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Consumer Preferences and Public Policy: A Case Study of Water Supply and Waste Management in Madras (Chennai), India

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Abstract

This thesis examines provision of water supply and waste management in the Indian city of Madras (Chennai). It is concerned with identifying the central features of these two services in Madras, and understanding public attitudes towards their provision. It is based on the micro-economic model of consumer behaviour and the random utility maximisation approach. The empirical work is based on a survey of 148 households drawn by cluster sampling method. Using focus groups, a small number of options, representing various combinations of attributes of interest, have been developed. In the survey, each respondent was presented with some of these options and the price (a monthly charge) at which each option is available. They were requested to choose the most preferred option. The analysis indicated that decisions were made by consumers mainly based on the attributes of the options. Respondent characteristics seem to have a fairly limited impact. In the case of water supply, whether an option provides a yard tap connection or not was a significant attribute. A negative preference for an option requiring the consumers to engage in rain water harvesting and recycling was also seen. In the case of waste management, primary collection was a significant attribute. In both cases, there was no clear evidence that respondents consider attributes in a hierarchical manner. Other issues explored in the thesis are: developing a water balance sheet, extending Sen's entitlements approach to water supply, and an exploration of co-operation (from a survey of 16 neighbourhood associations in Madras, called Civic Exnoras). It appears that co-operation has a weak (negative) relationship with group size; an ambivalent relationship with the number of services. Where committee members work collectively, co-operation from households is likely to be high. Limitations of the micro-economic framework are noted and some issues for further research have been identified.

Contents

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Abbreviations

ASC	Alternative Specific Constant
CS	Compensating Surplus
CV	Compensating Variation
CVM	Contingent valuation method
DFID	Department for International Development
EPWRF	Economic and Political Weekly Research Foundation
ERM	Environmental Resources Management
EV	Equivalent Variation
GDP	Gross Domestic Product
IIA	Independence from Irrelevant Alternatives
lpcd	Litres per capita per day
LR	Likelihood Ratio
MLD	Million litres per day
MMA	Madras Metropolitan Area
MMDA	Madras Metropolitan Development Authority
MNL	Multi nomial logit
MUA	Madras Urban Agglomeration
NMNL	Nested multi nomial logit
OLS	Ordinary least squares
Rs.	Indian Rupees
RUM	Random Utility Maximisation
TMCft	Thousand million cubic feet
WHO	World Health Organisation

Chapter One
Introduction

1.1 The Background :

This thesis examines provision of water supply and waste management in the Indian city of Madras[1] and its adjoining human settlements within the metropolitan area. In particular, it is concerned with identifying the central features of these two services in Madras, and understanding public attitudes towards their provision.

Not having adequate and safe water supply and sanitation is a characteristic of less developed countries[2]. For over a decade, many global studies have highlighted the need for improving these services because of the health impact in terms of morbidity and mortality burden (The World Bank,1992; The World Bank 1994; WRI,1996; UNCHS, 1996; The World Bank,1999). Such concern is also reflected in discussions at all levels from global declarations[3] to tips and advice for travellers[4]. Improving access to water and sanitation has been considered an important target by itself[5] and also an important aspect of the international development target of reducing by one-half the proportion of people living in extreme poverty by 2015 (DFID, 1997: 48). It is estimated that "...an additional 2.2 billion people will need access to sanitation

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[1] The official name of Madras has been changed to Chennai in 1996. In this thesis both Madras and Chennai are used interchangeably.
[2] The World Bank (1992 : 11) and Shafik,1994, report negative relationships between per capita GDP and percentage of population not having access to water supply and sewerage.
[3] For instance, Chapter 18 of *Agenda 21* (para 18.47) states: "An estimated 80 per cent of all diseases and over one third of deaths in developing countries are caused by the consumption of contaminated water, and on average as much as one tenth of each person's productive time is sacrificed to water-related diseases."
[4] For example, advice to travellers from the UK Department of Health website : "Travellers' diarrhoea is very common, especially in hot countries. Travellers' diarrhoea, as well as diseases such as cholera, typhoid and hepatitis A can all be caught from contaminated food and water....... If you have any doubts about the water available for drinking, washing food or cleaning teeth, boil it, sterilise it with disinfectant tablets or use bottled water – preferably carbonated with gas – in sealed containers." : http://www.doh.gov.uk/traveladvice/eatdrink.htm - retrieved on June 26, 2001. Similar advice to travellers from WHO website is : "Drinking-water should be boiled or chlorinated and filtered, except if its safety can be ensured". http://www.who.int/ith/english/general.htm
[5] Bradley et al., 1991, argue, however, that improving infrastructure is a blunt instrument to deal with water borne diseases. Also see Kolsky and Blumenthal, 1995.

and 1.5 billion will need access to water supply by that date"(WHO-UNICEF, 2000 : 2).

A significant share of the world's poor live in the rural areas. In general, world-wide, a higher proportion of population in urban areas has access to water and sanitation than their rural counter-parts[6]. However, the problems of water supply and sanitation in urban areas can have far greater impact because of the high population density, specially in areas where the urban poor live (Hardoy et al., 1990; Hardoy and Satterthwaite,1991). In addition to the health impact and impact on quality of life, deficiency in water and sanitation can also have an impact of the contribution of urban areas to national economic development (The World Bank, 1991; Peterson et al., 1991; The World Bank, 1999)[7]. A country economic memorandum of India by the World Bank (1996 : 47) states : "..there is growing evidence that India's cities and towns are facing a crisis of serious proportions stemming from chronic underinvestment in urban areas and consequent shortages of key urban services". The report goes further to note that "development of infrastructure in urban areas would go a long way in mitigating the hardships of the urban poor".

Improving water and sanitation infrastructure is not easy. The main reasons for this can be summarised very briefly as follows:

(a) In general, infrastructure improvements require lumpy investments, which the governments in developing countries are unable to mobilise internally.

(b) Even if resources are mobilised, in many developing countries, there is limited capacity to plan and execute the investment projects and maintain the assets

[6] See chapter 2 of WHO-UNICEF, 2000 : As of 2000, coverage of water supply figures are 94% of urban population compared to 71% of rural population; coverage of sanitation figures are 86% of urban population compared to 38% of rural population. See Satterthwaite, 1995 for a critique of such indicators. This issue is discussed later in chapter 5.

[7] From a study of Bombay, Harris (1995), notes that the deficient infrastructure which "appears to impose such heavy costs on economic activity that one must presume that the rates of return are unusually high to compensate for this". He adds "only the apparently *limitless patience* of the citizens allows the city to operate at all" (emphasis supplied).

thereafter – both in terms of appropriate organisational structure and trained personnel.

(c) While the necessary technical capacity can be created (by training) in a short period of time, progress with regard to creating the necessary organisational structure, often, remains limited. While state's responsibility for *providing* infrastructure does not mean that state has to *produce* these services (Musgrave and Musgrave, 1989 : 45; emphasis supplied), many governments in developing countries followed a model where state assumed this role. In the early 1990s, (i.e., prior to the east Asian currency crisis), privatisation of infrastructure was considered to be a main option to generate resources for infrastructure investment from private sector (The World Bank, 1994: Government of India, 1996). After the 1997 financial crisis, both capital markets and international donors have been cautious. Public-private partnership is being suggested as an option but creating the necessary legal, regulatory and other institutional frameworks will take time. In the mean time, the responsibility for improving water and sanitation remains with the governments[8]. However, civil service progression and career structures (oriented as they are towards generalists) often do not encourage the development of specialisation in managing infrastructure.

(d) When government organisations provide the service, it is assumed that they are contributing to well-being. There is no incentive for such a service provider to consult with consumers. In such an atmosphere, the organisations believe that the 'planner (expert) knows best'[9]. The World Bank Water Demand Research Team (1993) studies indicate that when water utilities are not responsive to consumer needs, consumers lose confidence in them and do not want to pay the tariffs; such utilities remain in deficit; they find it difficult to invest in

[8] A survey of 50 water utilities in Asia and the Pacific (McIntosh and Yniguez, 1997 : 13) noted that 24 of the 50 utilities have some form of involvement by private sector. However, only six of these had started to implement or proposed major involvement of private sector management.

[9] Bardhan's (1984:38) comment about India's development planners may apply equally well to water and sanitation planners: "...the state elite from its commanding heights formulated goals and pointed policy directions, neither at the behest of nor on behalf of ..." the people concerned!

improvements; and finally fall into a 'low-level equilibrium trap' (Singh et al., 1993).

There has been some change in recent years as governments at different levels have made attempts to make the service providers accountable to the 'customer'[10]. A mention was already made about privatisation. Other approaches include : encouraging water utilities and other such service providers to develop citizen's charters[11]; keeping them in public sector but creating some degree of autonomy (and create ombudsman institutions to which the consumers can prefer an appeal if they need to challenge the decision of the service provider); adapting a participatory approach to planning and decision making and involving consumers; or formalising the relationship between the organisation and consumers via democratic decentralisation[12]. This list is not exhaustive but indicates some generic institutional approaches. This is summarised in figure 1.1.

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[10] See Osborne and Gaebler, 1992.

[11] On the citizen's charter approach in Britain see Greenaway, 1995; Meehan, 1998.

[12] In India, the Constitution (Seventy-Fourth Amendment) Act,1992, introduced provisions concerning municipalities. Under article 243W, it is for the legislature of a state to decide which powers and functions should be given to the municipalities. In many states in India, the functions of water supply and sewerage are provided either by a state government department or a state government undertaking. In case of cities such as Mumbai, these functions are provided by the municipal corporation.

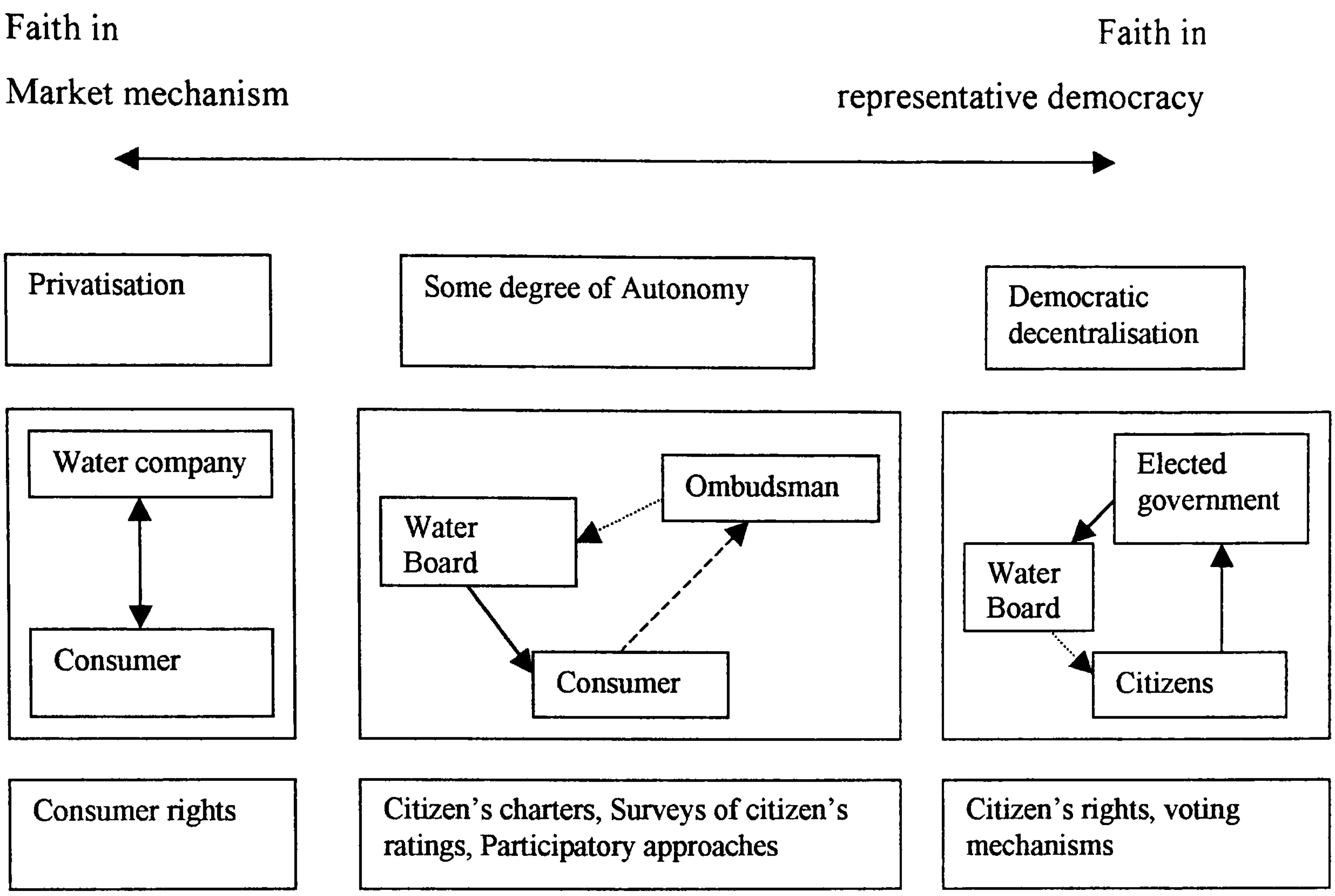

Figure 1.1 : Alternative approaches to reforming water and sanitation provision

Each of these approaches has its critiques[13]. My interest is in exploring the use of surveys and interviews of a cross section of people as a means to consulting the consumers. Paul (1992, 1994) used surveys where citizens in some Indian cities are asked to rate various urban services[14]. However, the rating approach is still reactive : that is, it is a useful instrument for *ex-post* evaluation rather than a tool for *ex-ante* consultation for planning. Some work has also been done in India on participatory approaches, but these have been used mainly in the context of village studies, where it is not difficult to gather the entire population of a village to conduct participatory

[13] For a discussion on ombudsman approach see Steiber, 2000. For a discussion on democratic decentralisation, see Dillinger, 1994; Davey, 1993; Blair, 2000. A strong proponent of participatory methods is Chambers, 1997. See Mitlin and Thomson, 1995, for a discussion on applying participatory methods in urban areas. For a critical discussion on participation, see Nelson and Wright, 1995; Cooke and Kothari, 2001; and Rehnama, 1992. Others argue that participation is (a means of manipulation) created by international donors (Carmen, 1996, chapter 3).

[14] This is briefly discussed in section 2.4 in chapter 2.

research. In extending this to cities, it is possible to consult specific groups of people; however, such studies will remain unrepresentative and hence, the results cannot be generalised.

1.2 Aims and Research Questions :

Against this background, this research aims to examine the scope for using surveys to understand the attitudes and preferences of consumers towards water supply and waste management services in Madras. In particular, it is an exploration to understand :

(a) the characteristics of these services in a city like Madras by contrasting and putting together the 'formal' or official statistics with primary data collected from surveys;

(b) issues of inequality in access to these services;

(c) the perceptions of consumers vis-à-vis alternative institutional arrangements such as provision of water supply by private suppliers or provision of waste collection services by neighbourhood associations; and

(d) the policy implications arising therefrom.

Some of the specific research questions[15] considered are :

(1) How relevant are water supply and sanitation services to quality of life in Madras?

(2) How do households in Madras rate the performance of water and sanitation services amongst various environmental services ?

(3) Are there any significant differences between the views of the poor and those of the rich concerning which services are performing well and which are not performing well?

With regard to water supply :

(4) Public policy for water and sanitation services is essentially based on information generated by the service providers themselves. How does this compare with information generated by an independent researcher using surveys? From a comparison of information from these two sources, what can be said about water supply scenario in Madras?

(5) What proportion of households in Madras have access to different sources of water supply? The official statistics indicate that over 90 per cent of the population in urban areas is 'covered' by water supply schemes (Government of India, 1999). However, the visual images in several parts of Madras indicate a significant number of people queuing up for water or carrying water over ground.

(6) In a survey of 50 water utilities in the Asia – Pacific, Madras is listed among the cities with 'no significant water vending' (McIntosh and Yniguez, 1997). However, water trade in Madras seems to be significant[16]. To what extent, do households in Madras depend on water vending? What kind of payments are involved ?

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[15] It may be noted that some of these lend themselves to standard hypothesis testing in a statistical framework. Others are questions of general nature and involve a discussion.
[16] For example, in the 1996 edition of Yellow Pages for Madras over twenty entries were listed under the heading 'Water suppliers'.

(7) The present indicators of water supply[17] are mainly city-level indicators and they do not reflect the inequality in access. Is it possible to understand the degree of inequality in access to water supply ? If there is some inequality, are existing institutional mechanisms adequate to correct these inequalities?

(8) What is the role of property rights in relation to sources of water and distributional impacts of water supply policies ?

(9) For the last several years, the completion of the project to supply water from the river Krishna has been considered a panacea for water problems in Madras. From household survey, is it possible to infer whether augmenting water supply from such projects benefits 'every one and particularly the poor' as the project appraisal documents claim ?

(10) How do households consider different attributes of water supply? For instance, if there is scope for sharing a yard tap connection (and hence the costs), would households prefer this to an individual yard tap connection?

(11) Are the views of those within Madras City (where water supply is provided by the Madras Metropolitan Water Supply and Sewerage Board - in short Metro Water Board) different from those living in the rest of Metropolitan Area (where the town or village local bodies are providing water supply)?

(12) Do households in Madras have any significant preferences as to who provides water between public sector and private sector, other things being equal ?

[17] Indicators such as the percentage of population covered or amount of water supplied in litres per capita per day (lpcd).

With regard to waste management :

Community groups based on collective action to deliver waste collection have been functioning in Madras since 1989. These are known as Civic Exnoras. In this arrangement, households in a street or neighbourhood organise payments and employ a person to collect wastes from all households and take it to municipal waste collection sites. A Master Plan for Waste Management in Madras (ERM,1996a - prepared as part of a World Bank project) is built on the premise that the entire primary collection can be left to such community based groups and that the local state should mainly focus on secondary collection, transport and disposal. This is in line with the optimism attached to 'community based' environmental management in the literature (for example, WRI, 1996). At the same time, debates on collective action cover a range of views. Taking Olson's (1965) views, issues relating to group size and economies of scope are considered to be important determinants of success. Other strands consider the importance of institution design and clarifying (or correcting) appropriate incentives (Ostrom, 1990) and developing a flexible and graduated system of sanctions (Bardhan, 1995). Against this background, the research questions are :

(13) How do Civic Exnoras function? What services do they provide and how are these financed?

(14) From the cost details, what can we say about group size in relation to Civic Exnoras ? If group size is not relevant why may that be so?

(15) Are all Civic Exnoras equally successful? If not, can we identify some of the conditions for their success? What can we say about some of the various hypotheses developed in the literature on collective action, about Civic Exnoras ?

(16) If Civic Exnoras are formed in every neighbourhood, what proportion of households are likely to join such schemes?

(17) Is awareness about various aspects of waste management an important determinant of household decisions to join such schemes?

(18) Are households primarily interested in getting the garbage 'out of sight' (i.e., primary collection only) or are they also interested in contributing to solving the 'problem' (and hence see their responsibility in secondary collection and disposal as well)?

(19) While Exnora has been recognised internationally among the best practices, why are Civic Exnoras operative in some parts of Madras but not in other parts?

1.3 Chapter Plan :

Chapter two summarises the background to understanding consumer preferences. It starts with a summary of the micro-economic model of consumer behaviour; its extension to public goods and aggregation issues. It then discusses the use of approaches known as choice models which are based on random utility maximisation. Some criticisms of these models are considered before identifying steps for operationalising the model for Madras case.

Chapter three describes the processes used in the field work and survey design. It starts with a discussion on focus groups and how questionnaire was designed. It describes how the sample was drawn by adapting the multi-stage cluster sampling methods.

Chapter four focuses on questions 1 to 3. This chapter focuses on aspects of quality of life in Madras. It also contains a discussion on how sample households rate 14 environmental services in Madras. Relevance of water supply and waste collection services to quality of life and the distribution of households in Madras according to quality of life levels are discussed

Chapter five focuses on questions 4 to 9. It contains a discussion on the water markets in Madras. It develops an extension of Sen's entitlements concept to water supply and using this it examines issues of inequality in water supplies in Madras. For this, a water balance sheet, the first of its kind for any metropolitan city in India, has been developed. It also contains an estimation of the actual costs incurred by households in terms of labour costs, monthly charges and imputed costs of water purification.

Chapter six examines questions 10 to 12. It discusses the results from the household survey where respondents were offered a number of hypothetical options referring to water supply improvements and were asked to indicate which option they would choose.

Chapter seven focuses on questions 13 to 15. It discusses the co-operation based arrangement for waste collection in Madras, (Civic Exnora) and how this is functioning. Cost functions for such organisations are developed. Some hypotheses well-known in the co-operation literature (concerning irrigation and rural water resources) are examined. Chapter eight focuses on questions 16 to 19. It discusses the results of the household survey in relation to solid waste management services. Households were again offered a number of hypothetical options and their responses are considered and some issues are identified.

Chapter nine summarises the main conclusions. Some potential issues for further research are also developed.

Chapter Two
Consumer Preferences and Public Policy

2.1 Introduction :

Public finance text-books (for example, Musgrave and Musgrave, 1989, chapter 4) tell us that: (a) in the case of private goods, a well-functioning market can allocate such goods efficiently; (b) in the case of public (or social) goods, when consumption is non-rival and exclusion is not feasible a market failure results. Such goods cannot be provided by the market in efficient quantities; besides, it may be inefficient for more than one supplier to provide them; or the benefits include externalities; and that (c) in the case of various 'mixed goods' the analytical models will need to be appropriately adapted. In this chapter, I will attempt to summarise the background of consumer preferences and the use of approaches to understand consumer demand.

In the context of environmental goods and services, some of the discussion on individual preferences and valuation has centred around public goods[1]. The topics of interest to me in this research, namely water supply and waste management, are not public goods (or more precisely, as I explain below, some of their attributes may have the property of being public good in nature – such as the beneficial effects on public health – but the attributes of most interest to us are largely private in nature). Nevertheless, there are three reasons why there is an important role for public policy concerning water supply, sanitation and waste management: (a) Left entirely to their own decision, consumers may not consume appropriate levels of certain goods due to *informational failure*. In such cases, even though markets would provide efficient quantities of this good, there is a role for public policy to correct for such failure. (b) Related to this is a concern about *distribution equity* that certain sections of the population may not be in a position to acquire adequate quantities of the goods. (c) Even though water supply and waste management are like other private goods, there are certain *externalities* in both cases, some of which may have public good properties. For example, in the case of water supply, individual decisions to pump ground water may affect the intrusion rate of sea water, beyond its natural movement. This may in turn have irreversible impacts if certain in-land fresh-water aquifers become brackish.

Business managers in the private sector know how important it is to understand consumer preferences[2]. Here, I make an assumption that planners or managers[3] in government, such as planners in the Water Board, are equally interested in knowing the preferences of their consumers[4]. A knowledge of consumer preferences can contribute to making public policy more effective.

If we assume that the goal of public policy is to maximise the welfare of the citizens, depending on the unit of analysis and assumptions made, one can approach this problem from different directions. One of these is the micro-economic approach of using the preferences of individual consumers or households (behaving as rational agents) to arrive at a policy that increases the society's well-being. Against this background, I want to explore in this chapter the background to use of demand theory to understand consumer preferences. Section 2 briefly summarises the background of this approach, which uses demand analysis to understand preferences; section 3 summarises the random utility maximisation approach and its

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[1] See Mitchell and Carson, 1989; and Braden and Kolstad, 1991, for example.

[2] Textbooks of marketing indicate: 'customer focus' is at the centre of market-driven management (Jobber, 2001 : 9) and in marketing, 'the consumer is king' (Engel et al., 1995 : 6).

[3] In the remainder of this chapter, I will be using the expressions planner, manager, analyst, researcher and economist as synonyms.

