000	0.242
Decile 4:	.757	0.000	0.000	.243
Decile 5:	0.742	0.000	0.000	0.258
Decile 6:	0.827	0.000	0.000	0.173
Decile 7:	0.895	0.000	0.000	0.105
Decile 8:	0.959	0.000	0.000	0.041
Decile 9:	0.910	0.000	0.000	0.090
Decile 10:	1.000	0.000	0.000	0.000

After revisions:

	Sec-Own	Squatter	Unit-Rnt	Room-Rnt
Decile 1:	0.672	0.000	0.000	0.328
Decile 2:	0.606	0.000	0.000	0.394
Decile 3:	0.758	0.000	0.000	0.242
Decile 4:	0.757	0.000	0.000	0.243
Decile 5:	0.742	0.000	0.000	0.258
Decile 6:	0.827	0.000	0.000	0.173
Decile 7:	0.895	0.000	0.000	0.105
Decile 8:	0.959	0.000	0.000	0.041
Decile 9:	0.910	0.000	0.000	0.090
Decile 10:	1.000	0.000	0.000	0.000

Are new values correct? (y/n) Y

Components of file A:YEAR1.001:

1) Income Growth by Decile
2) Number of New Households by Decile
3) Tenure Distribution of New Households
4) Existing Dwelling Transition Rates
5) Replacement Rate
6) Volume of Formal Financing

Enter choice of component to modify or "0" to exit
0

Do you want to save current version? (y/n) y

Enter extension of file to contain new version: 002
New file has been successfully stored as A:YEAR1.002

Do you want to print new version? (y/n) n

HOUSING QUALITY SIMULATION MODEL
DATA ENTRY AND PREPROCESSOR PROGRAM

Please select one of the following:

1) Edit Base Input Data File
2) Edit Annual Transitions Data File
3) Edit Formal Finance Policy Terms File
4) Edit Infrastructure Policy Terms File
5) Edit Sites and Services Policy Terms File
6) Edit Formal Policy Allocation File
7) Edit Infrastructure Policy Allocation File
8) Edit Sites and Services Policy Allocation File
9) Change default input file drive from: A
0) Exit preprocessor program

Please enter your choice: 0

Annual Transitions Data File (after editing)

A:YEAR1:002

```
0.028 0.028 0.028 0.028 0.028 0.028 0.028 0.028 0.028 0.028
    1315    1315    1315    1200    1315    1315    1315    1315    1315
0.6720 0.0000 0.0000 0.3280
0.6060 0.0000 0.0000 0.3940
0.7580 0.0000 0.0000 0.2420
0.7570 0.0000 0.0000 0.2430
0.7420 0.0000 0.0000 0.2580
0.8270 0.0000 0.0000 0.1730
0.8950 0.0000 0.0000 0.1050
0.9590 0.0000 0.0000 0.0410
0.9100 0.0000 0.0000 0.0900
1.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0043 0.0000 0.0000 0.0000 0.0000 0.0000
0.0043 0.0164 0.0000 0.0000 0.0000 0.0000
0.0043 0.0164 0.0016 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.0000 0.0000 0.0000 0.0000 0.0000 0.0000
0.009
 95000000
```