[4] In the case of privatisation of state owned enterprises, indeed such managers may need to behave like private sector managers. See The World Bank, 1995a; Shirley, 1999; and Ramamurti, 1999. Here, I am talking about a manager in government. The textbook case of public finance considers the public sector manager to (a) have rational behaviour; and (b) work in public interest. If either of these conditions is relaxed, we will have alternative models of bureaucratic behaviour. Basu, 1991, considers some of these in relation to public expenditure management in India. Here, I consider both conditions a and b to work. In the light of freedom of information movement and other developments in India (as discussed in chapter 1), many public sector managers are adapting an approach that is more accessible to consumers. The Metro Water Board has adapted citizen's charter (briefly discussed in chapter 5); the managing director of metropolitan transport corporation in Chennai is reported to have grievance days regularly when consumers can approach him (reported in http://www.hinduonline.com on July 2, 2001).

use in discrete choice models; section 4 identifies issues for empirical design in this research.

2.2 Consumer Preferences :

At the centre of the economic model of consumer behaviour is *a consumer choosing the best things that she can afford* (Varian, 1996 : 33 : italics mine). A summary of the micro-economic theory of consumer behaviour (in terms of uncompensated and compensated demand functions) is given in Appendix 1. Before summarising the main points, the notation used may be explained:

m	=	income (m^0 initial income and m^1 final income)	
x	=	a commodity bundle of n commodities	$= \{x_1, x_2, \ldots . x_n\}$
p	=	price vector of the n commodities	$= \{p_1, p_2, p_3 .. p_n\}$
$\mathbf{p}^0$	=	initial prices	
$\mathbf{p}^1$	=	final prices	
U	=	consumer's real valued utility function	$=U(\mathbf{x}\ (\mathbf{p}, m))$
V	=	indirect utility function	$=V(\mathbf{p}, m)$
e	=	expenditure function	$=e(\mathbf{p}, U)$
$\mathbf{x}^{\sim}$	=	a given commodity bundle (or one attained at a given utility level of $\bar{U}$)	
λ	=	Lagrange multiplier of the budget constraint – also represents the marginal utility of income	
μ	=	Lagrange multiplier of the cost minimisation problem ($\mu = 1/\lambda$)	

The main points of consumer behaviour and demand can be summarised as below:

a. It is assumed that the consumer has well-behaved preferences (i.e., preferences are complete, reflexive and transitive) and well-behaved utility functions (see item *e* in Appendix 1).

b. Given the budget constraint, the consumer chooses that commodity bundle which maximises her utility[5]. Here, (ordinal) utility is a real-valued function, like an index, reflecting the orderings of two commodity bundles.

c. Solution to the first order conditions (obtained by partially differentiating the utility function) gives the ordinary or Marshallian demand functions (demand for commodity x_i given the prices and income).

d. The disadvantage of such demand functions is that the effect on demand due to changes in the relative prices and real income are bundled together. Compensated or Hicksian demand functions do not have this disadvantage since they focus on price effects alone.

e. From the demand curves, an appropriate welfare measure is estimated[6]. Compensating variation (CV) is the maximum amount of money (at final prices) that can be taken from a consumer while leaving her as well off as she was before a fall in prices (hence, maintaining utility at U^0) or (in the case of a price rise) the minimum amount of money that must be given to the consumer to leave her as well off as she was before the price rise (Johansson, 1987 : 30-31). Equation 14 in the appendix shows compensating variation (CV) in income with a change in prices from $\mathbf{p}^0$ to $\mathbf{p}^1$ and of income from m^0 to m^1 defined as :

$$\begin{aligned} CV &= m^1 - m^0 + e(\mathbf{p}^0, U^0) - e(\mathbf{p}^1, U^0) \\ &= \Delta m - \int_c [\, \mathbf{x}^{\sim}(\mathbf{p}, U^0) d\mathbf{p}] \qquad 2.1 \end{aligned}$$

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[5] The conception of consumer in marketing studies is similar to the micro-economic model in many respects: consumer is the decision maker; decisions are mainly consequence-based (desire fulfilment or happiness); in many cases, commodities (or characteristics/attributes of goods) are comparable. However, in marketing studies the decision process is seen to consist of a number of steps including, pre-purchase evaluation of alternatives, purchase, post-purchase evaluation and even divestment (i.e., returning the good). In micro-economic theory, all these steps are collapsed into assumptions about preferences and consumer's ability to process enormous information. Bounded-rationality approach attempts to modify the conception of consumer. However, many of the criticisms of utilitarian approach (discussed briefly in section 2.4) apply to the conception of consumer in marketing research as well.

[6] In this chapter, a welfare measure estimated from ordinary or uncompensated demand functions is denoted as S. Compensated measures are : compensating variation (CV); equivalent variation (EV); compensating surplus (CS) and equivalent surplus (ES).

where c is a path between the initial and final price-income vectors.

f. Similarly, equivalent variation (EV) is the amount of money that must be taken from the consumer at initial prices and income to leave her as well off as she would be at final prices and income (hence maintaining utility at U^1).

g. Surplus measures (S) derived from ordinary demand functions and compensating variation (CV) and equivalent variation (EV) measures will coincide only if the utility function is quasi-linear. In general, S will also depend on the sequence in which the prices of commodities change (and hence, path dependent). Hicksian measures are path independent (under certain assumptions – see Appendix 1, in particular, items *g* and *i* there and also the equation A1. 15 there).

h. An analyst using the ordinal utility approach is mainly interested in the ranking of two or more commodity bundles. If income is fixed and utility function fulfils certain properties, S can rank any number of commodity bundles correctly. In the case of CV and EV measures, income need not be fixed (see item *i* in Appendix 1).

   However, CV and EV measures rank commodity bundles correctly when either only two bundles are considered, or irrespective of the number of bundles at initial prices, if only one bundle is considered at final prices (Johansson, 1987: 43).

i. The analyst cannot observe compensated demand functions[7] (Johansson, 1987 : 49). She can observe or derive ordinary demand functions. However, surplus measures from these can rank commodity bundles correctly only under very restrictive conditions, whereas CV and EV measures rank bundles correctly. Hence, the analyst has to use either Hausman approach (using partial differential equations) to directly calculate the CV/EV measures from ordinary demand functions or make other assumptions about specification of the utility function (in which case no monetary measures are calculated : Johansson, p. 50). A third approach is to use the bounds suggested by Willig :

$$\frac{CV - S_i}{S_i} \approx - \frac{S_i \eta}{2m^0} \qquad 2.2$$

where S_i is ordinary consumer surplus (for consumer i); η is the income elasticity (change in demand of good x due to change in income); m^0 is the initial income. The above equation gives the relative error due to using S instead of CV.

j. Mitchell and Carson (1989 :23-25) discuss some issues in choosing the appropriate benefit measure depending on the consumer's property rights to the good. This is summarised in their table reproduced as table 2.1. The two surplus measures are compensating surplus (CS), equivalence surplus (ES); the two variation measures are compensating variation (CV) and the equivalence variation (EV).

Table 2.1: Hicksian welfare measure for surveys of preferences for public goods

	WTP	WTA
Quantity increase	CS	ES
Price decrease	CS, CV	ES, EV
Quantity decrease	ES	CS
Price increase	ES, EV	CS, CV

Source : Mitchell and Carson, 1989 : 25

Similar suggestion is also made by Pearce et al., 1994.

[7] On welfare measures, Mohring, 1971; McKenzie and Pearce, 1976; Hausman, 1981 and Vartia, 1983 are widely cited. Hausman and Newey, 1995, discuss non-parametric approaches. Also see Irvine and Sims, 1998; and Slesnick, 1998.

Extending this to public/social goods[8]

Johansson (1987 : chapter 6) extends the above results to the case of public goods. In this case, the utility function of a consumer contains two arguments: a commodity bundle of n private goods $\mathbf{x} = \{ x_1, x_2, x_3 \ldots x_n \}$; and another commodity bundle of k public goods $\mathbf{z} = \{ z_1, z_2, z_3 \ldots z_k \}$:

$$U = U(\mathbf{x}, \mathbf{z}) \qquad 2.3$$

All the properties of utility function (discussed in Appendix 1) hold. The consumer's budget constraint is :

$$\mathbf{px} - m = 0 \qquad 2.4$$

where $\mathbf{p}>0$; $m>0$; (i.e., positive prices and positive income). The consumer does not pay anything for the public goods as these are assumed to be provided by the government via tax revenues.

Using the Lagrangian of equations 2.3 and 2.4 and applying first order conditions, the uncompensated or ordinary demand functions can be derived. Substituting these ordinary demand functions into the utility function, gives the indirect utility function:

$$\begin{aligned} V(\mathbf{p}, m, \mathbf{z}) &= \max\{U(\mathbf{x},\mathbf{z}) \text{ such that } \mathbf{px}-m=0\} \\ &= U(\mathbf{x}(\mathbf{p},m,\mathbf{z}),\mathbf{z}) \qquad 2.5 \end{aligned}$$

[8] Though my interest is in applying this framework to water supply and waste management which are not public goods, I am providing this section, mainly to complete the discussion.

Similarly, the expenditure function is specified as the minimum expenditure needed to reach the utility level, given prices of private goods and level of provision of public goods:

$$e(\mathbf{p},\mathbf{z},\bar{U}) = \min\{\,\mathbf{px} \text{ such that } U(\mathbf{x},\mathbf{z}) \geq \bar{U}\} = \mathbf{p}\mathbf{x}^{\sim}(\mathbf{p},\mathbf{z},\bar{U}) \qquad 2.6$$

In general, one would expect that an increase in the provision of **z** affects demand for **x** through the marginal utilities and "since, an increase in **z** increases utility, expenditure on private goods must fall, in order to maintain the individual at the specified level of utility"(Johansson 1987:77). However, he points out that the total effect of a change in the public good on the demand for private goods may be ambiguous. This is overcome based on two assumptions: the separability assumption (that utility function is weakly separable in **z** thereby fulfilling the requirement that there is a monotone transformation such that $U \equiv u(\mathbf{x}) + v(\mathbf{z})$ – which eliminates the influence of **z** on demand for **x** and marginal utility of income : Johansson, p.75); and that private goods are normal goods. Therefore, an increase in **z** decreases demand for private goods. He then derives CV as :

$$CV = [e(\mathbf{p},\mathbf{z}^0,U^0) - e(\mathbf{p},\mathbf{z}^1,U^0)] = \int_c (\partial e/\partial \mathbf{z})\, d\mathbf{z} = \int_c (\mu\,(\partial U(\mathbf{x}^{\sim},\mathbf{z})/\partial \mathbf{z}))d\mathbf{z} \qquad 2.7$$

where μ is the Lagrange multiplier of the cost minimisation problem (and $\mu=1/\lambda$). In this case, CV is the maximum amount of money that a consumer is willing to pay to secure the increased provision of public good (Johansson : 1987: 78). In the case of a comparison between two vectors ($\mathbf{z}^0$ and $\mathbf{z}^1$) of public goods, CV and EV measures will rank these correctly (that is in the same way as the consumer does : Johansson, 1987:.81) .

With regard to choice of measure, Mitchell and Carson (1989:23) point out that ".the Hicksian [compensating or equivalent] variation measures are to be used when the consumer is free to vary the quantity of the good concerned, and surplus measures when the consumer is constrained to buy only fixed quantities of a public good". It is also useful to recapitulate their discussion (p. 28-29) on Hicksian surplus measures for public good. According to them, the analyst would be interested in estimating the parameters of the inverse Hicksian compensated demand function (from the first order condition of expenditure function):

$$\Pi\,(\mathbf{p}, z, T, U_i) \qquad 2.8$$

where p is the vector of prices of private goods, z is the level of the public good[9], T represents tastes, U_i is the level of utility being held constant. For a discrete change in z from z_0 to z_1, the compensating surplus measure is:

$$CS \quad = \int_{z_0}^{z_1} \Pi\,(\mathbf{p}, z, T, U_0)\, dz \qquad 2.9$$

and the equivalent surplus measure is :

$$ES \quad = \int_{z_0}^{z_1} \Pi\,(\mathbf{p}, z, T, U_1)\, dz \qquad 2.10$$

Mitchell and Carson (1989 : 29) point out that estimating the parameters of such a function is in general not easy. The main problems listed by them are: (a) lack of information about appropriate taste variables; (b) even if known, there being only poor-quality proxies for the variable comprising T; (c) there being no guidance on the functional form of Π.

[9] In the discussion earlier, we have used z as a vector. If (a) the level of provision of only one public good (say z1) is being changed, (b) all other public goods remain unchanged, and (c) a change in z1 does not affect the demand for other public goods, then the earlier approach of Johansson and the above approach of Mitchell and Carson will coincide.

Aggregation over individuals

So far, the discussion has centred around a single consumer. In the case of public policy, however, views of a large number of consumers may need to be taken into account. For example, if the policy concerns a change in the level of provision of a public good, its impact on various consumers depends on how the public good affects the demand for the various private goods, and whether marginal utility of income is related to income itself.

The difficulties involved in making decisions on the basis of individual preferences are captured by Arrow's impossibility theorem (Varian, 1996 : 547) which states that in non-dictatorial settings such decision making system will violate one of the features:

a. Suppose, a society comprises n individuals. Each of these individuals has preferences which are complete, reflexive and transitive. Then the aggregation mechanism should result in preferences of the society which also have this property.
b. If every one of the n consumers prefers commodity bundle (or a state of being) **x** to another such bundle (or state) **y**, the social preferences also should rank **x** to be preferred to **y**.
c. Preference between **x** and **y** should depend only on how consumers rank **x** and **y** and not on how they rank other alternatives.

Varian points out that even if a decision mechanism violates the third condition above, it generates some useful information for policy concerning ranking of alternative states of being[10].

[10] The issue of single-peaked preferences in relation to a majority voting mechanism may be relevant here. See Musgrave and Musgrave, 1989:89-91. Sen (1982 : chapter 5) discusses some alternative approaches for the consistency of majority decisions to work.

A social welfare function can be defined as a function that depends only on the utilities of the individual consumers[11]. Johansson (1987: 46-47) uses a Bergson (or individualistic) welfare function for a society consisting of H consumers:

$$W \quad = \quad W(U^1(\mathbf{x}^1), \ldots\ldots, U^H(\mathbf{x}^H)) \qquad 2.11$$

Some of the properties of such a function are: (a) an increase in the utility level of an individual consumer, while everyone else's utility levels remain unchanged, increases social welfare; (b) if the utility of one individual is reduced, then the utility of another individual must be increased, to maintain social welfare unchanged; (c) the welfare weight of an individual depends on her utility level.

Any such aggregation rule will be useful only if different individuals measure their utility in the same way. Assuming comparability of inter-personal utilities allows us to maintain this property[12]. Even though one uses ordinal utility approach, if everyone is using exactly the same measures to rank similar bundles, inter-personal utility comparability allows us to aggregate this information for social decisions. Further assuming that the welfare function is continuously differentiable, totally differentiating the welfare function and substituting the indirect utility function and marginal utility of income[13] (to represent change in utility due to change in income):

$$dW \quad = \Sigma \frac{\partial W}{\partial V^h} dV^h = \Sigma \frac{\partial W}{\partial V^h} \lambda^h [-\mathbf{x}^h \, \mathbf{dp} + dm^h] \qquad 2.12$$

where $\partial W/\partial V^h > 0$ for all consumers and this is the welfare weight of each consumer. As explained in the appendix, the term in square brackets is a surplus measure from ordinary demand functions for consumer h, due to an infinitesimal change in prices and /or income. To consider a discrete change in income and prices, the above equation must be integrated between initial and final price-income vectors. By

[11] Also known as 'welfarism': see Sen, 1982 : 328; also see Sen, 1987: 39.
[12] See Sen, 1987: 30 for a brief discussion on this. Sen points out that inter-personal comparison need not take an 'all or nothing' form but partial interpersonal comparability can be envisaged.
[13] See equation 12 in Appendix 1.

evaluating the area to the left of the market (or aggregate) demand curve, the planner can measure the total surplus. However, Johansson points out that this depends on whether the product of welfare weight and marginal utility of income (λ) is equal and constant across all consumers. Such an assumption will have an unreasonable implication that a consumer with high-income will have a larger welfare weight than a consumer with lower income (if λ is a strictly decreasing function of income). If we allow welfare weight and marginal utility of income (λ) to vary across consumers, then the sum of surpluses and the change in social welfare need not have the same sign. Johansson (p.48) thinks that CV and EV are less restrictive compared to S. In particular, it is suggested that the CV measure is closely related to Hicks-Kaldor compensation criteria. If sum of CVs over h consumers is positive ($\Sigma CV^h > 0$), the gainers can more than compensate losers[14].

Using Surveys for Understanding Consumer Preferences

Studies such as Mitchell and Carson (1989) outline the contingent valuation method (CVM) where a planner conducts a survey of a sample of consumers and collects information on 'willingness to pay' for an increase in the level of provision of a good (or willingness to accept compensation in the case of a decrease). Then such information is used to calculate the appropriate Hicksian measures (based on assumptions about welfare weightings and marginal utility of income). Literature on this method is vast and growing[15]. In essence, the CVM involves the following components :

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[14] Sen argues that a difficulty with the so-called potential compensation criteria is that (a) losers could include the worst off and the most miserable in the society in which case, even though from efficiency point of view, the decision can be supported, it cannot be supported from equity considerations; and (b) when there is actual compensation, there is Pareto improvement and there is no need for a supplementary rule. Thus the potential compensation criterion is *unconvincing* or *redundant* : see Sen, 1987 : 33 (italics in the original).

[15] For various issues concerning this method and some criticisms, see Cummings et al.,1986; Kahnemann and Knetsch, 1992; Anon., 1992; Coker and Richards, 1992; Arrow et al., 1993; Hausman, 1993; Hanemann,1994, 1995; Hausman and Diamond, 1994; McFadden, 1994; Portney,1994; Bishop et al., 1995; Willis and Corkindale, 1995; and Bjornstad and Kahn, 1996; O'Connor and Spash,1999; Clark et al., 2000.

a) Identification of the population concerned; selection of a representative sample if the entire population cannot be surveyed;
b) Formulation of a description of the conditions under which the public/social good in question is proposed to be supplied - referred to as the 'scenario';
c) Selection of an appropriate payment mechanism – referred to as the 'payment vehicle' and value elicitation mechanism;
d) Presenting this information to the respondents through a structured questionnaire or interview - referred to as the 'survey instrument';
e) Aggregation of the results obtained using appropriate criteria and drawing policy conclusions.

Academic opinion on CVM is divided with arguments in favour of (Mitchell and Carson, 1989; Hanemann, 1994) and against CVM (Desvousges et al., 1993 and several other papers reported in Hausman, 1993; Hausman and Diamond, 1994; Kahnemann and Knetsch, 1992; Knetsch, 1994). The NOAA Panel (Arrow et al., 1993) made various recommendations on methodology and procedural requirements for a CVM study to be considered acceptable (in the context of damage valuation, but these guidelines are being seen as general guidelines for all CVM studies). Some of these recommendations are being questioned (for example, see Carson et al., 1995b; Carson et al., 1996; several papers in Willis and Corkindale, 1995). Dubourg et al., (1997) opine that "...in the course of trying to implement this approach,....many researchers have found that the elegant theory and persuasive principles that underpin CV[M] do not translate smoothly into practice and policy: all too often, instead of giving robust and plausible numbers, CV[M] studies have produced a variety of unexpected disparities and inconvenient anomalies".

In the context of water and sanitation, though these are not public goods, a number of studies have used the CVM to arrive at consumers' willingness to pay. The World Bank Water Demand Research Team (1993), Singh et al., (1993), Altaf et al., (1993), Griffin et al., (1995), Altaf and Deshazo (1996), Reddy (1999) are examples. Blore (1996) and Whittington (1998) discuss several issues in relation to administering CVM surveys in developing countries. Some of the shortcomings of CVM studies in developing countries are :

a. A majority of these studies have focused on rural water supply (WBDT,1993; Singh et al., 1993; Altaf et al., 1993; Reddy, 1999). The task of sampling is more complicated in the case of a large metropolitan city. Of course, a few studies have attempted to conduct surveys in large cities (in Kumasi, Ghana, by Whittington et al., 1993; on Ouagadogou, Burkina Faso, by Altaf and Hughes, 1994). However, few such studies have been reported from Indian cities[16].
b. Some of these (such as Reddy,1999) have used open ended question format for the willingness to pay question. That by itself is not problematic but there are criticisms that open ended question format makes it difficult for the respondents to answer, forcing them to look for cues (Mitchell and Carson, 1989: 97). Others have argued that open-ended format yields lower values than closed-ended or dichotomous choice formats (Ready et al., 1996).
c. Some studies used bidding game format where the interviewer starts with a suggested price and depending on the response goes on either increasing it or decreasing it till the respondent indicates the price as being acceptable (Altaf et al., 1993; Whittington et al., 1993). Others have pointed out that such an approach is highly susceptible to the starting point from where the bidding started (Mitchell and Carson, 1989 : 241; Boyle et al., 1985).
d. Some studies have used dichotomous choice formats[17]. While dichotomous choice question (specially with a follow up) is considered to be efficient for estimation purposes, such questions can be informationally restrictive for the respondents. For example, in Singh et al. (1993) study in Kerala, the respondents were asked three separate questions one on connection cost, one on monthly

[16] At the time of commencement of this research, the only CVM study relating to a sample of respondents from an Indian city was that of Mumbai households' willingness to pay for preserving Borivli national park : see David et al., 1995. However, it seems that the sample was a convenience sample and not a probability based sample of Mumbai population. During this research, I came to know that a study of willingness to pay for waste collection in one zone of Madras City was in progress (ERM, 1996b). They used an open ended question.

tariffs and one on improved service (for those already having a connection). Seeking valuation of several goods in a single survey is not uncommon (for example, Kemp and Maxwell, 1993). However, when a series of valuation questions relate to the same good, there is a danger that conversational norms and logical consistency requirements may force the respondents to choose particular answers.

e. In many of these studies, various attributes of the good in question are considered in the regression equations as independent variables. However, these studies do not explore respondents' preferences for these various attributes themselves[18]. An exploration of preferences is relevant for policy purposes because public spending on water supply can be done in a number of ways, by changing the levels of any one or more of these attributes. For example, spending may be targeted to increase the quantity of water; or while the quantity is maintained at the same level, investments may be made to improve the quality of water; or the same quantity of water is supplied but at a higher pressure; and so on. Hence, from the planner's point of view, it is important to know : (i) respondents' preferences for the various attributes; (ii) whether respondents consider some of these attributes being more 'valuable' or important than others; and (iii) whether such preferences have implications for overall welfare change.

Mu et al., 1990, use an approach where respondents are presented with a number of options and the respondent chooses the most preferred alternative. Such methods are referred to as choice experiments or choice modelling studies or polychotomous choice questions.

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[17] That is, the consumer is presented with information about a good. The consumer can either choose the good ('yes') or refuse to choose it ('no').

[18] This approach where a consumer's demand for a commodity x is considered in terms of the utility achieved by different attributes (characteristics) of commodity x, is also known as Lancaster's characteristics approach. See Lancaster, 1966a and 1966b; Dobson et al., 1995 : 59-62; Hanley and Spash, 1993 :chapter 4. Currie and Steedman, 2000 examine consumer's beliefs about commodity characteristics; Peitz, 1997 compares consumer behaviour in Lancaster approach with other approaches. Also see Vagliasindi, 1994.

3. Choice Models and Random Utility Maximisation :

A set of approaches, broadly referred to as choice experiments or choice models have been developed on the basis of random utility maximisation theory. Such models have been used widely in the discrete choice models in transport literature (Ben-Akiva and Lerman, 1985 – chapters 3 and 4; Ben-Akiva and Boccara, 1995; McFadden,1986). In a survey[19] of the history of random utility maximisation (RUM) model, McFadden (2000 : 2-3) traces the development of this approach from Thurstone's (binomial probit) model of imperfect discrimination (1927); through Marschak's generalisation of this model in 1950s to stochastic utility maximisation; to Luce's study published in 1959 on the independence from irrelevant alternative property; McFadden's conditional (or multinomial) logit model in 1965 and a number of studies of 1960s and later. McFadden (p.11-12) summarises RUM in relation to the micro-economic model of consumer discussed earlier:

(a) "..consumers seek to maximise innate, stable preferences whose domain is the vector of the attributes of the commodities they consume";
(b) "the desirability of commodities will be determined by their attributes even if there are intermediate steps in which *raw goods* are transformed by the individual to produce *satisfactions* that are the proximate source of utility" (italics in the original);
(c) "preferences are predetermined in any choice situation, and do not depend on the alternatives available for choice".
(d) The randomness[20] in RUM is from the point that "...features of the taste template that were heterogenous across individuals and unknown to the analyst, as well as unobserved aspects of experience and of information on the attributes of alternatives, [are] interpreted as random factors".

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19 Also see chapter 5 of Ben-Akiva and Lerman, 1985. A survey of such models in marketing research is provided by Baltas and Doyle, 2001.
20 Ben-Akiva and Lerman, 1985,: 58, point out that utilities are seen by the analyst to be random because of observational deficiencies resulting from: (a) unobserved attributes; (b) unobserved taste variations; (c) measurement errors; and (d) use of instrumental or proxy variables.

The theoretical basis for and application of choice modelling in the context of social/public goods relating to the environment is discussed by Adamowicz et al., (1994); Hanley et al, (1998); Blamey et al, (1998; 2000); Stevens et al. (2000). Louviere (1996) provides a discussion on the conjoint analysis methods in marketing context and the scope for extending the method for social/public goods. In a current research programme on choice modelling, Morrison et al. (1996) compare various stated preference methods. Morrison et al. (1998) use choice modelling approach to estimate values placed by respondents on different attributes of a programme to improve wetlands.

Sampling issues in relation to choices

Choice modelling approach to understanding consumer preferences can be operationalised in two distinctly different ways. These are known as exogenous sampling and the choice-based sampling[21]. In "...exogenous sampling the analyst selects decision makers and observes their choices, while in choice-based sampling the analyst selects the alternatives and observes decision makers choosing them" (Manski and McFadden, 1981: 7).

Following Manski and McFadden (1981: chapter 1), we have a finite choice set **C** = {1,2...M} of mutually exclusive alternative responses (options), a space of attributes **Z**, a probablility density, p(z), [$z \in Z$] giving the distribution of attributes in the population[22]. The choice probability(of choosing i from z) is P(i | z, θ*). This θ*

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[21] See Ben-Akiva and Lerman, 1985 : chapter 8.

[22] In the context of choice experiments, it is not necessary that each option be meaningful. An option is considered to be completely described by the values of various attributes. The attributes are also considered to be independent of each other. If we have z attributes, and each attribute can take n values, the (maximum) number of options is z*n. A sample of these can be drawn and given to the respondents to observe the choice process. This approach is sometimes referred to as orthogonal design. (See Keppel, 1973 for a discussion orthogonal designs of experiments : "...when two comparisons are orthogonal, they provide independent and nonoverlapping pieces of information"). In many studies of choice experiments, however, researchers have used a small number of (meaningful) options. Either these options can be 'labelled' or 'generic'. Labelling an option is

is a parameter vector contained in Θ. The analyst is aiming to estimate θ^* from a sample of subjects and their responses. Manski and McFadden point out that the probability density of (i, z) pairs in the population[23] is given by

$$f(i, z) = P(i \mid z, \theta^*)\, p(z) , \qquad [(i,z) \in \mathbf{C} \times \mathbf{Z}] \qquad 2.13$$

In the absence of "...any knowledge of the process relating i's to z's ", the analyst may obtain a random sample from $\mathbf{C} \times \mathbf{Z}$ **to** examine the joint distribution of f(i, z). In this case, it is assumed that **Z** is finite. An alternative approach "...if one believes [that] the elements of **C** index conceptually distinct populations of z values", would be to decompose $f(i, z) = q(z \mid i)\, Q(i)$ where $q(z \mid i)$ gives the distribution of z within the population indexed by i and Q (i) is the proportion of population. Against this background, Manski and McFadden point out: "..in exogenous sampling the analyst partitions **Z** into subsets $\mathbf{Z_b}$, $b \in \mathbf{B}$ and lets $\mathbf{A_b} = \mathbf{C} \times \mathbf{Z_b}$. In endogenous or choice based sampling, he partitions **C** into subsets $\mathbf{C_b}$, $b \in \mathbf{B}$ and lets $\mathbf{A_b} = \mathbf{C_b} \times \mathbf{Z}$."

In the absence of any prior-knowledge about the parameters of attributes[24], our planner will have to settle for exogenous sampling.

Using RUM theory to understand choices

Hanemann (1984) presents a framework for modelling responses to a discrete choice CVM question, using random utility theory[25]. I will follow the framework suggested by Hanley et al., 1998; Maddala, 1983 and Ben-Akiva and Lerman, 1985.

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similar to branding of a private good and hence, may be important. See Bennett, 1999: 12. Also see Kooreman, 2000 with regard to labeling effects of child benefits.

[23] Also see Ben-Akiva and Lerman, 1985:230-233.

[24] Ben-Akiva and Lerman (1985 : 246-248) highlight two important points: (a) that "the optimum sample for estimating the parameters of a discrete choice model will depend on the values of the unknown parameters"; and (b) that "there is no single sample design for discrete choice analysis that is unambiguously optimal for all values of the parameters. Rather, whether a sample design is good or bad depends on the unknown parameter values".

[25] Also see Cameron, 1988 and McConnell, 1990 for a discussion on Hanemann's approach.

The universal choice set is referred to as **C** ; respondent i considers j options (consideration set in marketing); since the socio-economic characteristics of this individual are unchanged between the options, the utility function contains an observable part which is a function of the attributes (**Z**) of the alternative and a random part summarising information about tastes and preferences. The respondent will choose that option which yields maximum utility. Ben-Akiva and Lerman (1985 : 31-32) summarise the respondent's selection of an option as an outcome of a sequential decision-making process involving five steps: (a) definition of the choice problem; (b) generation of alternatives; (c) evaluation of attributes of the alternative; (d) choice; (e) implementation.

The planner can present the various alternatives to a sample of respondents; collect information on which of these options is chosen; and then use this information to construct a model, by making appropriate assumptions about the deterministic part and the (random component) error terms. The attributes of an option j faced by individual i is a vector Z_{ij} . The specification of a model of choice depends on assumptions about the choice process. Following the random utility theory, the individual i's utility function has the form :

$$U_{ij} = U(Z_{ij}, S_i) \qquad 2.14$$

where Z_{ij} is the vector of the attributes[26] of option j available to individual i and S_i is the vector of the socio-economic characteristics of individual i. However, this utility function cannot be observed by the researcher. The utility function is assumed to contain a deterministic part (V) that can be observed by the researcher and a random component, which is unobservable. Thus,

$$U_{ij} = V(Z_{ij}, S_i) + \varepsilon_{ij} \qquad 2.15$$

[26] Blamey et al (1997) and Blamey et al (1999) discuss the scope for labelling i.e., giving each alternative a specific name or including such information as a generic attribute.

The probability that individual *i* will choose option *j* among *n* options (from a choice set C) is :

$$\text{Prob}\,(j \mid C) = \text{Prob}\,\{ V_{ij} + \varepsilon_{ij} > V_{in} + \varepsilon_{in}, \quad \text{all } (n \neq j) \in C\} \qquad 2.16$$

By making appropriate assumptions about error terms, the above can be rewritten such that the probability of choosing an alternative is a function of Z_{ij} and S_i. If the error terms are assumed to be (a) independently distributed and (b)identically distributed; and (c) following McFadden (1974), each of the error terms is assumed to be Gumbel (or type-1 extreme value) distributed[27], then the probability of choosing option j (hereafter, denoted as P_j) is given by:

$$P_j = \frac{\exp^{\mu V j}}{\Sigma_{n \in C} \exp^{\mu V n}} \qquad 2.17$$

Hanley et al. (1998 : 414) point out that μ here is a scale parameter, which is often assumed to take a value of 1 (i.e., constant error variance). This equation can be estimated by multi-nomial logit (MNL) regression.

In these models, the choice probabilities are homogeneous of degree zero in parameters. That is, if any variable has the same value across the various alternatives, such variables drop out of the probability model (Greene, 1995 : 494). Therefore, in the discussion of such models, the focus is mainly on the various attributes of water supply options or waste management options.

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[27] Domencich and McFadden (1975 : 56 – 65) discuss various alternative specifications. Also see Maddala, 1983 : chapter 2 and also chapters 3 and 5; Ben-Akiva and Lerman, 1985 : chapters 3,4,and 5. McFadden (1984:1411) classifies models into three families : probit models (binomial and multinomial); logit models (binomial, multinomial and generalised extreme value- GEV); elimination models (hierarchical elimination by aspects- HEBA). Models under both GEV type logit models and HEBA models, are referred to as nested multinomial logit (NMNL) models.

Define V(•) to be linear such that V = $\beta\mathbf{Z}_n$, where Z is a vector of observable attributes and β is a vector of parameters to be estimated[28]. Because of the assumptions made about errors, the probability of choosing an option j is[29] :

$$P_j = \frac{\exp^{\mu\beta' Z_j}}{1 + \exp^{\mu\beta' Z_j}} \qquad 2.18$$

Dividing both numerator and denominator of RHS, by [$\exp^{\mu\beta' Z_j}$], we have :

$$P_j = \frac{1}{1 + \exp^{-\mu\beta' Z_j}} \qquad 2.19$$

Multiplying both sides by ($1 + \exp^{-\mu\beta' Z_j}$) and dividing by P_j and subtracting 1 leads to :

$$\exp^{-\mu\beta' Z_j} = 1/P_j - 1 = (1 - P_j) / (P_j) \qquad 2.20$$

Therefore,

$$\exp^{\mu\beta' Z_j} = P_j / (1 - P_j) \qquad 2.21$$

Taking logarithms on both sides and setting μ to 1 we have :

$$\beta' Z_j = \log (P_j / (1 - P_j)) \qquad 2.22$$

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[28] The function V is specified to be linear in parameters. I am using $\beta.(\mathbf{Z}_n)$

[29] In my view, there is a small error in equation 5 of Hanley et al., 1998 : 415. While the starting point is their equation 4 (on which my equation 2.17 above is modelled), their equation 5 is shown as : Prob (j) = [$\exp^{-\mu\beta' (Z_{jn} - Z_{kn})}$]/ [1 + $\exp^{-\mu\beta' (Z_{jn} - Z_{kn})}$]. I believe, the negative sign before μ in the power operand is an error. This negative sign is important as can be seen from equations 2.20 and 2.21 here whereby, the log-odds ratio is defined.

Rewriting this :

$$\log\ (P_j / (1 - P_j)) = \beta' Z_j \qquad 2.23$$

The left hand side is the log of the odds that a particular choice is made. The planner/researcher can collect data on which of the options are chosen and use this information along with information on attributes to estimate the parameters.

The RHS is a linear function of attributes. Maddala (1983 : 34-37) elaborates how this method can be applied in the case of polychotomous choice (i.e., more than 2 options). If the error terms are assumed to be multivariate normal distributed, then multi-nomial probit models can be used. However, evaluation of multi-nomial probit regressions involves evaluating several integrals. McFadden (1984 : 1420) and Maddala (1983 :63) consider that this computation burden is an impediment to using probit models.

IIA Property of MNL models

With regard to MNL models, there is an important property known as the axiom of independence from irrelevant alternatives[30] (IIA). This IIA property "....states that the odds of *i* being chosen over *j* is independent of the availability or attributes of alternatives other than *i* and *j*" (McFadden, 1984 : 1413). Because of this "...the ratio of the probabilities of choosing any two alternatives is independent of the attributes of any other alternative in the choice set" (Hausman and McFadden, 1984 : 1219). Further, McFadden (1984 : 1414) notes that "...when the IIA property is valid, it provides a ...useful restriction on model structure....Thus, for example, one can use the model estimated on existing alternatives to forecast the probability

[30] McFadden (2000 :4) points out that due to Debreau, the IIA axiom was cast as 'red-bus, blue-bus problem'. Also see Domencich and McFadden, (1975:77). Ben-Akiva and Lerman (1985 :52-53) cite Tversky's point that IIA is a special case of order independence.

of a new alternative so long as no parameters unique to the new alternative are added".

Hausman and McFadden (1984) provide an extension of the Hausman specification test for MNL models using the IIA property. Their test "...is based on eliminating one or more alternatives from the choice set to see if underlying choice behaviour from the restricted choice set obeys the independence from irrelevant alternatives property." (p.1220). They suggest that the unknown parameters from both the unrestricted and restricted choice sets are estimated. If the parameter estimates are approximately the same, they suggest that the MNL model is not rejected. According to them, the specification test statistic is based on the parameter difference δ. Hausman and McFadden (1984 : 1224) note :

> "Rejection of $\delta = 0$ indicates a failure of the restrictive structure of the MNL form embodied in the IIA property, or a misspecification of the explanatory variables.., or both...[While] this test is consistent against this family of alternatives....it is not necessarily consistent against all members of the family of alternatives defined by a given specification of explanatory variables and *any* distribution of these variables" (italics in the original).

Hausman and McFadden suggest a procedure to derive an asymptotic test statistic. Thus the model is estimated first without any restriction (u). The parameter vectors and also covariance vectors are saved; then the model is estimated once again, this time imposing restrictions to reflect the IIA property (for example, dropping one of the alternatives). The parameter and covariance vectors are estimated once again (the restriced case r). Then, Hausman and McFadden test statistic is :

$$T = (B_u - B_r)' [CovB_u - CovB_r]^t (B_u - B_r) \qquad 2.24$$

where B are parameter vectors in unrestricted (u) and restricted(r) cases (thus, same as δ in the previous paragraph); superscript t denotes a generalised inverse of the matrix of difference between covariances of the two models. This test statistic is shown to have chi-square distribution with degrees of freedom equal to the rank of the matrix [$CovB_u$ - $CovB_r$].

While IIA property is useful as a test of specification, McFadden (1984 : 1418) cautions that "...this test is an omnibus test which may fail because of misspecifications other than IIA. Empirical experience and limited numerical experiments suggest that the test is not very powerful unless deviations from MNL structure are substantial".

Deriving welfare estimates

Following Hanemann (1984) and Adamowicz et al. (1994), compensating surplus can be estimated by comparing two situations where there is a change in the level of an environmental resource from R_0 to R_1. The individual should be indifferent between the initial state (represented by 0) and the new state (represented by 1) :

$$V_0(Z_{iR0}, m) = V_1 (Z_{iR1}, m\text{-}CS) \qquad 2.25$$

where income (m) is assumed to be the sole individual characteristic; Z_i represents a vector of attributes relating to the good in question. Subscripts R0 and R1 indicate the levels of these attributes before and after the change. Based on this, CS can be estimated (Morrison et al., 1998 : 4) :

$$CS = -\frac{1}{\beta_M}\{\ln(\Sigma_i \exp{}^{V}{}_0) - \ln(\Sigma_i \exp{}^{V}{}_1)\} \qquad 2.26$$

where β_M is the coefficient of the monetary attribute and is interpreted as the marginal utility of income (to transform the change in utility into monetary measure). For a single option, the above equation reduces to:

$$CS = (-1/\beta_M)(V_0 - V_1) \quad 2.27$$

Based on this, inferences can be drawn about household preferences for specific policy packages.

Some Advantages of choice approaches

According to Adamowicz (1995:151), one of the advantages of the choice methods is the scope that these provide to expand the informational base to understand the choice process better. Further, he thinks that choice methods have some advantage over CVM methods with regard to minimising the problem of 'yea -saying' and minimsing embedding. According to Hanley et al. (1998:416), there are two advantages of using choice methods as compared to CVM:

- "It is easier to estimate the value of the individual attributes that make up an environmental good...This is important since many management decisions are concerned with changing attribute levels ...".
- "[Choice methods provide] the opportunity to identify marginal values of attributes that may be difficult to identify using revealed preference data because of co-linearity or lack of variation."

As I have already mentioned, understanding consumer preferences about various attributes for water supply and sanitation can contribute to targeting the policy more effectively. In making a decision about using choice models, the planner will have to consider the advantages (as listed above) but also several limitations and restrictions: the entire approach depends on decisions about how choices are generated; how the sample is approached (i.e., exogenous sample or choice-based sample, which in turn depends on prior information about parameters); what kind of assumptions are made about error terms and the functional form of utility function (i.e., linear in parameters of attributes).

2.4 Criticisms and Implications for Empirical Study :

The discussion so far focused on the rather fragile (if elaborate) micro-economic framework of consumer preferences and its extension to choice situations using random utility maximisation. Before discussing issues in operationalising the models discussed so far, a brief note is taken of alternative approaches (see van den Bergh et al., 2000 and Spash, 2000 for a discussion).

In the utilitarian model discussed earlier, the decision process is 'compensatory' because an option is chosen based on the total utility given by that option and not by judging how much each attribute contributes to this utility. Thus, shortcomings in one attribute can be compensated by higher values of other attributes (for example, rationed water supply but reliable, versus unlimited water supply, but unreliable). An alternative is to approach the decision rules as being 'non-compensatory'. Two widely known models of this kind are lexicographic rules and elimination by aspects rules (Engel et al., 1995:222-225; Ben-Akiva and Lerman, 1985:35-37). Preferences are called lexicographic "...because they give absolute priority to one commodity over all others and therefore, imply a strict ordering, as in a lexicon" (Spash, 2000:198). Lockwood (1997:85) points out that "...a person with noncompensatory preferences can produce a value ranking of the alternatives such that one can be said to be better than another, but is unwilling to make tradeoffs between the alternatives". If consumers use a lexicographic rule, they would rank goods on the most important attribute and then on the second most important attribute and so on. Lexicographic preferences indicate that the consumer considers different dimensions differently (and hence attributes are non-continuous) and she is not willing to trade-off one attribute for another. (The example of a woman who refused to give her consent to build a sky-scraper even if she were offered DM 20 million, cited by Spash, 2000, is relevant here.)

A second type of non-compensatory behaviour is reflected in elimination by aspects (EBA) and hierarchical[31] elimination by aspects (HEBA) models (Maddala, 1983:64-70). EBA models are similar to lexicographic models where ordering of relevant aspects (attributes) is specified *a priori*. Though EBA model is consistent with random utility maximisation, Maddala points out that if there are n aspects, the number of subsets that one must consider is $2^n - 2$ which can be very large as n increases. HEBA has been proposed where the alternatives are represented by a tree graph. The decision maker here selects a link from the tree and all other alternatives that do not include that link are eliminated (Maddala,1983:66; also McFadden,1981:section 5.16). To accommodate such non-compensatory preferences within the random utility maximisation approach discussed earlier, nested multinomial logit model is considered. McFadden (1978) used such a model to examine housing characteristics. McFadden (1984) and Ben-Akiva and Lerman (1985) discuss a comparison of a NMNL model with a multi-nomial logit (MNL) model.

However, a critic may feel that this misses the point for three reasons. First, consumers are likely to have lexicographic preferences "..when a good is essential[32] or has a moral or other irreducible form of value" (Spash, 2000:201). Thus, coercing the woman mentioned earlier to accept DM 25 million "...would misconstrue the values she was trying to maintain" (Spash, 2000:199). Lockwood (1997, 1998) argues that compensatory methods can only handle exchange values. He suggests an integrated value assessment method to incorporate value expressions of exchange with those of noncompensatory and weakly comparable modes of value expression. Secondly, while, lexicographic preferences may be indicating a non-consequentialist motivation, bringing them into utility maximisation framework tantamounts to ignoring this and assuming that

[31] van den Bergh et al., 2000 : 52 suggest a link with Maslow' theory of hierarchy of needs.
[32] Johansson (1987 :46) briefly discusses the question of essentiality of goods in relation to whether a consumer surplus measure can be infinitely large. He points out that "...the assumption of non-essentiality is both necessary and sufficient in order for the compensated surplus measures to be finite". Non-essentiality assumption means that goods are substitutable.

consumers are motivated only by consequences[33]. A third criticism relates to how attributes are considered. In some cases, certain attributes may be relevant only if certain other attribute takes a relevant value. This case of causally-prior attributes has received some attention (see Blamey et al.,1998). However, another important aspect that has not received much attention is the absence of information about some attributes. In some cases, a consumer cannot know the values a very relevant attribute (for example, the taste in the case of a food product) takes until after making a decision to consume. In such cases, the consumer will use the values of other surrogate attributes (brand name, freshness date, country of origin, condition of packaging, etc.) to make the (first time) purchase decision. The model of consumer[34] in marketing studies handles this by including 'post-purchase evaluation' and 'divestment' as stages in purchase process. In the RUM based models discussed above, the consumer is assumed to have full information on all relevant attributes (and the random error represents any gaps) and decision process does not include feedback possibility[35].

Sen criticises the utility-based approach of welfare economics both for its inadequacy as a theory of distributive justice[36] and also for its failure to distinguish between well-being and agency[37].(For a critique of welfare economics and its focus on utility maximising individuals see chapters 1 to 7 in Sen, 1982; Sen, 1985; Sen,

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[33] van den Bergh et al., (2000:51) very briefly allude to the teleological versus deontological approaches. See Spash, 1997, for a discussion.

[34] See for instance, Engel et al., 1995 :p.134 and also chapter 8.

[35] Manski,1999, discusses some issues relating to choice expectations in incomplete scenarios. Also see McFadden, 1999, who argues that "...both theoretical and empirical study of economic behaviour would benefit from closer attention to how perceptions are formed and how they influence decision-making". The concept of procedural rationality proposed by Simon can be incorporated to overcome the assumption about information.

[36] See for example, his Tanner lecture titled 'Equality of what?' (reproduced as chapter 16 in Sen, 1982) and Sen, 1984 (chapter 13) where Sen makes comparisons between various models of distributive justice such as a rights based approach (Nozick); Rawlsian approach of primary goods and the difference principle (giving highest weight to the worst-off); and the utilitarian equality.

[37] Sen (1987: 41) points out : "...there is an essential and irreducible duality in the conception of a person in ethical calculation. We can see the person, in terms of agency, recognising and respecting his or her ability to form goals, commitments, values etc., and we can also see the person in terms of well-being". He clarifies that the well-being aspect of a person "covers the person's achievements and opportunities in the context of his or her personal advantage whereas the latter [i.e, the agency

1987:40-47; also see Sugden, 1993; Qizilbash,1996). As an alternative, Sen focuses on functionings and capability approach. Sen (1984:315-316) points out : "a characteristic – as used in consumer theory – is a feature of a good, whereas a capability is a feature of a person in relation to goods". Capabilities to function are positive freedoms. While Sen's capability approach is theoretically rich, Slesnick (1998:2109) points out that this "...approach to welfare measurement is not considered in depth largely because of the relative scarcity of applications". Some efforts to operationalise Sen's approach are currently being discussed[38]. Qizilbash (1996) thinks that James Griffin's concept of well-being based on prudential values[39] is more promising than Sen's capability approach.

Some researchers have suggested the use of social or public choice approach. While the voting rules considered earlier do not resolve the problem except in the case of many assumptions, in the social choice approach the decision is considered from an institutional point of view rather than utility maximising individuals. (On social choice theory see chapter 8 in Sen, 1982 and Sen, 1996; Pardo and Schneider, 1996; on the use of social choice theory for environmental policy see Sen, 1994 and Oates, 1996.)

McFadden (1999) would like to call a consumer conforming to the standard economic model as the Chicago man. He would like call an alternative conception of individual based on psychological views of decision making (as opposed to economic views) as that of a K-T man, to trace it to the work of Kahneman and Tversky on cognitive anomalies : "circumstances in which individuals exhibit surprising departures from rationality". The concept of choice (or decision making –

aspect] goes further and examines achievements and opportunities in terms of other objectives and values as well, possibly going well beyond the pursuit of one's own well-being" (Sen, 1987:58-59).
[38] Sen, 1999 provides some discussion on this; also see Alkire, 2001 and various papers in that conference.
[39] According to Qizilbash (1996: 1216), Griffin's idea of prudential values are distinct from moral values and aesthetic values. He also cites Griffin : "to see anything as prudentially valuable we have got to see it as enhancing life in a generally intelligible way, in a way that pertains to human life". The following are suggested : (1) accomplishment; (2) the components of a characteristically human

see figure 2.1) is determined by a number of factors in addition to information, perceptions and preferences. He points out that (following psychology) attitudes are multi-dimensional with no requirement of consistency across attitudes, whereas preferences are constructed from more stable attitudes by a context-dependent process. There is feedback so that perceptions and beliefs may be modified from the experience, but also that preferences may be affected.

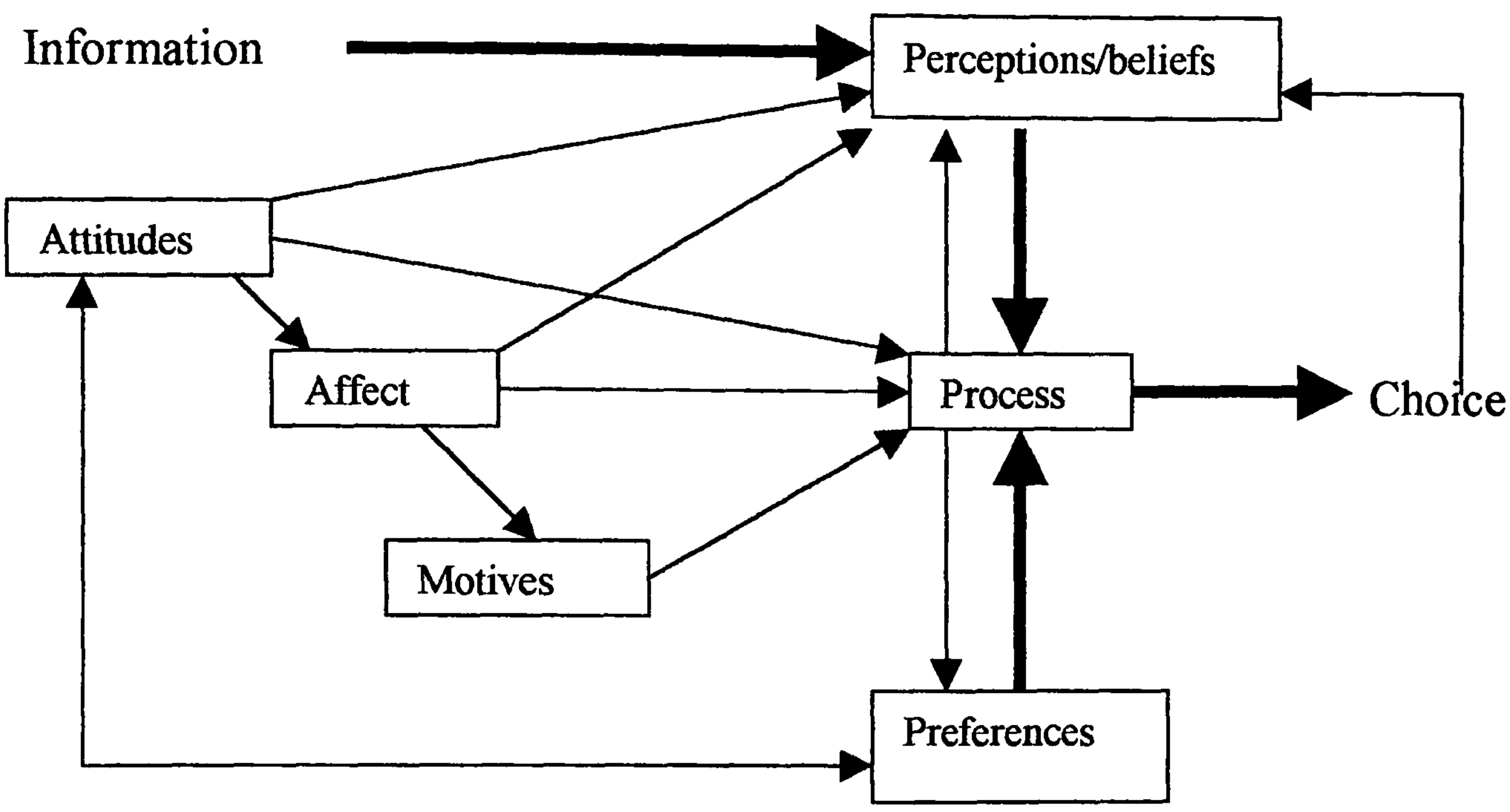

Figure 2.1 : The decision process according to McFadden, 1999.

According to McFadden, the challenge for economists is to evolve the Chicago man in the direction of K–T man, "...adapting those features needed to correct Chicago man's most glaring deficiencies as a behavioural model, and modifying economic analysis so that it applies to this hybrid". He thinks that this is a challenging task but not an impossible one.

At a procedural level, some analysts have attempted to directly ask respondents about specific preferences rather than deduce these from responses to hypothetical

existence (autonomy, liberty and minimum material provision); (3) understanding; (4) enjoyment; and (5) deep personal relationships.

questions. For example, Paul (1992, 1994) uses survey methods asking citizens to evaluate the performance of various public sector organisations (providing different social/public goods). In these surveys, no monetary valuations are involved. Paul (1992) has attempted to extend Hirschman's *exit* and *voice* framework to that of local public services. Paul argues that the choice (for citizens) between exit and voice depends on the degree of market failure. (For instance, for goods with low levels of market failure - and hence, more amenable to provision by private supplier - if the public provision is inefficient, citizens may simply exit and buy the service from the market. For goods with higher degree of market failure, exit may be more expensive than voice and citizens then may look for collective action.). Thus, a policy maker using Paul's framework, can see where citizens are likely to use 'exit' for a local public good (to be provided by market). Creating the necessary institutions for the markets to function effectively (for instance, creating the regulatory framework or ombudsmen; clarifying consumer rights and creating procedures for protecting these rights etc.), then becomes the policy priority. If the good is one with high degree of market failure, the policy maker sees that the good will need to be provided by public sector. In such case, creating the necessary institutions to ensure accountability[40] of public sector (rules on access to information; complaints procedures; citizen's charter etc.) becomes a priority. The problem, however, is that the policy maker needs to know 'the degree of market failure' for each local public good before hand and these are static.

While this is an interesting framework, its usefulness for infrastructure services such as water supply and waste collection is limited. First, because these goods have private good properties, market failure is not the main argument for public policy (as already noted). Otherwise, from a narrow interpretation of Paul's approach one may conclude that citizens are already using exit for water and hence, the role of public policy should be to enable these markets to function well. Second, though procedurally the above approach is based on consulting the consumers, it suffers

[40] For a critique of Paul's emphasis on ombudsmen approach to accountability, see Jenkins and Goetz, 1999.

from a weakness that it shares with the utilitarian approach. This weakness relates to the conception of individual. In Paul's framework also the individual is taking the decision whether to exit or to use voice, mainly as a self-interested person.

Another criticism of a social planner taking decisions on the basis of individual preferences relates to the 'top-down' model of policy that is at the centre of this approach[41]. Analysts in this school would prefer wider consultation and participation of local people as a main approach to determining policy (Nelson and Wright, 1995; Schneider and Libercier, 1995; Krishna et al., 1997; Jackson and Kassam, 1998). The three main schools of thought concerning participation are : participation as means to improve effectiveness of planning (for example, Chambers, 1997); participation as an end as a source of transformation and change (for example, Fals-Borda, 1985); participation as the only morally acceptable social science (Uphoff, 1996).

In the light of these criticisms, what should the planner do to understand preferences of consumers in relation to public/social goods? Philosophical criticisms (such as those of Sen or Uphoff, or those about compensatory decision mentioned above) suggest that the concept of exchange based values and material focus underlying the utility framework should be substituted by a richer conception of individual and various dimensions of values. A kind of multi-criteria analysis is a possibility. It is relatively easier to accommodate some of the procedural criticisms (for example, Chambers' view of participation as a means to improve planning) in operationalising the utilitarian approach. For example the planner can use a participatory or deliberative method[42] to identify appropriate policy questions.

The planner can see the following steps in a basic process of operationalising the concept of using surveys to understand consumers' preferences. (This is basic in that

[41] Also, see section 3.3 in Inman, 1988, where alternative mechanisms under the rubric of 'dictator as benevolent planner' are discussed.

[42] Citizens' jury is suggested as a deliberative process to identify environmental policy. See for example, O'Connor,2000; Aldred and Jacobs, 2000.

the scheme can be enriched, for example, by integrating participation at different stages in this process.)

a. Defining the public/social goods in question

In this research, water and waste management are the issues of interest. These are not pure public goods as exclusion is technically possible (for example, in water supply, a connection can be denied). However, the case for public policy and intervention has already been discussed. In such a context, public policy makers can improve the policy by understanding preferences.

b. Defining the population of relevance and deciding how they will be contacted

In this case, the relevant population is of Madras Metropolitan Area. Various methods were used to contact the relevant population. I used focus group discussions, household survey, interviews with service-providers, etc. (These are discussed in chapter 3.)

c. Creating choice sets

As already mentioned, to use choice based sampling, prior information is required on the parameters of attributes. Though Kerala studies of rural water supply (Singh et al., 1993; Griffin et al., 1995) are relevant, they do not give us adequate information about attributes. Hence, an exogenous sample method has to be used, using attributes that are relevant for policy purposes. Various options need to be developed to reflect different combinations of the attributes.

d. Developing a survey instrument

Based on the nature of alternatives being considered and the appropriate method of communicating this information (for example, through physical models, or photographs or drawings or verbal description), the analyst/planner will need to develop the survey instrument. Much advice is available from the field of questionnaire design (for example, Payne, 1951), sample surveying (for example, Schuman and Presser, 1982; Rossi et al., 1983; Moser and Kalton, 1992) and also from CVM studies (for example, Mitchell and Carson, 1989; Arrow et al., 1993; Schuman, 1996). A participatory approach is often used where the questionnaire design is done in a number of steps. Selected representatives of (target) respondents can be consulted using focus group discussions (for example, Morrison et al., 1997). Pretesting is also suggested to see whether the survey instrument is working as planned.

e. Conducting the survey

Having developed the survey instrument, the planner is now ready to conduct the survey – be it a random digit dialling method of telephone survey or a postal survey or a in-person interview of an appropriate sample from the target population. In developing countries, it is highly likely that the last mentioned method will be the most appropriate one mainly because the sampling frame obtained from telehone access or mail addresses may be incomplete.

f. Analysing the information

Using the information from the survey, the planner can proceed to estimate alternative specifications of models and estimate the parameter vector θ^*. From these estimates, then she can proceed to calculate appropriate welfare estimates and draw the appropriate conclusions for policy. There is some scope to examine issues such as whether respondents were making decisions in a hierarchical manner (using nested multinomial logit or NMNL models), though the potential of such models to examine lexicographic processes is limited (as noted).

2.5 Summary :

This chapter has attempted to summarise the background to approaching the problem of consumer preferences and incorporating these in public policy. I started with a summary of consumer demand and welfare measurement. I have focused in section 3 on the random utility maximisation theory and the concept of choice modelling based on that theory. Some modelling issues have been considered there. In section 4, some criticisms from alternative approaches to the utilitarian approach were briefly touched upon. While many of these are philosophical criticisms about the concept of person at the centre of the consumer demand theory, the narrow ethical basis of decisions based on assumptions of self-interest driven rational behaviour, etc., others are procedural criticisms. In my view, some of the procedural criticisms can be accommodated in operationalising a choice approach to understand consumer preferences for water supply and sanitation, whereas philosophical criticisms suggest that alternative models or approaches are needed.

Chapter Three

Fieldwork and Survey Design

3.1 Introduction :

This chapter presents the details of the various components of the fieldwork of this research in Madras. The fieldwork[1] was undertaken during 10 June – 21 October 1996. (Two follow-up visits provided an opportunity to present some of the preliminary results to local researchers and also to update other aspects. These follow up visits were during March-May, 1998 and July-August, 2000.)

The fieldwork for this research was designed with both qualitative and quantitative components. The framework adapted is shown in figure 3.1. By quantitative research, I mean a sample survey drawn from a probability sampling method; I refer to all other methods of collecting information as qualitative research[2]. These included: archival research, depth interviews, participant observation, and focus group discussions. In section 3.2, I will provide a summary of these various qualitative research methods used in this research. Section 3.3 will summarise the various aspects of the sample design for the household survey and how it has been operationalised and some of its limitations.

[1] Before commencing field work in Madras, brief visits were also made to Mumbai and Calcutta to discuss with local researchers there. At Mumbai, discussions were held with Dr. Singh and Dr. Ramasubban (co-authors of Singh et al., 1993); and with Dr. Kirit Parikh and Sharma at Indira Gandhi Institute (co-authors of David et al.,1995). At Calcutta, a discussion was held with Ian Blore. A visit was made to FOCUS, an organisation working for the welfare of waste pickers.
[2] This is in line with the definition of qualitative research given by Denzin and Lincoln (1994 : 3-13)

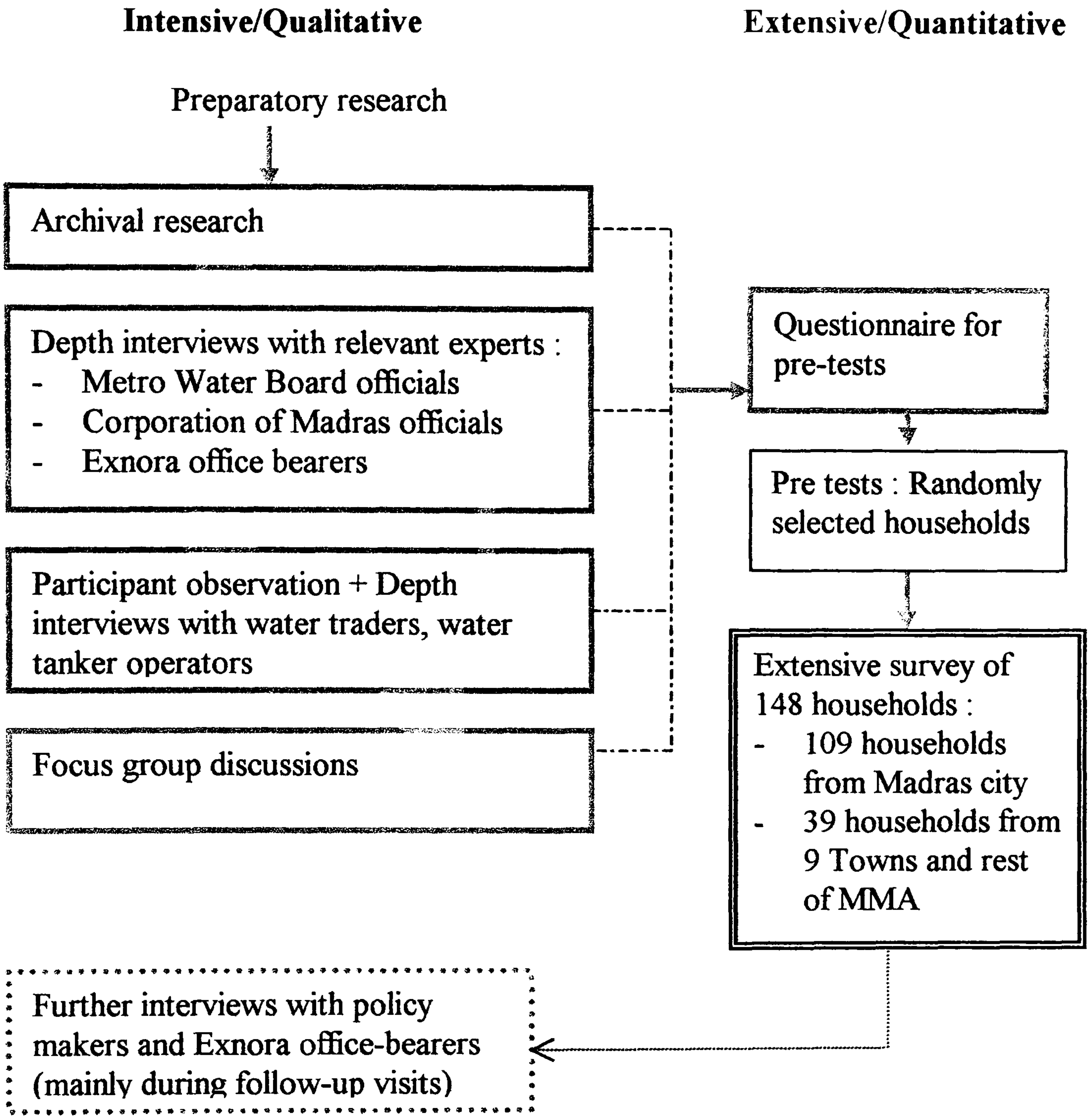

Figure 3.1 : Various elements in fieldwork.

3.2 Qualitative Research Components in Madras Fieldwork:

3.2.1 Archival research

Research in developing countries involves collection of information (sometimes even basic statistics) which is often unpublished and available only with the respective service provider or regulating agency. Hence, the researcher has to sit in the office of the service provider and peruse the documents (as in case of archives). In particular, I have used this in the following cases:

a. Madras Water Supply and Sewerage Board concerning two main aspects : the Master Plan for Water Supply and Sewerage[3] prepared in 1991 by Binnie and Partners as part of a World Bank assisted programme; and the financial statistics from the annual report of 1994-95;

b. Institute of Water Studies of the Government of Tamil Nadu, for perusing a report on hydro-geological studies of Madras basin and ground water potential prepared as part of a UNDP study in 1978;

c. Details from Census of India, 1991, housing tables for Madras urban agglomeration, from the office of the Census of India in Madras.

[3] Also see item (b) in section 3.2.2. It was not easy getting access to these documents. As per the then policy and leadership of Metro Water Board, researchers were not encouraged or given access to information. (This philosophy is reflected in a letter in response to my further request for information which states that "as a policy Metro Water is not in a position to divulge any information required by you for studies" : letter dated 21 April, 1997; reproduced in Appendix 2.) I had to make several attempts to get access to Master Plan documents. Nearly towards the end of my field work when I was about to give up, I was given permission on September 30, 1996, to consult the Master Plan documents in the office of Executive Engineer.

3.2.2 Depth Interviews :

This approach, in some cases in the form of unstructured and open interviews and in some cases partly structured interviews, was used in several stages.

a. Interviews with Metro Water Board officials were not easy as well. During the time of my fieldwork, I have attempted to meet various officials. The questions I wanted to explore were : what is the official position on water supply in Madras; how much water is supplied to different parts of Madras; why are tanker trucks used by Metro Water Board; how many of these are used; what are the various water charges collected from consumers; how are these collected; how are the water taxes and charges set; what is the progress on the project to supply water to Madras from river Krishna in Andhra Pradesh. At the time of fieldwork, I found Metro Water Board officials to be highly inaccessible. It appeared that there was an informal directive from the very top that unless the Managing Director grants permission, no information shall be given to any researchers.

b. Interviews with water tanker operators were the most difficult ones to arrange. However, three of them had kindly agreed to these interviews. In each case, semi-structured interviews focused on two aspects: about the overall water trade by tanker trucks in Madras; and their own operations. Questions focused on number of trucks, number of trips made, cost estimates, regulations and licensing requirements.

c. Depth interviews were also conducted with relevant officials in the Corporation of Madras dealing with solid waste management issues. The questions explored were : how much waste is collected by Corporation of Madras every day; where are these wastes taken to; how are these disposed of; what are current plans to deal with future increases in waste arisings; any information on unit costs of waste collection and disposal.

d. The entire study of 15 Civic Exnoras and 1 civic organisation by name Madras City Clean Council was done by semi-structured depth interviews. In each case, after identifying a Civic Exnora, the key persons managing the Civic Exnora were identified and interviewed. The questions explored were : when and why was the Civic Exnora in this neighbourhood started; what services are provided; how much fee is charged; how is collected; how co-operative the households were; whether any plans were being considered to improve the neighbourhood. The details given by them were crosschecked by interviewing a local household.

3.2.3 Participant observation :

In this method, the researcher observes as a participant. In Madras, participant observation was used in the following circumstances (with some degree of conversation either during the activity being observed or on its completion):

a. *To understand the retail water trade by water vendors – how they collect empty containers from their clients, travel to the source of water, fill up the containers and engage in transactions concerned, deliver water to the clients* : Retail water vending is present in all parts of Madras. However, only a small percentage of them use a special purpose vehicle for water delivery – many use an ordinary bicycle for the job. There is no previous estimate of the total number of water vendors. My estimate is that there would be about 2,000 retail water vendors, but the number of those having a special purpose vehicle would be about 100. For a large majority of them, it is only a part-time occupation. I approached two water vendors who had kindly agreed to my participation and 'tagging on' to them on one of their water delivery rounds. One of them uses a tricycle cart and the other uses a special purpose cart with a big drum to be hauled by himself. In addition, I interviewed two water vendors – both using bicycle for transporting water. In all the four cases, their selection was not based on any strict sampling procedures but more of a first encounter.

b. *To understand the delivery of water by tanker trucks supplying water to the static tanks in different parts of Madras as part of gratuitous supply of water by the public sector water board (details discussed in chapter 5)* : Drivers of three vehicles were interviewed and a participant observation approach was used by joining the driver and his helper from the point of start (filling station) on one complete trip delivering water to three static tanks.

c. *To observe water transactions between bore-well owners and private water tanker-trucks* : Five bore well owners in different locations in the metropolitan area were interviewed. Even while interviewing the water trade was going on giving a rare opportunity to corroborate what was being said.

d. *To learn about the collection of household wastes by the street beautifiers in different co-operative institutions named Civic Exnoras (discussed in chapters seven and eight)* : In four cases, the street beautifier was interviewed while I accompanied him on one trip of collecting wastes and transporting it to the location where it is tipped into municipal bin or in the transfer station.

e. *To observe the transport of wastes from municipal transfer station to the final disposal site near Kodungaiyur in north Madras by the Corporation of Madras* : The officials of waste management department arranged for me to join an Assistant Executive Engineer of the Corporation of Madras to visit B-Depot (a transfer station in North Madras), the Kodungaiyur land fill site and weighing station there.

In all cases, I was able to take notes and in some cases use of camera was allowed (some times requiring a clarification that I was not a journalist). In some cases, price information is best available by collecting this information as a prospective customer[4]. This approach was used to collect information about (a) the price paid by consumers of water from static tanks; (b) the retail price of mineral water in different parts of Madras. In another instance, the sale counter of Metro Water Board was approached as a prospective applicant seeking water and sewerage connections. A set of forms was purchased at the official price.

3.2.4 Focus Groups and the development of questionnaire:

Two focus group discussions were undertaken to talk to the local households about the key issues to be explored by the proposed survey. A questionnaire that I had already developed during preparatory research was discussed extensively at these focus groups.

The first focus group discussion took place on July 7, 1996, with a group of middle income households in a complex of residential flats. The second focus group discussion involving two high-income households took place in the last week of July. In each case, all members of the households were invited to join the discussion. The purpose of the discussion was explained. The first focus group discussion lasted over four hours and the second one lasted about three and a half-hours. (After the first focus group discussion, some aspects of the questionnaire were revised and the revised questionnaire was discussed at the second discussion.) Participants preferred that these discussions should not be tape-recorded. Notes were taken during the discussions.

A focus group discussion was planned with low-income households but regrettably it did not take place. The local political workers began to take too much interest side-

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[4] To find out the cost imposed by numerous regulations and legal requirements on small firms in Peru, Hernando de Soto and his colleagues set up a fictitious clothing factory and attempted to apply

lining (and even silencing) the local households. Instead, separate discussions were held with three low income households as part of pre-testing of the questionnaire.

Based on these discussions, the questionnaire was modified. The questionnaire contained six parts :

- Part 1 was the introduction section. Here I introduce myself and then the purpose of the survey was explained.
- Part 2 contains questions on ratings for various local services in Madras (including water supply and waste management).
- Part 3 focused on preferences for water supply. It also explored present sources, how these are; whether any methods are used to improve the quality of water.
- Part 4 focused on preferences for waste management services. It also explored waste disposal habits of households and their awareness about waste management issues.
- Part 5 explored details of the demographic and economic characteristics of the household members and attributes of the house (and physical quality of living).
- Part 6 was to conclude with evaluative comments on the survey.

The most significant points emerging from the focus group discussions were the following:

a. The need to explain why I am doing this survey and that this is an independent research and that I am not being hired by the Metro Water Board.

b. The need to mention that the information will be used confidentially and purely for research purposes only.

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for the various necessary permissions which took 289 days. See de Soto (1989) and Mario Vargas Llosa's paper in Corbridge,1995.

c. The need to mention that the interview may take some time.

d. With regard to questions relating to preferences for water supply and waste management (in part 3 and part 4), the focus group discussions clearly favoured a question with a number of options rather than a question about a single option.

e. At the time of first focus group discussion, the options for water supply included an independent yard tap connection from Metro Water Board; a yard tap connection from Metro Water Board to be shared among 5 households; a yard tap connection by private sector and buying water from tanker trucks. Based on the discussion there, an option about recycling water and harvesting rain water was also developed. This was discussed in the second focus group discussion.

f. With regard to waste management, the discussion at focus groups suggested that there is need for exploring waste management habits and awareness.

g. For both water supply and waste management, a relevant monetary variable was suggested to be a monthly payment.

The questionnaire so developed was later pre-tested[5]. 8 households were interviewed as part of the first pre-test. Based on this, the questionnaire was further revised and in the second pre-test, 3 households were interviewed. Compared to the average interview time of 1 hour and 20 minutes in the first pre-tests, the average time taken in the second pre-tests was about 55 minutes to 1 hour. An improvement in terms of clarity was evident from the reduction in the number of times clarifications and explanations were needed. A copy of the questionnaire is reproduced in Appendix 3.

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[5] I used the following questions suggested by Converse and Presser (1986) to further improve the questionnaire during pre-tests : (a) Did any of the questions seem to make respondent uncomfortable? (b) Did you have to repeat any questions? Did respondent misinterpret any questions? (c) Which questions were the most difficult or awkward for you to read? (d) Did any of the sections seem to drag? (e) Were there any sections in which you felt that the respondent would have liked the opportunity to say more?

3.3 Household Survey : Sampling Design Issues :

This section concerns the sample design for the household survey in Madras. In regard to sampling design, Foreman (1991) points out that:

> "..the term sample design refers to the processes by which decisions on a sample plan are reached, together with any incidental research, analysis and calculations. The essential decisions include the sample units to adopt, the sample selection method, the frame to use, the size, stratification, allocation and clustering of the sample, the sample estimation procedure, and if required, the procedures for evaluating sample and nonsample errors to which needed sample estimates may be subject."

While all of these issues are important, these are seen to be largely falling under three sets : those relating to sample selection (*how to select the sample*); those relating to sample size (*how many to select*); and those relating to operationalising these decisions. Availability of secondary data on relevant variables, costs of collecting primary data and local conditions are among the main factors affecting the decisions in this regard.

3.3.1 Sample Selection Method :

Survey research is based on the principle of probability sampling which requires the fulfilment of the condition that *each element in the population is given a known nonzero probability of being selected into the sample* (Frankel, 1983:21). In dealing with very large population, it may not be feasible to construct a sampling frame that lists all the individual enumeration units or listing units (which is necessary to fulfil the condition of each element having a **known** non-zero probability of selection.

Benneh et al., (1993) in the study of environmental problems of Greater Accra Metropolitan Area in Ghana used a stratified sampling strategy. In a study of measurement of demand for improved sanitation services in Ouagadougou, Altaf and Hughes (1994) improvised a clustering procedure. Their two-stage stratified sampling procedure was done by "....a 1-inch square grid ... drawn on a 1:25,000 map of the city, yielding 244 possible enumeration blocks. Of these, 20 were selected at random. The numbers of housing units in three of these were counted yielding an average of 300 units per block. Based on this, every tenth unit in a block was interviewed to yield a sample of 600 households.". In a study to measure the demand for improved household sanitation in Kumasi, Ghana, Whittington et al.,(1993) used a two-stage stratified sampling procedure to select a random sample of 1,633 households. In a study of water markets in Jakarta, Indonesia, Crane (1994) reported a household survey of 291 households in North Jakarta using a sampling strategy of "...a modified cluster approach". Madanat and Humplick (1993) in their study of Faisalabad, Pakistan, collected household data by a two-stage stratified random sampling. Their sample consisted of 300 households from each of the three areas : developed areas, *katchi abadis* (i.e., squatters on government lands) mostly in city-centre; and slums (built on private land converted from agricultural use) mostly on the periphery.

In this research, I felt that the method of cluster samples[6] should be used. Clusters are groups of listing units just as listing units consist of elementary units. If clusters are made of listing units of the elementary units, it is called one stage cluster sample. If sample clusters are selected by simple random sampling, it is termed *simple one stage cluster* sampling. Similarly, simple two-stage cluster sampling[7] involves simple random sampling of clusters in the first stage and in the selected clusters, simple or

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[6] Cluster sampling approach seems to have evolved in the USA between 1936 (when a small but carefully drawn sample provided better result than a nation-wide survey of readers by *Literary Digest)* and the 1948 re-election of Harry Truman. See Chapter 19 of Freedman et al.,1991 for a brief discussion.

systematic random sampling of listing units in the second stage. (Levy and Lemeshow,1991:176). Thus, more than one sampling frame may be involved in cluster sampling. For instance, the sampling frame in the first stage can be all census wards in a city; the sampling frame for the second stage may be all enumeration blocks in a selected census ward and so on.

While *feasibility* and *economy* are cited as the main reasons for use of cluster sampling, Levy and Lemeshow point out the disadvantage of cluster sampling : *the standard errors of estimates obtained from cluster sampling designs are often high compared with those obtained from samples of the same number of listing units chosen by other sampling designs*. The reason for this is the likelihood that listing units within a cluster are likely to be more homogeneous with respect to many characteristics. However, cluster sampling is still the most favoured method in certain circumstances for it is capable of giving the lowest possible standard error at a given cost (Levy and Lemeshow,1991 : 181).

Another important aspect in cluster sampling designs is that of the number of clusters to be sampled because of the trade-off 'between the number of clusters selected and the number of units chosen within it' (de Vaus,1993 : 69). Let us presume, the target sample size is N and there are M clusters from which this sample can be chosen. However, if in the first stage we choose *m* clusters, the sample allocated per cluster will be N/m. It is often recommended that the number of initial clusters chosen should be maximised, though that may have an impact on travelling costs.

[7] Cochran,1977 (pp. 274) uses the term "subsampling, since the unit is not measured completely but is itself sampled". It is also mentioned that the term two-stage sampling is used after Mahalanobis.

3.3.2 Sample Size :

Taking into account various factors including time and resource costs, in Madras survey, a sample size of 200 households was proposed[8]. Given the resources available and given that the target area is a metropolitan city of over 1 million households, cluster sampling was favoured. However, it was proposed to maximise the number of first stage clusters to improve the representativeness of the final sample selected. Further, stratification was proposed to be used in the selection of second stage units and also in the selection of sample households. My final sample yielded 148 responses[9]. As shown in table 3.1, this consists of 109 households from Madras City, 32 households from 9 towns[10] in the adjoining area and 7 households from the rural parts of MMA.

Table 3.1 : Target sample and actual completion

	No. of Households 1991	Percentage of MMA Households	Target sample S	Sample completed C	Completion rate (C/ S)
Madras City	798,279	70%	140	109	78%
9 Towns	221,086	19%	38	32	84%
Other towns and villages	120,073	11%	22	7	32%
Total for MMA	1,139,438	100%	200	148	74%

The final sample distribution is such that share of households from Madras City (109 divided by 148 = 73.6%) is slightly higher in the sample than share of Madras households in total MMA households (which is 70%). Similarly, the share of rest of

[8] Statistics and survey research text books contain suggestions on calculating the sample size. See for example, Cochran, 1977; Rossi et al., 1983; Foreman, 1991; de Vaus, 1991; Levy and Lemeshow, 1991 and Moser and Kalton, 1992. Assumptions need to be made about standard errors.
[9] Sample non-response in Madras survey is discussed in sections 3.3.7 and 3.3.10.
[10] These 9 towns are : Kattivakkam, Tiruvottiyur, Madhavaram, Ambattur, Avavdi, Alandur, Pallavaram, Tambaram and St. Thomas Mount. Together these contained 1 million population (221,086 households) as per 1991 Census.

MMA (i.e., 9 towns plus rural areas) in the sample is slightly lower than population share (26.4% in the sample compared to 30% in population).

3.3.3 Operationalising the Sample Selection Process[11] :

The universe for the sample is formed by all households in the Madras Metropolitan Area (MMA). However, the following two critical assumptions were made in sample selection :

a. *Universe based on 1991 Census* : The only source of reliable information about the universe (i.e., all households in MMA) was the 1991 Census. In the absence of any other information, the 1991 Census data was used. The underlying assumption is that household distribution in Madras Metropolitan Area has not significantly changed from the one reflected by the 1991 data. One danger in making such an assumption is that the sample could be biased if the population distribution has drastically changed between 1991 and 1996. However, studies of cities in South Asia in general and in India in particular, point out that the process of restructuring of cities is slow and long-drawn out one and mainly it relates to a few economic activities such as wholesale trade and transport and storage functions. In the case of Madras, we are helped by the rather slow population growth rate of Madras, which is about 2.1% per annum. Though some of the peripheral areas are fast growing, such high growth rates have got to do with the base population, which is fairly small.

b. *Distinction between house and household* : Though the target is a household, in implementing a sampling method that requires enumeration, it is cheaper and less time-consuming to count houses as these are physically visible. Such procedure masks and lowers the selection probabilities of households living in multi-tenanted premises. However, in Madras, this method has been used. Though the ratio of number of houses to number of households as per Census 1991, was found to be fairly close to 1 in case of a majority of wards, there could still be some bias in using this approach[12].

The target sample was distributed between Madras City and the peripheral towns in proportion to their respective shares in MMA households. In the case of Madras City, sample selection strategy involved a 3-stage cluster sampling while in case of peripheral towns and villages, a 2-stage sampling design was used. This is summarised in Table 3.2.

Table 3.2 : Clusters for sample selection

	Madras City	*MUA Towns and rural areas*
1 st level Clusters Option 1 : Option 2 :	 15 Planning Divisions as per MMDA 10 Zones as per Corporation	 Wards or super-blocks formed by streets
2nd level Clusters	155 Wards	Blocks formed by streets
3rd level	Blocks formed by streets	....
4th level	Sample household	Sample household

3.3.3-A. Sample Selection -- Madras City

For the purpose of selecting the sample, the issue of dividing the city into clusters was considered based on administrative boundaries. Madras City is officially divided

[11] The sample design and operationalisation issues are discussed in detail in Anand, 1996.
[12] So long as the variation in the number of households per house (or dwelling unit) is reasonably small, this approach of counting houses does not bias sample selection. Though population densities vary from one part of the City to another, within a given ward, densities are usually uniform.

into 155 wards[13]. However, using these wards as first level cluster will result in a very large number of first level clusters with serious implications for the survey costs[14]. Therefore, it was decided to use a three-stage cluster selection process.

There were two options for selection of first stage clusters. Option 1 was to use Planning Divisions for first stage clusters and Census wards for second stage clusters. The City was divided by the Madras Metropolitan Development Authority into 16 Planning Divisions. This was done some time in early 1970s at the time of preparation of the First Master Plan. The *advantages* of this option were that :

a) a map showing the Planning Divisions was available,
b) also the population distribution across the 16 Planning Divisions was available from the Master Plan.

However, the *disadvantages* of using this option were that

a) the Planning Divisions were artificial creation of the planners and had no physical or administrative criterion;
b) further, they were created without regard to the ward boundaries and hence in some cases posed problems of overlap (as some wards cut across planning division boundaries).

The **second option** was to use Zones and Divisions created under the Madras City Municipal Corporation Act, 1919. In this scheme, Madras City is divided into 10 zones and for each zone, there is one zonal office with a Zonal Officer. Each Zone was originally created as a node for 15 wards. However, in 1991, the then 150 wards

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[13] These are referred to as 'wards' by Census. However, the Madras City Municipal Corporation Act, 1919, refers to them as 'divisions'. To avoid confusion with Planning Divisions, I use the term ward.

were re-organised into 155 wards, but the system of 10 zones remained intact. The *advantages* of using a zone as first level cluster were that

a) each zone was an administrative and legal entity and

b) each zone was formed by a given number of wards as shown in table 3.3 (and hence, problems of overlap or a zone boundary cutting through a ward are avoided).

Table 3.3 : Wards contained in different zones in Madras City

Zone number	Number of wards	Average no. of households in a ward
1	13	5,350
2	18	3,731
3	18	4,750
4	14	6,292
5	14	7,352
6	18	3,498
7	17	3,783
8	16	5,711
9	12	6,509
10	14	6,307
Madras City as a whole	*155*	*5,150*

[14] This is in line with the suggestion by Foreman (1991 : 179) that "in choosing the nature and size of the clusters to be used, the objective should be to balance the advantages of lower cluster sizes in improving accuracy with those of higher cluster sizes in reducing survey costs".

The disadvantage of using Zone as first level cluster was that the Census data on population etc., were available at ward level and not at zone level. However, this was overcome by aggregating the details from wards to zone level[15].

It was seen that the second option of using zones as first level clusters rather than planning divisions is more advantageous. Also, the variability in population size is somewhat higher in case of planning divisions as compared to the zones and 155 Census wards. Thus, the second option was chosen. It was decided that the target sample will be distributed to all the 10 Zones in the City in proportion to the population[16] (details in Table 3.4).

Table 3.4 : Sample selection - Madras City : Distribution of sample in 10 zones

Zone	Area[17] Square km.	Population 1991 Census	Density persons/ Hectare	Share of Madras City's population	Number of Households 1991 Census	A zone's share of Madras City's households	Sample allocated	Sample completed
1	17.64	334,206	189	8.70%	69,548	8.71%	12	10
2	9.38	354,993	378	9.24%	67,162	8.41%	12	0
3	14.06	436,824	311	11.37%	85,508	10.71%	15	11
4	18.8	417,642	222	10.87%	88,087	11.03%	15	12
5	31.01	471,372	152	12.27%	102,932	12.89%	18	18
6	8.38	319,267	381	8.31%	62,958	7.89%	11	11
7	13.63	322,002	236	8.38%	64,300	8.05%	11	10
8	13.54	420,915	311	10.96%	91,377	11.45%	16	11
9	23.52	359,544	153	9.36%	78,105	9.78%	14	12
10	27.61	404,631	147	10.53%	88,302	11.06%	16	14
Madras City	**172.00**	**3,841,396**	**223**	**100.00%**	**798,279**	**100.00%**	**140**	**109**

[15] For example, Zone 1 contains divisions (wards) 1 to 13. From 1991 Census, population of each ward was available. By adding these together, we obtain population of zone 1. The process is repeated for each of the 10 zones.
[16] Such a design has advantage in minimising variance. On the other hand, it is common in cluster sampling designs to choose a random sample of clusters and select further sample from these selected clusters.
[17] The area data is calculated based on area of 1981 Census wards. It is not totalling to 172 square km.

It may be noted that in zone 2, no interviews could be conducted[18]. However, in terms of population characteristics, this zone has many similarities with zones 1 and 3 from which a number of households have been represented in the sample. Since we have sampled from 9 out of 10 zones i.e., 90 per cent of 1st level clusters, the danger of under-representing any specific socio-economic group is likely to be fairly limited.

As seen in table 3.3 earlier, on average each zone contains 14 to 16 wards. The sample allocated to a zone was further distributed to two or three wards in that zone. The selection of sample wards in each zone followed a stratification procedure. Population size, population growth rate, density of population, average household size, sex ratio and female literacy levels were used as the criteria for selection of the sample wards[19]. (Classification of wards according to some of these criteria is presented in the maps in Anand, 1996). Wards which exhibited extreme values in case of more than one variable were included in the final sample. The selected wards in each zone are shown highlighted in Table 3.5.

[18] As per the original plan, I was going to do these in the second week of October. However, field work had to be stopped by first week of October. See section 3.3.7.
[19] Stratification according to income or according to consumption of the good in question (water, solid waste collection services, visit to beach etc.), would have been ideal. However, such information is not available at ward level.

Table 3.5 : Selection of sample wards based on stratification criteria

	Ward number corresponding to the lowest and highest value of the parameter concerned among all wards in a given zone										
Zone	Density		Household size		Sex Ratio		Female Literacy rate		Population Gr. rate 1981-1991		Other
	Low	High	Low	High	Low	High	Low	High	Low	High	
1	*1*	12	3	4	6	13	*11*	2	4	5	
2	28	21	20	27	*30*	*22*	14	23	22	27	
3	47	41	37	49	49	*37*	42	37	49	45	*44*
4	55	56	58	51	*56*	54	60	50	61	62	*63*
5	64	71	77	69	*74*	*71*	72	70	71	74	*65*
6	*80*	89	85	82	80	93	91	85	92	*89*	
7	98	100	*107*	103	111	113	97	*102*	102	110	
8	*126*	125	129	119	129	114	116	*125*	115	127	
9	134	*141*	132	139	141	133	136	133	140	130	*135*
10	153	*144*	255	145	153	148	154	*151*	147	155	

Note : Italics correspond to wards selected.

In four cases, wards other than those fulfilling the stratification procedure were included :

Zone 3 : 44 is chosen as it is one of the four wards in Madras declared to be having very high incidence of mosquito breeding and malaria parasite index (MPI) as per a recent notification by the Madras Corporation.

Zone 4 : 63 is chosen as it is part of fringe areas added to City limits in 1978; also it is very fast growing.

Zone 5 : In this zone, instead of two, three wards were chosen since this zone covers a widely divergent set of wards from core to the periphery. While wards 71 and 74 have qualified on chosen criteria, ward 65 was chosen to represent peripheral areas without water mains.

Zone 9 : Ward 135 is a fast growing ward and is also an area that faces flooding and poor drainage.

In addition, the following specific points were taken into account in choosing the sample wards :

Zone 1 : Ward 11 was chosen because it is the ward with lowest female literacy rate not only in this zone but in entire Madras. Ward 1 is on the periphery, and is of low density. Water and sewerage services are not available. Also, a large garbage dump is located close to this area.

Zone 6 : Though ward 80 was originally chosen, during the survey, it was found most this ward is predominantly occupied by a defence property with residential quarters for armed services personnel. They are not covered by municipal law and have their own water supply arrangements. Hence, in place of ward 80, survey was conducted in ward 81 (a neighbouring ward, sharing many environmental characteristics).

Zone 7 : Ward 107 was chosen since it covers a very high income area in part and some low income clusters; secondly, a very large water works station for Krishna water project is under execution in this ward and thirdly, there is a large garbage transfer station right on the main road.

In each of the selected ward, blocks were created using street maps[20]. These blocks were assigned serial numbers and then randomly, the requisite number of blocks are chosen. In the selected block, a random binary number and two random numbers

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[20] If there is one aspect of research in developing countries that is most constrained, it relates to availability of good quality maps. In Madras, all the available maps from different sources were examined and finally a Madras City map prepared by a local map-publishing private company called TTK Limited was used. The ward boundaries were obtained from a map given by Corporation of Madras and these were transferred to the TTK map.

were drawn (depending on the estimated number of households in that block). The binary number determines whether the sample will be selected from the left hand side of the road or the right hand side[21]. The first random number indicates from where the counting will start; the second random number gives the destination to reach the sample household. (For instance, 1 and 19 meant, one started at a corner of the block and chose the 19th house on the right hand side of the road.) If the house so reached in uninhabited or is under non-residential use, the first house of similar type that follows is chosen (*nearest neighbour* principle[22]).

In the selected household, an available adult member was interviewed. First, an inquiry was made whether head of the household was available and whether he/she would like to participate. The participation of other members of the family was encouraged.

3.3.3-B. Sample Selection -- 9 Towns and Suburban Areas

In case of the 9 towns in suburban area, and other towns and villages, the major constraint was the non-availability of any map. Hence, for the purpose of sample selection in these towns, efforts were made to contact the concerned local body and collect a town map. This was one of the most time-consuming tasks. The sample selection was achieved by either dividing the town into wards (where such information was available) or into different parts (or super-blocks) using the major roads in the area as dividers.

These super-blocks were assigned serial numbers and randomly the requisite number of super-blocks were selected. In the selected super-block, the procedure is repeated once again by creating blocks formed by streets and pathways. In the selected block, the household is chosen by choosing a random binary number (either 0 or 1) to

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[21] This procedure was not needed when only one side of the street falls in the selected block.
[22] See section 3.3.8 on this.

decide which side of the street and two random numbers -- one for random starting point and the other for the target household. For instance, a set of 0,4, 16 means that the sample household will be on the left side of the street; the counting will start from the fourth house and the 16th house in that line will be the sample household.

3.3.4 Are Low Income Households Adequately Represented?

At an early stage in the sampling design, it was decided that a control would be set up to ensure adequate coverage of low-income households. In cities in developing countries, the number of low income households is significant (estimates range from 30 to 50%). Often, they live in areas which are legally declared to be uninhabitable and hence may be shown on the maps as water bodies or open spaces etc. Using a sampling procedure that relies on creation of blocks from street maps may not capture all the low income areas and therefore could lead to under-representation of low income households in the final sample.

In Madras, as per earlier studies, about 31 per cent of population is classified as low income groups living in slums, squatter settlements, tenements constructed by Slum Clearance Board and on pavements and river margins (Dattatri and Anand, 1991). Therefore, it was decided that in each sample ward, approximately 31 per cent of the target sample will be selected from among the low income clusters in that ward. This may slightly bias the sample because the low income households in Madras are not uniformly distributed in all the wards. An alternative would be to estimate the number of low income households in each ward and stratify the sample allocated to a ward in accordance with that distribution. However, in the absence of ward-wise data on number of low income households, that approach could not be used.

3.3.5 Are Women Adequately Represented?

In many cultures, who responds to a knock on the door or an interviewer asking questions depends on a number of norms and factors including : the gender and perceived status of the visitor, the time of the day, the likely benefits from the interaction (or risks of facing costs), whether it is a unique or a regular event and so on. So, for instance, if a formally dressed male visitor knocks on the door, he could be a government official; he could be a person who determines whether or not the household gets certain benefits. Therefore, details are ascertained before it is decided worth the while to participate in the interview : typical questions posed to me were : why I came to their house; whether all other neighbours will also be visited; what details are needed; what will they be used for. In some cases, documentary evidence and my credentials and identity were sought to be established. In such light, it is quite easy for a majority of interviews to be dominated by male members of households. On the other hand, some researchers point out that survey research unwittingly can represent the views of only male-members and systematically become biased. There is also some discussion suggesting a scope for gender-based differences in environmental priorities. Two steps were taken in Madras research to ensure participation of women in the survey (in spite of it being conducted by a male researcher) :

a. *Timing of interviews / house-visits* : Based on focus group discussions as well as experience during the first few interviews, the interview timings were so fixed as to include sufficient number of cases where the respondent is the principal female member (home-maker). It was found that on week-days (Monday to Friday) two time slots were most suited to women : between 10.30 am and 12 noon; between 2.00 pm and 5.00 pm. In low income households, 6.00 pm to 9.00 pm slot was also used, though in some cases it was difficult to proceed with the interview due to lack of electricity or street lights.

b. Leaving the door open or encouraging neighbours to be present : The respondent was specifically told that they may like to leave the door open or they may like to invite (while I wait outside) any neighbours to join the interview. Pre-tests indicated that the presence of neighbours did not have any negative effect on the interview process.

As a result of these steps, on the whole nearly 43 per cent of the respondents are women. Of these, nearly 40% are the principal homemakers of the respective households. (Another 41% being heads of the household; the remaining 19% being 'members other than head of household or homemaker'.)

3.3.6 Medium of Language of Interview :

The final questionnaire was translated into Tamil with the help of professional translators. It was then re-translated (using double blind process) and was compared with the original English version for translation consistency. For some terms, it was decided to use the English expressions rather than Tamil expressions. [Examples include - *drainage, Metro water* (meaning water supplied by the Metro Water Board - a local expression), *tanker, fire service, electric trains, buses, charge, Corporation Office, connection.*]

The choice of language of the interview was left to the participant. However, in some cases, if the participant was found to have difficulties with interview in English, additional explanation was given in Tamil. In general, low income households preferred interview in Tamil; medium and high income households preferred English.

3.3.7 Conducting the Final Interviews & Handling Non-Response :

The final interviews started from August 7 and continued till October 2, 1996. The proposed sample size was 200 households to be drawn up from Madras City and the suburbs in proportion to the distribution of households. However, 148 interviews only could be completed. This gives a sample completion rate of about 74% (as shown in table 3.1 earlier). Achieving 100% completion was not possible because of the following reasons :

a. *Time taken by preparatory research* : The fieldwork programme envisaged some preparatory research in terms of archival research and depth interviews with officials of the Metro Water Board, Corporation of Madras and Exnora office-bearers. However, these tasks required more time than anticipated, consequently pushing the start date of final interviews to first week of August.

b. *Commencement of Krishna Water Project* : The Krishna Water Project was officially declared open at a public function on September 29, 1996, chaired by the Governor of the State and the presence of the two Chief Ministers of the participating States. There was a publicity blitz accompanying the programme giving many details about the Krishna Water Project. Therefore, it was felt there would be systematic differences in the level of information available to the households before the event and after the event. Therefore, the responses to valuation scenario using the project would be prone to bias from additional information. Though the survey design anticipated that Krishna Water Project would soon be inaugurated, there was no idea about exact dates. Hence, this was an external event on which we had no control.

c. *Elections to local bodies* : Local government elections were announced towards the last week of August. The elections were to be held on October 7, 1996 for suburban municipalities and on October 12, 1996 for Madras City Corporation. The publicity and door-to-door campaigning reached their peak in early October and by the last week of September, surveying already became difficult : participants were getting fed up with the increasing number of visitors coming in promising improvements in local services. It was becoming difficult to explain to them that this survey has no link with elections.

On an average, each interview took about 50 minutes, though some interviews took as long as 90 minutes. The entire fieldwork involved a local travel of approximately 3,800 km., within Madras Metropolitan Area or roughly 25.6 km per interview. Every effort was made to avoid the 'road' side bias – or the bias due to interviewing people who are easily reachable (Chambers, 1983). The first few weeks of the survey period were of hot, dry period of late summer and the later part of the survey had seen some days of very heavy rains.

3.3.8 Substitute households :

Response to surveys can be affected by various factors. During focus groups and initial period of final interviews, the suitable time for interviews were determined and these timing were used in subsequent interviews. Therefore, some of the potential sources of non-response such as dress code, inappropriate time etc., were minimised. However, three types of non-response occurred :

a. Non-response due to unsuitability of time or non-availability of elder members. Such event occurred in less than 5% of the cases.

b. Non-response due to lack of interest to participate in the interview : Only in 2 cases such situation arose.

c. Non-response due to house being vacant or locked : If the house is vacant, then the house can be eliminated from counting and the next inhabited house can be chosen. However, if a house is locked, ideally, a follow-up visit should be used. Such an event occurred in less than 10% of all sample households.

In case of the first type, the participant / respondent was requested to suggest a more appropriate time and a follow up visit was made at that time. In case of second and third type of non-response, a substitution strategy was used. In statistical theory, it is suggested that those who respond on the first time and those who respond subsequently shall be treated separately. The questionnaire design provided for recording this information. Statistical theory discusses various strategies to address non-response and the likely bias that may be created due to non-response. The various options proposed are :

- Substitution approach : where a substitute household is surveyed in the event of nonresponse from sampled household. Two types of substitution are discussed : selection of a random substitute wherein, potential substitutes are selected by a random procedure, prior to the data collection phase of the survey; or selection of a specially designated substitute (normally referred to as backup or *nearest neighbour*) involves identification of one or two substitute units that have similar characteristics similar to those of the sample unit.(Chapman,1983 : 46)

- Network sampling : utilising the information that individuals not necessarily residing in the same households are able to report about one another by virtue of their relations. (Sirken,1983 : 81).

- Double sampling methods : in which a probability subsample of the non-respondents are selected and interviewed and the data is analysed either by randomised approach (see Rao,1983 : 97) or by Bayesian approach (Singh,1983 : 107).

In Madras survey, the nearest neighbour principle was applied keeping the characteristics of the original house in mind, i.e., if the non-response was from a high income household, a similar household was chosen as a substitute. If it was from a low income household (for example living in a slum type of house), another similar household in the vicinity was chosen.

Initially, response from households in multi-family apartments was very poor. After considering the likely factors[23], an alternative strategy was developed. In this approach, the President or Secretary of the house-owners' association of the concerned apartment complex was approached. The purpose of the survey and my background was explained to them and the letters of introduction were produced. Then, their help was sought in randomly choosing one household from the complex and for introduction. This strategy worked well and the response rate from flats/apartments after the adoption of the strategy was 100 per cent.

3.3.9 Are substitute households systematically different from the rest of the sample?

As mentioned earlier, the use of nearest neighbour principle was adapted when a household did not respond or was not available even after a repeat visit. Here, comparisons are presented between the 130 households who were available when first contacted and the 18 households who are substituted for households who were not available for various reasons. The former are referred to as 'original sample households' and latter as 'substitute households'.

a. Variance in average household size for substitute households is not systematically different from that for original sample households.

$F_{1,146}$: 0.3770 p : 0.54 Not rejected.

[23] Mainly security seemed to be the concern. Even though I had my identity card displayed on my person and carried the necessary introduction letters, some people were reluctant even to open the doors.

b. Mean household income for substitute households is not significantly different from that for original sample households.

$F_{1,146}$	:	1.5585 p: 0.213	Not rejected.

c. Average number of rooms in the house of substitute households is not significantly different from that of original sample households. Or the density (persons per room) of substitute households is not different from that of original sample households.

$F_{1,146}$	:	0.0188 p: 0.891	Not rejected.	(Rooms)
$F_{1,146}$	:	0.0000 p:0.998	Not rejected.	(density)

d. Educational level of respondents of substitute households is not different from that of original sample households.

$F_{1,144}$	:	0.0001 p: 0.991	Not rejected.

The above F-tests indicate that in terms of variance (of the variables concerned), the substitute households are not systematically different from the original sample households in terms of general socio-economic characteristics. In addition to the above, independent samples t-test was done to compare means of various variables for substitute households and original households. These are shown in table 3.6. Each row in the table provides the result of a t-test comparing the means of the two groups, namely, the 130 households who were interviewed on first attempt and the 18 substitute households.

Table 3.6 : Independent samples t-tests comparing means of substitute households and original households

Variable	Degrees of freedom	t-ratio	Null hypothesis of equal means
Average household size	146	-0.440 (0.660)	Not rejected
Mean household income	146	-1.248 (0.214)	Not rejected
Average number of rooms	146	0.137 (0.891)	Not rejected
Educational level (years of schooling)	144	0.073 (0.942)	Not rejected
Age of respondent	146	0.795 (0.428)	Not rejected

Note : Figures in parentheses are significance for a 2-tailed test.

3.3.10 Non-response rate :

Defining non-response rate depends on whether any substitutes were used when original household was unavailable and whether a distinction is made between substitute households and the others. For Madras survey, we can define non-response rates in three ways (shown in table 3.7). If no distinction is made between substitute households and others, the survey completion rate is also the response rate, i.e., 74 per cent (method 1). This seems to compare favourably with many well-known surveys[24].

[24] For instance, the large-scale CVM study (Carson et al., 1992) for determination of passive use values of Prince William Sound in Alaska had a response rate of 75 per cent. Bishop et al.1995, recommend that "..for a general population where silence of the issue under study is likely to be highly variable across the population, one should still hope for [a response rate of] between 65 and 70 percent".

A second way to define response rate would be to consider those who agreed to be interviewed on first approach as being systematically different from substitute households. If so, 130 of the 148 households approached agreed to be interviewed. The response rate then works out to 87.8 per cent (method 2). A third way is to combine these two. 148 households out of 200 form a truncated sample and of this truncated sample 130 (or 87.8 per cent) are the original respondents. This gives an effective response rate of 65 per cent (method 3).

Table 3.7 : Different estimates of response rate

	Number targeted	Number actually interviewed	Response rate
Method 1	200	148	74%
Method 2	148	130	87.8%
Method 3	200	130	65%

As seen earlier, a comparison of the substitute households versus those who were interviewed in the first attempt itself did not indicate any systematic differences between these two groups. Therefore, response rate here can be considered as that estimated under method 1 above.

3.4 Summary :

This chapter has discussed various aspects of field work of this research. Qualitative research methods such as archival research, depth interviews and participant observation were used to understand water supply and waste management provision in Madras. Focus group discussions and pre-tests were used to improve the questionnaire which was subsequently used in the household survey. The survey in Madras was conducted using the cluster sampling method. The original target was to interview 200 households. However, due to the announcement of local government elections and the arrival of heavy rains due to the on-set of monsoon, I could complete only 148 interviews. When the house identified from sample design was empty or when the identified household refused to be interviewed or was unavailable, substitute households were identified by the 'nearest neighbour' principle. 18 of the 148 households interviewed were substitute households. However, we saw that these substitute households are not systematically different from the remaining 130 households in terms of various demographic variables. The sample completion rate in terms of 148 households against the target of 200 households (or 74%) compares favourably with the experience in other surveys reported in the literature.

Chapter Four
Some Aspects of Quality of Life in Madras

4.1 Introduction :

Discussions on quality of life[1] cover a wide range of issues. It is possible to approach quality of life as fulfilment of certain basic rights (Nozick), or as a fulfilment of basic needs (Streeten, 1995) or as the ability to fulfil several dimensions of needs (Maslow; also Allardt,1993) or as the freedom to achieve various capabilities (Sen, 1999). In this chapter, my focus is limited to the physical conditions of quality of life of households in Madras. My aim is to understand how water supply and waste management are seen by households in Madras in relation to other services.

This chapter presents a number of cross-tabulated results from the household survey. Three main issues discussed here are : (a) some demographic characteristics; (b) housing and quality of living conditions and (c) perceptions about the quality of various services in Madras. With regard to (b) above, an attempt is made to construct a quality of life index based on survey responses. Some of the results from the sample survey are compared with those from Census 1991. *It needs to be emphasised that the rather small size of sample does mean that sample variability is likely to be the main reason for differences between distributions from this sample and those of the Census.* Other potential reasons for a difference between sample data and the population data (from the secondary source) may be differences in definitions, the quality of data, the reference time period of the two data sets.

[1] For a discussion on quality of life, see Nussbaum and Sen, 1993. The expression physical quality of life index was used originally from epidemiological perspective (mainly based on infant mortality rate and life expectancy at age one) by Morris (1979). See Saith and Harriss-White,1999 for a discussion on gender dimensions of such indicators. The focus in this chapter is on physical conditions of quality of life constituted by housing quality, access to water supply, sewerage, waste management services, electricity, television etc. I am not considering other dimensions such as :

The remainder of the chapter is organised as follows: section 2 summarises some demographic characteristics of the respondents from the sample; section 3 focuses on quality of life aspects; the first part of that section considers housing quality; the availability of various services are considered in the second part of that section; the remainder of that section discusses the construction of a quality of life index; section 4 focuses on perceptions of respondents about the quality of various services in Madras; section 5 considers whether the rich and the poor think differently about the various services; the chapter concludes with a brief summary in section 6.

4.2 Demographic Characteristics :

Here, the information from the sample survey concerning the following characteristics is summarised: income, age-group of respondents, and household size.

4.2.1 Household Incomes :

It is well established that asking details of income in household surveys does not produce reliable information due to various reasons (Rudra,1989; Deaton 1997 : 30). Instead of income, it is recommended that one should explore details of actual consumption expenditure in a reference period (last one month or last one week) and use that information to impute income. However, even this kind of information is difficult to collect.

In the Madras survey, I decided to use a number of criteria and assign the household to one of the five income groups, namely: very low, low, medium, high or very high income. (Distribution of sample households in Madras Metropolitan Area as per the five income groups is shown in table 4.1 and also in figure 4.1.) The criteria used were : the number of earners and their occupations and educational level,

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fundamental liberties; political freedoms; property rights; and social dimensions (interactions with friends, family), etc.

characteristics of housing, and ownership of consumer durables. Depending on these criteria, respondents were placed in one of the five income groups. Based on discussions with focus group participants and also local researchers, the likely range or band of monthly incomes for each category was specified. The average monthly income figures for each category shown in table 4.1 are based on this range. During the pre-tests of the questionnaire, I asked the respondents whether I could place them in a particular income group and showed them the range or band of income of that group and they agreed.

Table 4.1 : Distribution of households in Madras Metropolitan Area : 1996

	Income group (and the mean monthly income of a household in the group in Rs.)					
Spatial unit	Very low (2,000)	Low (3,000)	Medium (4,500)	High (8,000)	Very High (20,000)	Total
Madras City	11.9%	28.4%	22.9%	21.1%	15.6%	100.0% (109)
9 Towns	12.9%	38.7%	16.1%	25.8%	6.5%	100.0% (32)
Rest of MMA	37.5%	12.5%	25.0%	25.0%		100.0% (7)
Entire sample (N)	13.5% (20)	29.7% (44)	21.6% (32)	22.3% (33)	12.8% (19)	100.0% (148)

Note : Figures are row percentages. (Figures in parenthesis are number of households in the sample).

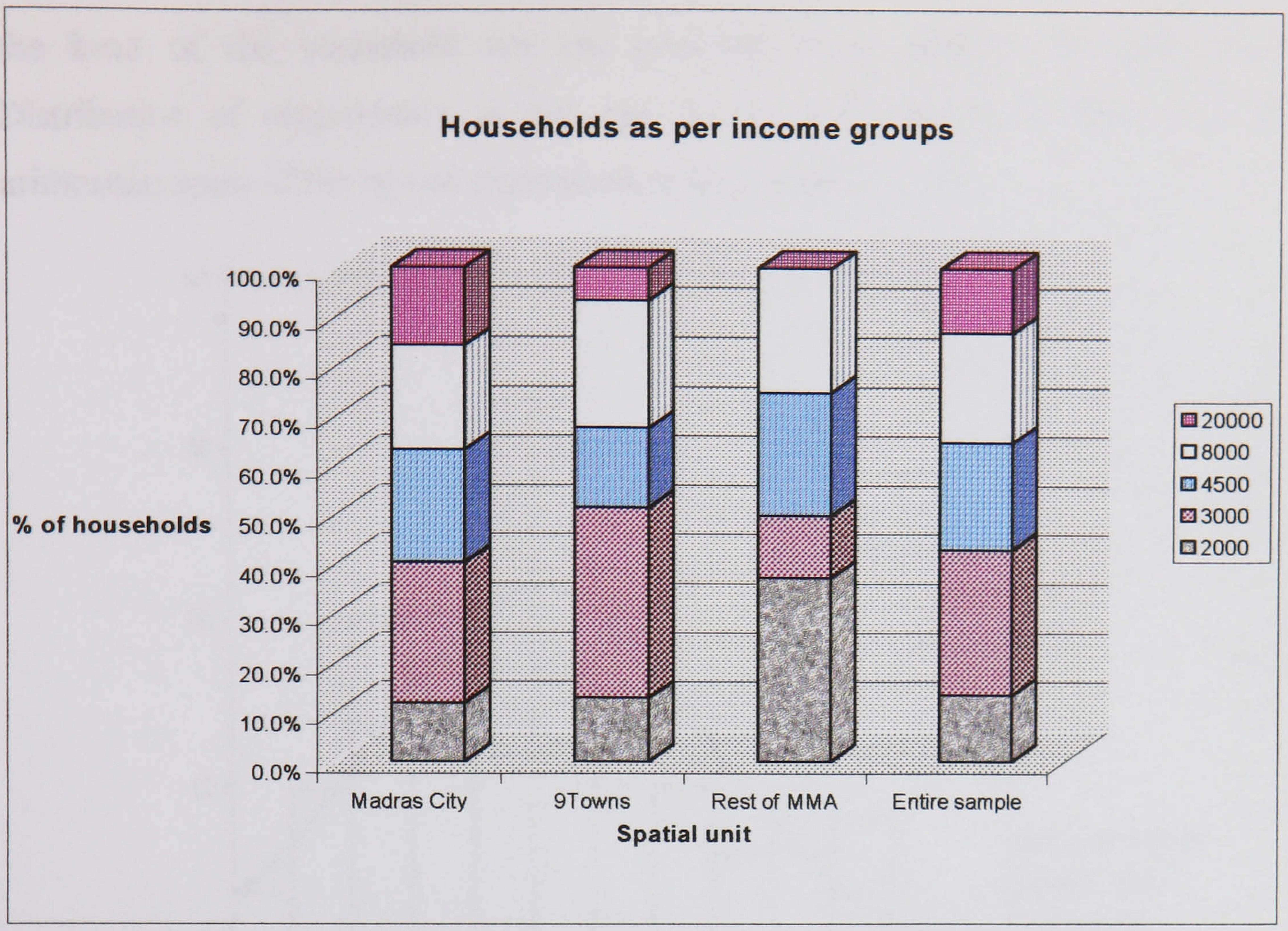

Figure 4.1 : Distribution of households as per monthly income

In analysing the data in subsequent chapters, for income figures, these mean monthly household income figures will be used. This may have the effect of limiting the explanatory power of, and restricting the contribution of, income as an independent variable in the analyses. However, the alternative was to use an open-ended question and ask the respondents to give a figure which (focus group and pre-test results indicate) would be very inaccurate in most cases anyway.

4.2.2 Age group of respondents :

Respondents[2] of the survey come from various age groups. In some cases, the head of the household was available and participated in the interview; in others, the principal home-maker, the main female member of the household was available and

[2] In the household survey, sampling design stopped with the identification of the sample household. The decision of which member within the household be interviewed was left to the respondents themselves.

was interviewed. In a small number of cases, an adult member of the family (but not the head of the household nor the principal home maker) was interviewed. Distribution of respondents as per age groups is presented in figure 4.2. The arithmetic mean of the age of respondent is 43.1 years.

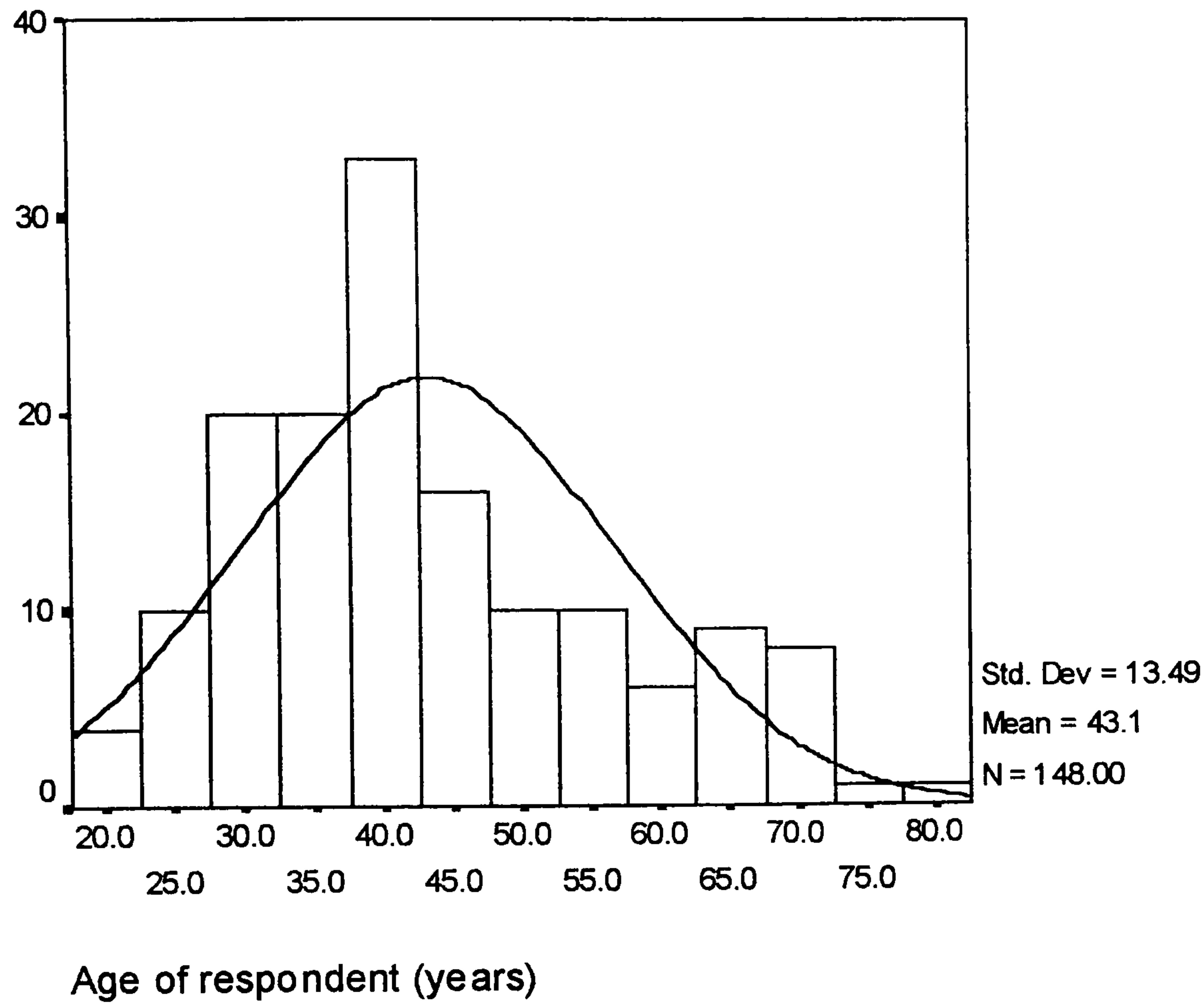

Figure 4.2 : Age of respondents in Madras Survey

Table 4.2 gives details of respondents as per their age group in each of three spatial units in the Madras Metropolitan Area. The median class (with the exception of 9 Towns) is that of the age group of 41 to 50 years.

Table 4.2 : Distribution of sample respondents as per age group of respondent : 1996

	Spatial Unit			
Age group of respondent	Madras City	9 Towns	Rest of MMA	Entire sample
≤ 20 years	0.9%			0.7%
21 to 30 years	12.8%	22.6%	25.0%	15.5%
31 to 40 years	33.0%	29.0%	12.5%	31.1%
41 to 50 years	27.5%	25.8%	37.5%	27.7%
51 to 60 years	10.1%	6.5%	12.5%	9.5%
61 to 70 years	11.9%	12.9%	12.5%	12.2%
71 to 80 years	3.7%	3.2%		3.4%
Total	100.0% (109)	100% (32)	100.0% (7)	100% (148)

Note : Figures are column percentages.

Figure 4.3 provides details of distribution of respondents as per gender and age group. It can be seen that no major differences or extreme variations are noticeable. Of the entire sample, 40 per cent of respondents were in the age group of up to 40 years.

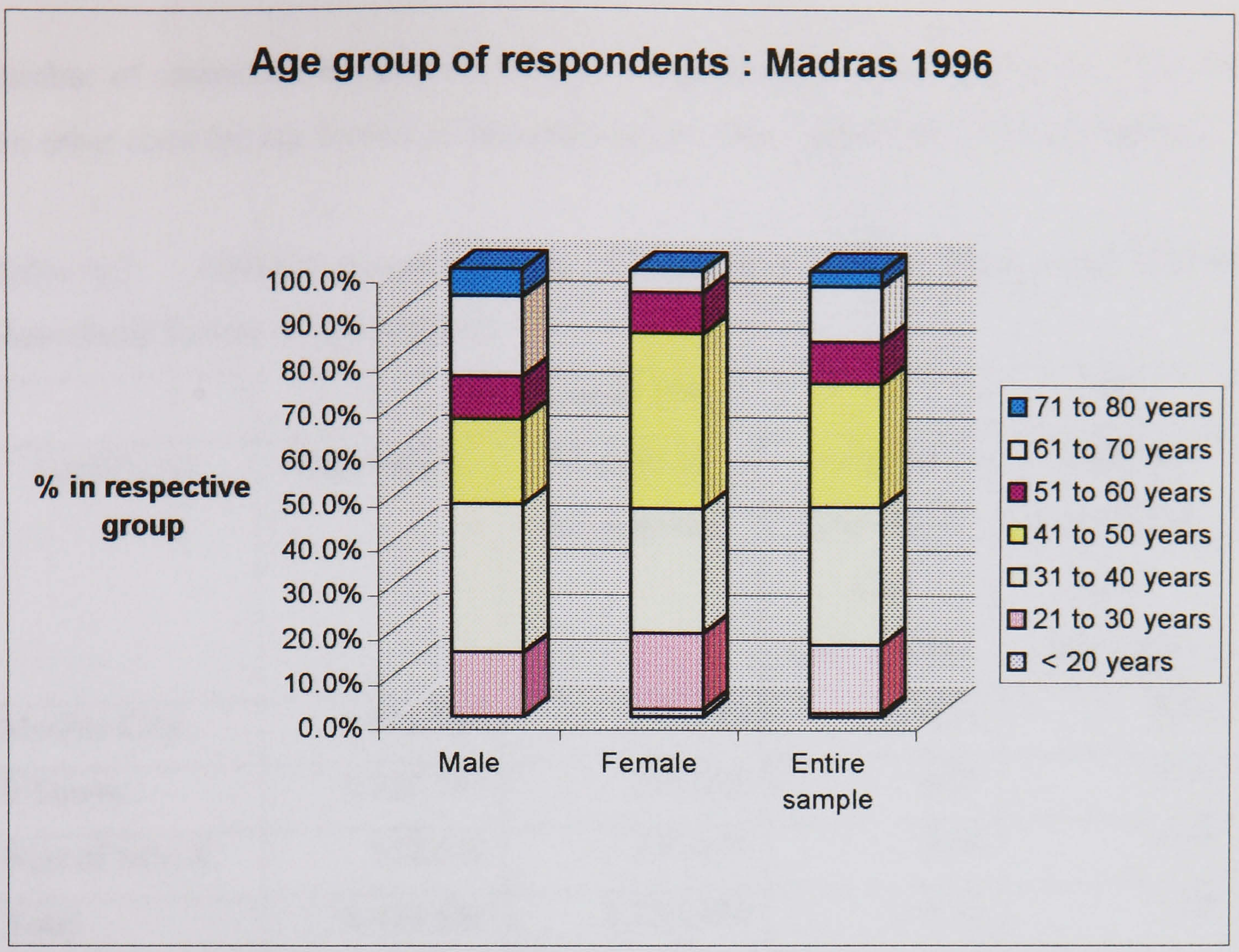

Figure 4.3 : Distribution of respondents as per gender and age group

4.2.3 Average household size :

As per 1991 Census, the average household size in entire MMA is 4.76 whereas in my survey the average household size for the entire sample is 5.08 and is on the higher side. However, the divergence is mainly in the case of households in 9 Towns and the Rest of MMA (representing 30% of the population). These details are shown in table 4.3. While this divergence could be partly due to sample variability (as already mentioned), it is likely that by placing a control of 30 per cent of sample to be drawn from low income households, my sample may have a slight over-representation of low income households[3]. Errors in reporting (deliberate or otherwise), a natural increase in household size between 1991 and 1996 due to marriage and birth of children, increased rural-urban migration (of single members who join their relatives in the city while looking out for a job), increase in the

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[3] Income and household size relationship is discussed further on in this section.

number of composite households (due to rising land and house prices) could all be the other contributing factors to this divergence. These issues need further thinking.

Table 4.3 : Average household size : Comparison of 1991 Census and Madras Household Survey of this research

	Census 1991			1996
Spatial unit	Population	Number of households	Average Household size: Census 1991	Average Household size : this study
Madras City	3,841,396	798,279	4.81	4.80
9 Towns	1,027,747	221,086	4.65	5.90
Rest of MMA	552,842	120,073	4.60	5.50
Total	5,421,985	1,139,438	4.76	5.08

Sources : Census of India,1991; and Madras Survey.

Studies in developing countries indicate a negative relationship between household income and household size. In Madras, no such relationship was observed as seen from Table 4.4 (showing the details of average household sizes in five income groups), though the average household size in highest income group is the smallest. The largest average household size is in a middle income group (mean income Rs. 8,000).

Table 4.4 : Mean household sizes in each income group : 1996

	Mean Monthly Income Rs.					Entire
Variable	2,000	3,000	4,500	8,000	20,000	Sample
HH size	4.9	5.3	4.7	5.5	4.6	5.1
No. of adults	2.9	3.6	3.4	4.1	3.8	3.6
No. of children	2.1	1.8	1.3	1.4	0.8	1.5

Note : Though HH size is made up of numbers of children and adults, the figures above are mean values for each variable and they will not necessarily add up.

Further details of household sizes for the zones in Madras City are presented in table 4.5. It can be seen that difference between Census and this sample survey is slightly high in case of zone 7. (This issue is examined further below).

Table 4.5 : Household size for zones in Madras City.

	Census 1991			1996
Zone	Population	Households	Average Household Size	Average Household Size from Survey
1	334206	69548	4.81	4.8
2	354993	67162	5.29	
3	436824	85508	5.11	5.5
4	417642	88087	4.74	4.2
5	471372	102932	4.58	4.1
6	319267	62958	5.07	4.9
7	322002	64300	5.01	6.8
8	420915	91377	4.61	5.3
9	359544	78105	4.60	4.6
10	404631	88302	4.58	4.1
Madras City	3841396	798279	4.81	4.8

However, no reason other than natural variability from sample to sample is obvious. Detailed analysis of the 10 households sampled from zone 7 indicates that only two of these 10 households, have reported a household size of above 10 persons. 5 of these 10 are composite households – or known in Madras as 'joint family'. Though household size is large, density, i.e., number of persons per (habitable) room should be the other indicator (Details of these 10 households are given in table 4.6). A density of up to 3 persons per room (2 adults and one child) is fairly common in Madras.

Table 4.6 : Details of sample households in zone 7 : 1996

Serial number of interview	Income Rs. p.m.	No. of adults	No. of children	HH size	No. of rooms	Density (Persons per room)
26	3,000	2	4	6	1	6.00
25	3,000	7	7	14	3	4.67
40	3,000	3	1	4	1	4.00
39	4,500	6	1	7	2	3.50
51	20,000	4	1	5	3	1.67
38	8,000	7	4	11	10	1.10
24	20,000	7	1	8	8	1.00
41	8,000	3	2	5	6	0.83
21	20,000	2	0	2	3	0.67
37	20,000	5	1	6	10	0.60

From the details in table 4.6 above, it is seen that 4 of the 10 households have density of over 3 persons per room. This issue will be discussed again in relation to housing conditions.

4.3 Towards an Index of Quality of Life :

4.3.1 Housing Conditions :

The quality of housing can be described in terms of the quality of wall, flooring and roof of the house and in terms of the number of persons sharing the living space and facilities. Table 4.7 provides information on households according to income group and wall material.

Table 4.7 : Housing conditions – 1 : Income group and wall material : 1996

	Mean Monthly Income Rs.					
Wall material	2,000	3,000	4,500	8,000	20,000	Entire sample
Mud	20.0%	4.5%				4.1%
Bamboo	5.0%					0.7%
Bricks	15.0%					2.0%
Bricks & Cement	60.0%	95.5%	100%	100%	100%	93.2%
All N	20	44	32	33	19	148

Note : Figures are column percentages (exception – last row).

It is seen that only a small number (10 out of 148) of households live in houses with walls made of non-durable materials. Table 4.8 presents similar information on housing conditions as per material used for flooring.

Table 4.8 : Housing conditions –2 : Income group and flooring material : 1996

	Mean Monthly Income Rs.					
Flooring material	2,000	3,000	4,500	8,000	20,000	Entire sample
Mud	15.0%	2.3%				2.7%
Slate				3.0%		0.7%
Cement floor	80.0%	81.8%	46.9%	15.2%		48.6%
Coloured cement	5.0%	13.6%	21.9%	21.2%		14.2%
Mosaic		2.3%	31.3%	60.6%	89.5%	32.4%
Marble					10.5%	1.4%
All N	20	44	32	33	19	148

Note : Figures are column percentages (exception – last row)

In low income groups, a majority of households live in houses having cement flooring (which is durable but unattractive, basic and accumulates dust easily and hence needs sweeping regularly). The progression seems to be to a smoother coloured cement (known as 'red oxide') floor, or to mosaic floor (which is the most preferred one for higher income groups).

Table 4.9 presents information of roof of the house across the five income groups. Low income households predominantly live in houses with roofs of temporary material such as thatch or coconut leaves. These households face the highest risks of houses being damaged at any time of the year : during the wet season, from the annual heavy monsoon rains (October-November) or cyclones which occur once in three or four years; during the rest of the year from fire hazards. A few of the low income households also live in houses with roofs of asbestos cement (AC) or galvanised cement (GC). Though these are equally at risk of being damaged during cyclones, they are somewhat less risky in terms of fire hazards or normal rains. Madras terrace roofs are brick arch roofs constructed with traditional technology and can be seen in houses constructed 30 or more years ago. Among houses constructed in more recent past, tiled roof seems to be next preferred option for the low income groups. A majority of the middle and high income group households, live in houses with reinforced cement concrete roof.

Table 4.9 : Housing conditions - 3 : Income group and roof material : 1996

	Mean Monthly Income Rs.					Entire
Roof material	2,000	3,000	4,500	8,000	20,000	Sample
Thatch, leaves	55.0%	11.4%				10.8%
AC/GC sheets	15.0%	9.1%				4.7%
Tiles	15.0%	40.9%	15.6%	3.0%		18.2%
Madras Terrace	5.0%	9.1%	31.3%	21.2%		14.9%
RCC roof	10.0%	29.5%	53.1%	75.8%	100%	51.4%
All N	20	44	32	33	19	148

Note : Figures are column percentages (exception – last row).

From the above three tables, among housing conditions, it appears that roof of the house seems to be a good indicator of poverty and deprivation.

Housing classification can also be used to describe the housing conditions. In Madras, seven classes have been used. To describe the characteristics of these seven types, distribution of households as per house type and roof material of the house is shown in table 4.10.

Table 4.10 : Housing conditions – 4: House type and roof material : 1996

	Roof material				
House Type	Thatch	AC/GC sheet	Tiles	Madras terrace	RCC roof
Hutment	53.6%	17.9%	28.6%		
TNSCB tenement					100.0%
Old Madras style		2.3%	36.4%	40.9%	20.5%
Semi-detached		11.1%		11.1%	77.8%
Apartment				14.3%	85.7%
Flat					100.0%
Independent	2.0%		6.1%	4.1%	87.7%
All N	16	7	27	22	76

Note : Figures are row percentages (exception – last row).

Hutments (known in Madras as 'cheris') are the most common housing typology of the poor. These are also known as slums; these are human settlements of very high population density, devoid of many services and often built by the households by themselves on marginal lands such as flood plains, river margins, land located adjacent to major roads. About 250,000 households (as per 1991) were estimated to be living in such settlements in MMA. There are a small number of the urban poor (estimated to be about 30,000 in 1996) sleeping on the pavements but the majority of slums are not on pavements. There is a state slum clearance board (TNSCB) which initially started with the programme of building four storeyed tenements after clearing a slum. The total number of tenements constructed in any given year has been about 250 to 300. As of 1991, it was estimated that about 45,000 households in MMA were living in such tenements (Dattatri and Anand, 1991 : 110). The World Bank funded urban development projects (which started in 1977) shifted the emphasis from clearance to slum improvement – where housing was to be seen as a process and not as a product - whereby security of tenure was to be given to the households and water and sanitation improvements were to be financed (For details of evolution of housing policy in Madras see Pugh,1990; Pugh,1995, de Wit, 1996).

About 100,000 households living in slums have been reported to be covered in these programmes.

Many of the middle income households live in formal housing – either old housing stock i.e., housing built more than 40 years or son; or apartments and semi-detached houses. The highest income group households live in independent houses (bungalows or free-standing or detached houses on their own plot of land) or more recently in a block of flats. Distribution of households as per house type and income is presented in table 4.11.

Table 4.11 : Housing conditions – 5 : Income group and house types : 1996

House type	Mean monthly income Rs.					Entire Sample
	2,000	3,000	4,500	8,000	20,000	
	a	*b*	*c*	*d*	*e*	*f*
Hutment	70.0%	31.8%				18.9%
TNSCB tenement		6.8%				2.0%
Old Madras style	25.0%	34.1%	53.1%	21.2%		29.7%
Semi-detached	5.0%	11.4%	6.3%	3.0%		6.1%
Apartment		2.3%	9.4%	6.1%	5.3%	4.7%
Flat				12.1%	21.1%	5.4%
Independent/ *Bungalow*		13.6%	31.3%	57.6%	73.7%	33.1%
All N	20	44	32	33	19	148

Note : Figures are column percentages (exception – last row).

Besides the quality of materials used, another important dimension of housing conditions is the number of rooms available. There are definition problems in collecting data on number of rooms : in some instances, what the household considers to be a room may be made of temporary partitions used to create functionally different spaces; in others the household may count as a room enclosed space devoid of any privacy or protection from elements (for example, a *verandah* – an entrance porch enclosed on all sides by grill is fairly common). It was thought that the best judge of what the household considers to be number of rooms is the household itself. Table 4.12 clearly indicates the relationship between income level and number of rooms[4].

Table 4.12 : Housing conditions – 6 : Income and number of rooms : 1996

	Mean Monthly Income Rs.					Entire Sample
	2,000	3,000	4,500	8,000	20,000	
1 room	55.0%	27.3%				15.5%
2 rooms	35.0%	52.3%	40.6%	9.1%		31.1%
3 rooms	10.0%	15.9%	40.6%	36.4%	31.6%	27.0%
4 rooms			6.3%	27.3%	15.8%	9.5%
5 rooms			9.4%	6.1%	5.3%	4.1%
6 or more rooms		4.5%	3.1%	21.3%	47.4%	12.8%
Mean No. of rooms	*1.6*	*2.1*	*3.0*	*4.4*	*5.6*	*3.18*

Note : Figures are column percentages.

[4] An OLS regression gives us the relationship : No. of rooms = 1.759 + 0.0002*Mean Income. Both the co-efficients were highly significant (t ratio above 8.0) and R square was 0.327.

As land and housing costs are relatively higher in Madras City as compared to settlements in the rest of the metropolitan area, we can expect overcrowding to be more prevalent in the City. This is evident from table 4.13. This table provides information on distribution of households as per spatial unit and number of rooms. Columns b. c, d and e provide information from 1996 household survey. It is seen that the median class in all spatial units relates to households having 3 rooms.

Table 4.13 : Distribution of households as per spatial unit and number of rooms : Comparison of 1996 Survey and 1991 Census results

	1996 Madras Household Survey				1991 Census		
Number of rooms	Madras City	9 Towns	Rest of MMA	Entire sample (Total for MMA)	Madras City	Rest of MUA	Total for MUA
	(b)	(c)	(d)	(e)	(f)	(g)	(h)
1	19.3%	6.5%		15.5%	42.8%	37.4%	41.2%
2	29.4%	35.5%	37.5%	31.1%	31.3%	32.9%	31.8%
3	22.9%	41.9%	25.0%	27.0%	14.4%	16.8%	15.1%
4	11.0%	3.2%	12.5%	9.5%	7.1%	8.6%	7.6%
5	4.6%		12.5%	4.1%	2.4%	2.6%	2.4%
6+	12.9%	12.9%	12.5%	12.8%	2.0%	1.7%	1.9%
Mean	3.2	3.0	3.6	3.2	2.01	2.11	2.04

Note : Figures are column percentages (exception – last row).

A comparison is also provided with similar distribution from 1991 Housing Tables of the Census of India. Between 1991 and 1996 either housing conditions in Madras improved significantly (less likely) or there is a considerable difference in the definition of number of rooms between my survey and the Census (more likely). In table 4.13, column b (1996 survey) is readily comparable with column f (Census, 1991) for Madras city. While column e relates to entire MMA, column h relates only to the Madras Urban Agglomeration area. The other columns are not strictly comparable. However, column c relates to 9 towns which are part of MUA (column g). The median class in all spatial units as per Census relates to households having 2 rooms. It is likely that the main source of difference between my survey and Census is in the treatment of number of rooms. In my case, the judgement as to whether to count entrance porch or *verandah* as a room or not was left to the household (and many of whom may have counted this as a room).

Another dimension of housing conditions is the density or crowding. This can be defined by the number of persons sharing a room. As an indicator of quality of living, density has an advantage that density is a relative measure as opposed to the number of rooms which is an absolute measure. For instance, for a small family (of say only two adults), a house with 2 rooms may provide better quality of living than for a family with 5 adults sharing three rooms. From the data, we find that in Madras, in extreme cases, there are some families with upto seven members sharing a single room. The mean density is 2.15 persons per room. Table 4.14 indicates that higher density is a living condition of the poor.

Table 4.14 : Housing conditions – 7 : Density (persons per room) : 1996

	Mean Monthly Income Rs.					Entire Sample
Density	2,000	3,000	4,500	8,000	20,000	
More than 3.0 persons per room	45.0%	27.3%	3.1%	3.0%		15.5%
More than 1 but upto 3 persons per room	55.0%	65.9%	71.9%	57.6%	31.6%	59.5%
1 or less number of persons per room		6.8%	25.0%	39.4%	68.4%	25.0%
All N	20	44	32	33	19	148

Note : Figures in column percentages (exception – last row).

The cut-off points used above are arbitrary but they indicate the negative relationship between income and density. This is further evident from the range of densities shown in table 4.15.

Table 4.15 : Housing conditions – 8 : Minimum and maximum densities for each income group : 1996

	Mean Monthly Income Rs.					Entire Sample
	2,000	3,000	4,500	8,000	20,000	
Minimum density	1.50	0.50	0.20	0.22	0.22	0.20
Maximum density	7.00	6.00	3.50	4.00	2.00	7.00
Mean	3.56	2.90	1.73	1.37	1.00	2.15

Note : Figures are densities in number of persons per room.

A regression in logarthmic form yields the following relationship :

$$\text{Log (Density)} = \underset{(10.816)}{5.860} - \underset{(-9.823)}{0.624} * \text{Log (Mean income)}$$

R square of 0.398 (t ratios given in parenthesis above). A 1 per cent increase in income is, thus, likely to result in 0.62 per cent reduction is density.

Earlier, a point was noted with regard to average household sizes that average household sizes in zone 7 in this survey seemed to be on the higher side compared to Census of India 1991 data. However, in terms of density (i.e., number of persons per room), we see from table 4.16 that zone 7 is not exceptionally different from other zones.

Table 4.16 : Density – persons per room : Comparison of zones in Madras : 1996

Spatial unit	Zone	Density persons per room
Madras City		2.15
	1	2.78
	3	2.73
	4	2.26
	5	1.85
	6	1.65
	7	2.40
	8	1.81
	9	2.37
	10	1.79
9 Towns		2.26
Rest of MMA		1.79
For entire sample		2.15

Another point that emerges incidentally is that densities in north Madras zones are higher than those in other zones.

A final point with regard to housing conditions concerns tenure of housing. However, the relationship of this with quality of living is not easy to deduce in comparison with other dimensions of housing quality discussed so far. In Madras survey, the respondent was asked whether they are owners or tenants. If they reported tenure as being tenants, monthly rent was ascertained. Table 4.17 provides details of tenure status for households in Madras and also compares this with Census 1991 data.

Table 4.17 : Households as per tenure : Madras Survey and Census 1991

	1996 Madras Household Survey				1991 Census		
Tenure of house	Madras City	9 Towns	Rest of MMA	Entire Sample (Total for MMA)	Madras City	Rest of MUA	Total for MUA
	(b)	(c)	(d)	(e)	(f)	(g)	(h)
Owner	61.5%	77.4%	87.5%	66.2%	39.7%	55.7%	44.4%
Rental	38.5%	22.6%	12.5%	33.8%	59.0%	43.4%	54.4%
Other					1.3%	0.9%	1.2%

Note : Figures are column percentages

Either my survey has an over-representation of households who are owners of their house rather than those living on rent; or some of the households who are actually tenants may have reported to me to be owners, or the 1991 Census could be biased. To understand this issue, the break up of tenure with regard to house-typology is presented in table 4.18.

Table 4.18 : Households as per house typology and tenure : 1996.

Housing typology	Tenure		Column percentage of all households
	Owners	Tenants	
Hutment	75.0%	25.0%	18.9%
TNSCB tenement	100.0%		2.0%
Old Madras style	38.6%	61.4%	29.7%
Semi-detached	33.3%	66.7%	6.1%
Apartment	42.9%	57.1%	4.7%
Flat	87.5%	12.5%	5.4%
Independent/ *Bungalow*	83.7%	16.3%	33.1%
Of all households	66.2%	33.8%	100.0% (148)

Note: Figures in columns 2 and 3 are row percentages; figures in the last column are column percentages.

From the above table, it appears that ownership levels may have increased owing to significant liberalisation of housing finance sector between 1991 and 1996. Other interpretations could be : (a) The question on ownership in my survey may have been interpreted as that of the shelter, in Census it may relate to land ownership. For example, 75 per cent of those living in hutments reported to be owners, whereas, the slum improvement programmes (under the World Bank funded urban development projects) have covered less than 50 per cent of hutments (and transfer of ownership of land to the hutment dwellers has been progressing slower than expected, see de Wit, 1996). It is possible that the households' interpretation that they are not tenants (in the sense of paying land rent to any one) is correct but that does not mean they are 'owners' as far as land may be concerned. (b) Another source of mis-reporting may occur due to security reasons : many households may not want to report to a stranger whether or not they are owners. (c) The definitions employed by Census and my study could be different.

4.3.2 Availability of Services :

Water, sanitation and electricity are the three essential services for urban living. As water and sanitation are the focus of this research, detailed analysis of household access to different sources of water and the inequalities therein are discussed further on in the following chapters. Here, a brief summary is provided on these issues in relation to the wealth ranking or quality of life index exercise.

A. Water supply :

With regard to water, households in Madras can be seen as belonging to one of three groups : households without access to any source of water within the premises; households having access to either a well or a tubewell in their premises (but no connection to municipal systems); and households having access to municipal or Metro Water connection. Table 4.19 provides the distribution of households in Madras as per this preliminary grouping.

Table 4.19 : Services –1 : Source of water and income group : 1996

	Mean Monthly Income Rs.				
	2,000	3,000	4,500	8,000	20,000
No source in the premises	40.0%	34.1%	9.4%		
Well or tubewell	55.0%	47.7%	43.8%	48.5%	15.8%
Tap connection[5]	5.0%	18.2%	46.9%	51.5%	84.2%
N	20	44	32	33	19

Note : Figures are column percentages (except N, the sample size).

[5] A significant number of these share a connection with other households. Some households in this group also have other sources, namely a well, or a tubewell or both. In the next chapter, a detailed discussion of sources of water and whether it is a good indicator of access to water is taken up.

Needless to say, the number of sources is a poor indicator of water security or water availability for the household. These issues are discussed in the following chapter.

Again, a quick comparison with the 1991 Census figures, is provided in table 4.20. The main source of difference here is likely to be in the treatment of households who share a connection. Typically, these are multi-family dwellings (with three or four households) but only one of the units may have the water connection.

Table 4.20 : Sources of water : Comparison of 1996 Survey and 1991 Census

	1996 Madras Household Survey				1991 Census		
Sources of water	Madras City	9 Towns	Rest of MMA	Entire sample (Total for MMA)	Madras City	Rest of MUA	Total for MUA
	(b)	(c)	(d)	(e)	(f)	(g)	(h)
No source	19.3%	16.1%		17.6%	38.7%	37.6%	38.4%
Well, tubewell	22.0%	54.8%	100.0%	33.1%	34.2%	54.0%	40.1%
Tap in the premises	58.7%	29.0%		49.3%	27.1%	8.4%	21.5%
Total	100.0% (109)	100.0% (32)	100.0% (7)	100.0% (148)	100.0%	100.0%	100.0%

Note : Figures are column percentages.

It is likely that in Census, it may be recorded as 1 household having tap connection and the remaining 2 or 3 households as not having any source within the premises. The support for this argument comes from Census data. Of all the households not having any source in their premises, 44 per cent in Madras City and 37 per cent in Rest of MUA reported a tap (out side the premises) as their source of water. If we adjust the Census figures correspondingly (and treat all those not having a source but reporting a tap outside their house essentially as those sharing a connection), the figures of people without any source of water in their premises will be : 21.7 per cent and 22.5 per cent in Madras City and Rest of MUA respectively, compared to 19.3 per cent and 16.1 per cent from the 1996 survey.

B. Toilet :

The availability of toilet is a very important factor in determining the environmental health risks faced by the households. Studies indicate that one of the determinants of diarrhoea is the need for a number of families to share a single toilet. Thus, besides availability of a toilet, information on whether it is shared with other families or whether it is exclusively available for the use of a given household seems to be important. Table 4.21 provides information on distribution of households as per income group and availability of toilet.

Table 4.21 : Services –2 : Household income and availability of toilet : 1996

	Mean Monthly Income Rs.				
	2,000	3,000	4,500	8,000	20,000
Toilet not available	55.0%	13.6%	3.1%	---	---
Toilet available but shared	40.0%	36.4%	18.8%	3.0%	---
Toilet available	5.0%	50.0%	78.1%	97.0%	100.0%
N	(20)	(44)	(32)	(33)	(19)

Note : Figures are column percentages.

In all, 12.2 per cent of household do not have any toilet. However, there are differences in terms of income group and house-type. One in every two households in the poorest (lowest income) group does not have a toilet. Table 4.22 gives the detail with respect to house-type and toilet availability.

Table 4.22 : Services – 2a : House type and toilet availability : 1996

	No Toilet	Toilet shared	Independent toilet
Hutment	39.3%	39.3%	21.4%
TNSCB tenement			100.0%
Old Madras style	9.1%	34.1%	56.8%
Semi-detached	33.1%	11.1%	55.6%
Apartment			100.0%
Flat			100.0%
Independent/ *Bungalow*		8.2%	91.8%
Entire sample	12.2% (18)	20.9% (31)	66.9% (99)

Note : Figures are in row percentages.

Many households who do not have a toilet either depend on one of the pay and use toilets built by the Corporation of Madras and operated by local NGOs (and known popularly as 'Sulabh toilets' after the name of the organisation which popularised their use through-out India) or use public spaces such as river margins to relieve themselves. From the above table, it is noticed that 8.2 per cent of those living in 'independent house' are sharing a toilet with some-one else – a seemingly anomalous phenomenon. However, in parts of Madras Metropolitan Area, specially in the 9 towns and smaller urban settlements within MMA, cluster housing is prevalent. In such houses, several members of a family share a common plot of land but each build their own house. In such cases, it is possible that toilets and other utilities are shared though each household has an independent house. Again, a quick comparison is made with Census 1991 figures in table 4. 23.

Table 4.23 : Availability of toilet : Comparison of 1996 Survey and 1991 Census

	1996 Madras Household Survey				1991 Census		
Availability of toilet	Madras City	9 Towns	Rest of MMA	Total for MMA	Madras City	Rest of MUA	Total for MUA
	(b)	(c)	(d)	(e)	(f)	(g)	(h)
No toilet	11.0%	12.9%	25.0%	12.2%	17.7%	34.8%	22.8%
Toilet available	89.0%	87.1%	75.0%	87.8%	82.3%	65.2%	77.2%

Note : Figures are column percentages.

In this case, the figures are similar in ball-park ranges. The difference could be partly due to slum improvement programmes and low cost sanitation programmes which may have been implemented between 1991 and 1996 contributing to the reduction in the number of households without a toilet. Variability from sample to sample could be another reason. As mentioned earlier, in my survey, pavement dwellers are not represented and that could also be one of the sources of difference.

The above table may give a false impression of the sanitation status and likely health risks. The reason is that even though many households may have an access to toilet, in the absence of a well-functioning sewage collection and treatment system, the wastes (and hence the pathogens) are likely to remain present in the environment posing serious health risks. Table 4.24 presents details of households as per access to sewerage in different spatial units in MMA.

Table 4.24 : Access to sewage system and spatial location of households : 1996

Spatial unit	No toilet	Septic tank	Sewerage	Entire sample N
Madras City	11.0%	6.4%	82.6%	109
9 Towns	12.9%	77.4%	9.7%	31
Rest of MMA	25.0%	75.0%		8
Entire sample	12.2%	25.0%	62.8%	148

Note : Figures in row percentages (exception – last column)

It is seen that beyond the City limits, more than three-quarters of all households do not have access to sewerage. There are differences of opinion about appropriate technology and whether expensive conventional sewerage systems should be preferred in developing countries (Kalbermatten et al., 1982). However, respondents indicate that construction workers who build these septic tanks may not have full knowledge of the technical details. From time to time, there were reports in the local news-papers that septic tanks in peripheral areas were posing serious health risks. From table 4.25 we can see the likely health risk implications in terms of people depending on ground water (wells and tube wells) who also have a septic tank.

Table 4.25 : Households in MMA as per source of water and sewage access : 1996

Source of water	No toilet	Septic tank	Sewerage	Entire sample N
No source	66.7%	8.1%	11.8%	26
Well or tube-well	33.3%	67.6%	19.4%	49
Connection		24.3%	68.8%	73
Entire sample	12.2%	25.0%	62.8%	148

Note : Figures in column percentages (exception – last column and last row).

Septic tank provides for anaerobic treatment, but the effluents need to go through aerobic treatment as well before all the pathogens are removed. While septic tanks are designed to retain the solids, effluent is let out so that the aerobic cycle is completed in the soil surrounding the septic tank. Therefore, a well or other source of water must be at a considerable distance away from the septic tank. However, given the limited regulatory capacity of local planning agencies, these regulations are difficult to implement. In practice, even if an individual household maintains these requirements with regard to location of septic tank and well in their own premises, they have no control over such location decisions of their neighbours. In a metropolis of 1 million households, those depending on a septic tank is nearly 250,000 (25 per cent). Nearly 170,000 of these are likely to be in the category of those depending on well or tube well for water and depending on a septic tank for sewage disposal.

C. Baths :

Bath-room, more specifically, the number of bath-rooms seems to be an indicator of luxury or wealth in Madras. For the sample as a whole, the mean number of bath rooms is 1.365, though some have no bath room and a few have several of them. Table 4.26.

Table 4.26 : Services –3 : Household incomes and availability of bath rooms in Madras : 1996

	Mean Monthly Income Rs.					Entire
Number of bath rooms	2,000	3,000	4,500	8,000	20,000	Sample
None	45.0%	6.8%				8.1%
1 bath room	55.0%	90.9%	78.1%	39.4%		60.1%
2 bath rooms		2.3%	18.8%	45.5%	68.4%	23.6%
3 bath rooms			3.1%	12.1%	10.5%	4.7%
4 bath rooms				3.0%	15.8%	2.7%
6 bath rooms					5.3%	0.7%
N	20	44	32	33	19	148

Note : Figures in column percentages.

88 per cent of the households have two or less number of bath rooms. Those having three or more bathrooms form less than 12% of all households. However, one should still view this set of households with caution. There could be definition problems, over-reporting, or in some cases, households live in multi-tenanted properties where a set of toilets and bath rooms are available but these are shared with all households in the premises. Interestingly, only 28.6 per cent of all households living in hutments (slums) do not have a bath room compared with 39.3 per cent of them without a toilet. When there is no sewerage, it is likely that effluent from bath rooms is channelled into storm drains (if they exist) or may simply be let out and allowed to run on their own course. (As mentioned earlier, sewers are present only in Madras City and a few adjoining areas; in the remaining areas, only toilets are connected to septic tanks and sullage is often let out into storm drains).

D. Electricity :

In urban areas, electricity is considered an essential service. While the tropical climate in Madras means no heating is required, main purpose of electricity tends to be for lighting and then for a ceiling or portable fan. Few households use electricity for cooking purposes (due to the relative cost per month of electricity compared with costs of other fuels). Only 3.4 per cent of all households in Madras do not have electricity. The picture in terms of electricity and income is presented in table 4.27.

Table 4.27 : Services – 4 : Availability of electricity connection - 1996.

	Mean Monthly Income Rs.				
	2,000	3,000	4,500	8,000	20,000
Electricity not available	20.0%	2.3%			
Electricity available	80.0%	97.7%	100.0%	100.0%	100.0%

Note : Figures are column percentages.

All households not having electricity are living in hutments – and all of them live within Madras City. However, 82 per cent of those living in hutments do have electricity.

Data from Census is available which provides information on availability of electricity and toilet (for no apparent link between them – but as a means of availability of services). Households can be grouped into four categories :

- ENA,TNA - electricity not available, toilet not available;
- ENA, TA – electricity not available, but toilet available;
- EA, TNA – electricity available, but toilet not available; and
- EA, TA – both electricity and toilet available.

Table 4.28 compares 1996 Madras survey data with that of Census 1991. Main difference concerns the group 'no toilet, no electricity' (ENA, TNA). By comparing these figures with those of the group 'having electricity, but no toilet', it is possible to argue that between 1991 and 1996, some of the people in ENA,TNA group may have got electricity connections (and consequently move to EA, TNA group).

Table 4.28 : Distribution of households as per availability of electricity and toilet : Comparison of 1996 Madras survey and 1991 Census data.

	1996 Madras Household Survey				1991 Census		
Availability of electricity and toilet	Madras City	9 Towns	Rest of MMA	Total for MMA	Madras City	Rest of MUA	Total for MUA
	(b)	(c)	(d)	(e)	(f)	(g)	(h)
No toilet, No electricity	2.8%			2.0%	12.9%	20.6%	15.2%
No electricity, but toilet available	1.8%			1.4%	3.6%	1.2%	2.9%
Electricity available, no toilet	8.3%	12.9%	25.0%	10.1%	4.7%	14.3%	7.6%
Both electricity and Toilet available	87.2%	87.1%	75.0%	86.5%	78.7%	64.0%	74.3%

Note : Figures are column percentages.

Again, omission of pavement dwellers from my sampling design also could have contributed to a small extent of this difference.

E. Cooking gas :

Due to high population density in metropolitan cities compared to smaller urban centres or rural areas, households in cities may have a preference for liquefied petroleum gas as the main cooking fuel. In Madras Metropolitan Area, 37.2 per cent of all households surveyed do not have a gas connection. From Madras survey it was found that cooking fuel is also an indicator of income levels.

Table 4.29 : Services – 4 : Household incomes and whether cooking gas (LPG) is available in their house : 1996.

	Mean Monthly Income Rs.				
	2,000	3,000	4,500	8,000	20,000
Gas Not available	100.0%	61.4%	21.9%	3.0%	
Gas available		38.6%	78.1%	97.0%	100.0%

Note : Figures are column percentages.

Availability of gas connections is also spatially skewed. Those in Madras City seem to be slightly better off than those in the 9 towns or peripheral areas in the metropolitan area.

Table 4.30 : Services – 4a : Households by location and gas connection : 1996.

	Cooking Gas not available (a)	Gas connection available (b)	Share of all households (c)
Madras City	34.9%	65.1%	73.6%
9 Towns	41.9%	58.1%	20.9%
Rest of MMA	50.0%	50.0%	5.4%
Total for MMA	37.2%	62.8%	100.0%

Note : Figures in columns (a) and (b) add up to 100. Figures in column (c) are column percentages.

Not having a gas connection can affect quality of life in two main ways : use of other fuels may mean higher risks from exposure to high levels of indoor pollutants; inefficiency of fuels makes the relative cost of boiling water higher and that may have health implications.

F. Television :

Television has been a medium of high penetration in urban areas in India. Over 90 per cent of India's territory is covered by terrestrial television transmission. Besides, in the urban areas, cable television also has a high penetration rate. In terms of global viewership of cable-television, it is estimated that next to USA, India occupies the second place. In Madras Metropolitan Area, as per this survey, 6.8 per cent of households do not have access to television. 44.6 per cent of households in MMA have a black and white TV receiver and 48.6 per cent have a colour television receiver. Table below indicates that this is also highly associated with income level.

Table 4.31 : Services – 5 : Households as per television availability : 1996.

	Mean Monthly Income Rs.				
	2,000	3,000	4,500	8,000	20,000
No television	40.0%	4.5%			
Black and white TV	60.0%	84.1%	46.9%	6.1%	
Colour TV		11.4%	53.1%	93.9%	100.0%

Note : Figures are column percentages.

There is an issue concerning awareness about environmental problems and whether it has an impact on household responses towards environmental improvement. Hence, this information on televisions was considered relevant.

4.3.3 Quality of living : Sundaram and Tendulkar approach :

Sundaram and Tendulkar (1995), in a study of shelter deprivation, classified households in urban areas based on information on services available from the Census housing tables on availability of electricity, water and toilet. Using their approach, it is possible to classify households into one of the 12 groups :

Table 4.32: Quality of living – 12 categories following Sundrama and Tendulkar, 1995.

		Source of water		
		No source of water in the premises	Source other than a tap	Availability of a tap
Electricity not available	Toilet not available	A	B	C
	Toilet present	D	E	F
Electricity Available	Toilet not available	G	H	I
	Toilet present	J	K	L

Group A households would be the most vulnerable, lacking all the three essential services. Group B and C are slightly better with regard to water but still suffer from not having electricity and toilet. Together, these three constitute households lacking in two of the three essential services. In urban areas, groups D,E and F are likely to form a small minority (see table 4.28 for these figures in Madras). The next layer in terms of vulnerability and lacking in basic services are households in groups G,H and I. Households in groups J,K and L tend to be reasonably better off though those in group J do not have a source of water. These and households in group K may be the main consumers of water vendors and mineral water markets. Group L are those households who have all the three services.

Table 4.33 : Quality of living in Madras – Estimates corresponding to the 12 categories : 1996

		No source of water in the premises	Source other than a tap (well or tube well)	Tap connection (in some cases shared)	Row total
Electricity not available	Toilet not available	2.0%			2.0%
	Toilet present	0.7%	0.0%	0.7%	1.4%
Electricity Available	Toilet not available	6.1%	4.1%	0.0%	10.1%
	Toilet present	8.8%	29.1%	48.6%	86.5%
Column total		17.6%	33.1%	49.3%	100.0%

Note : Figures are percentage of all households in MMA.

It can be seen that in Madras, 2 per cent of households form the most vulnerable (corresponding to group A in previous table). It is likely that this percentage is slightly under-estimated here because of not interviewing pavement dwellers in the survey. Only a small percentage of households fall in categories D and E (toilet present but electricity unavailable). The cells corresponding to A, D and G represent households lacking in at least two of the three basic services : in Madras, such households constitute 8.8 per cent (2.0% + 0.7% + 6.1%) . In terms of public health perspective, cholera outbreaks have been common in Madras during the annual monsoon periods. It can be seen that slightly more than 50 per cent (17.6 + 33.1) of all households in Madras Metropolitan Area constitute a high risk category, either due to not having any source of water (hence involving transport of water when it can be contaminated) or having to depend on ground water (again which can be contaminated due to leaching from septic tanks or when contaminated run off flows into the well).

4.3.4 Quality of living : A composite index approach

An alternative way of analysing differences in quality of living is to segregate households based on the housing characteristics and availability of services. For this exercise, information on housing characteristics and the availability of services can be used. I did not collect data on neighbourhood characteristics. Otherwise, one could include some appropriate indicators relating neighbourhood characteristics and services also. From the information I have collected, there were at least ten items of relevance to quality of life. Of these, four items were housing characteristics (material used for walls, flooring, roofs and density in terms of persons per room), and the remaining six items were relating to the availability of services (water, toilets, bathrooms, electricity, gas and television). In case of six of these variables, the households could be placed into one of three categories corresponding to low, medium or high quality of life. In case of four items, (wall material, roof material, electricity and gas), the households could be placed into one of two categories. To avoid arbitrariness in scaling of elements based on which the quality of life index is constructed, I have omitted the above mentioned four items and limited the information to the six items only. These six items and the three possible levels of values that each of them could take are shown in table 4.34.

Table 4. 34 : Construction of quality of life index

		Meaning of score 0	Meaning of Score 1	Meaning of score 2
1	Floor material	Mud floor	Cement floor	Mosaic/marble floor
2	Density	Above 3 persons per room	Below 3 but above 1 person per room	Below 1 person per room
3	Water	No source	Well or tube well	Tap Connection
4	Toilet	Not available	Available, but shared	Independent toilet
5	Baths	None	1 bath available	2 or more baths
6	Television	None	Black and White receiver	Colour receiver

Distribution of households in Madras as per these 6 characteristics (according to the scores) is shown in table 4.35.

Table 4.35 : Distribution of households as per scores for each of the 10 characteristics : 1996

		Score 0	Score 1	Score 2
1	Floor material	2.7%	63.5%	33.8%
2	Density	15.5%	59.5%	25.0%
3	Water	17.6%	33.1%	49.3%
4	Toilet	12.2%	20.9%	66.9%
5	Baths	8.1%	60.1%	31.8%
6	Television	6.8%	44.6%	48.6%

In the above scheme, a household who has the highest level of attainment in each of the six items will have a quality of life index of 12. A household with poor quality of life will be deficient in some or all of these items and thus, have a score of less than 6. Distribution of households as per different score levels are shown in table 4. 36. These are also shown in figure 4.4.

Table 4.36 : Distribution of Madras households : Quality of life index : 1996

Quality of life index level	Percentage of households in each income group as per quality of living index					All income groups
	2,000	3,000	4,500	8,000	20,000	
1	15.0%	2.3%				2.7%
2	10.0%	4.5%				2.7%
3	20.0%	4.5%				4.1%
4	*35.0%*	2.3%	3.1%			6.1%
5	0.0%	25.0%	3.1%			8.1%
6	15.0%	*25.0%*	0.0%			9.5%
7	5.0%	15.9%	9.4%			7.4%
8		13.6%	*40.6%*	12.1%		*15.5%*
9		6.8%	21.9%	21.2%		11.5%
10			18.8%	*36.4%*	5.3%	12.8%
11			3.1%	18.2%	*57.9%*	12.2%
12				12.1%	36.8%	7.4%

Note : figures in column percentages. Italicised cells refer to median class for each column.

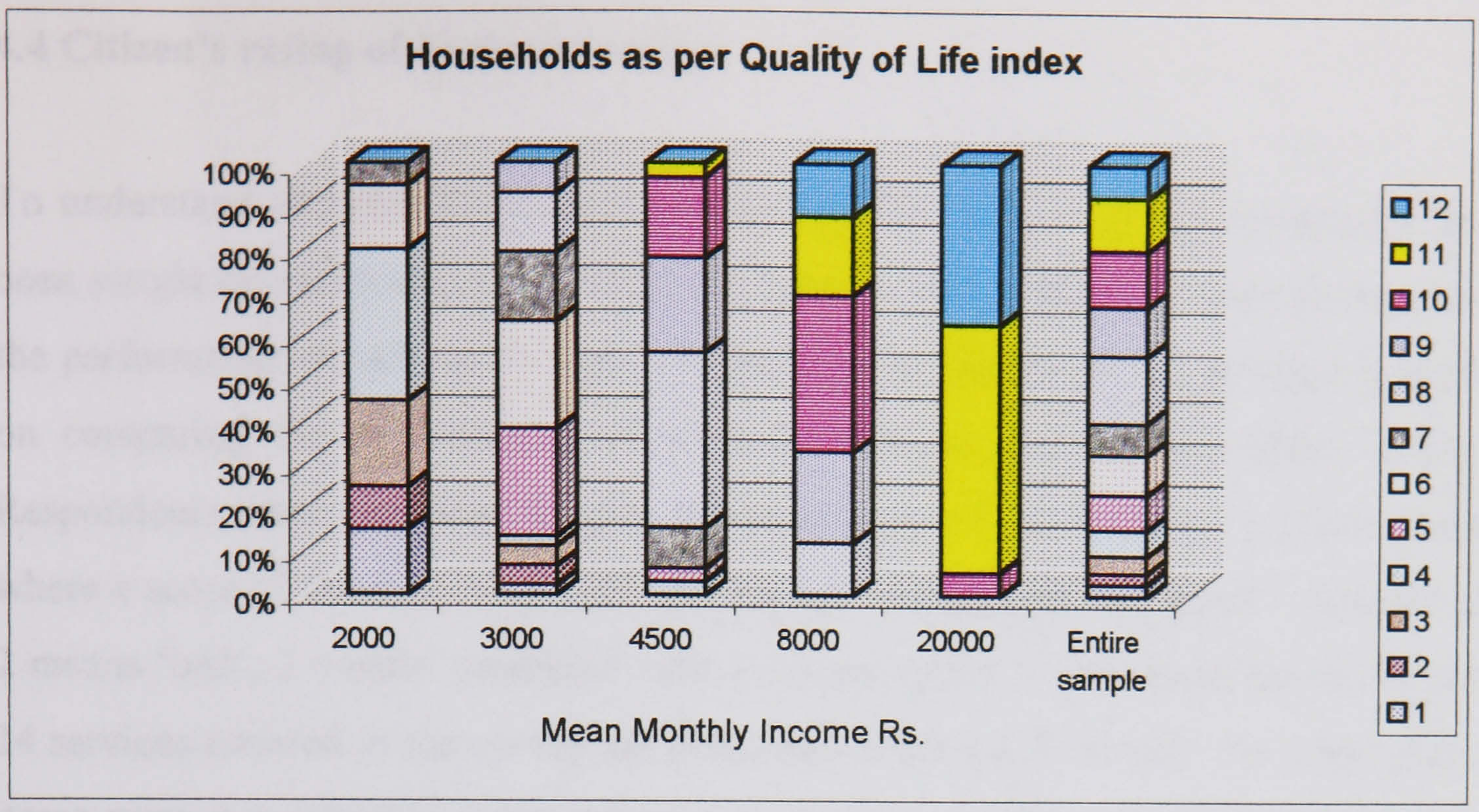

Figure 4.4 : Distribution of households in different income groups as per quality of life index.

From table 4.36 and figure 4.4, it is clear that for a majority of households in Madras, quality of life in terms of quality of housing accommodation and services available is not too bad (median quality of life index for the entire sample of 8). In the entire sample, less than 24 per cent households have quality of life index of below 6. The index gives some idea of the significant disparity in quality of life between the lowest income group (with a median quality of life index of 4) and the highest income group (with a median quality of life index of 11).

This discussion in this section on quality of life may be criticised of being reductionist (and it may well be). However, in my view, there is merit in developing such synthetic indices that can help the analyst to combine the effects of various services and help identify the most vulnerable groups.

4.4 Citizen's rating of Various Services :

To understand attitudes toward public services, the opinion of the households has been sought on various services. This was done by asking how the respondents view the performance of various services, on the lines of Samuel Paul's pioneering work on comparing the performance of services in some Indian cities (Paul, 1994). Respondents were requested to give marks to each of the items on a Likert scale where a score of 1 meant 'very bad' and a score of 5 meant 'very good'. A score of 2 means 'bad'; 3 means 'moderate' and 4 means 'good'. The mean scores for the 14 services covered in the survey are presented in table 4.37 below. As some of the items were not asked in some interviews, there is a truncated sample bias issue. However, this was a random event and no particular income group or social class were systematically given different treatment and hence the results may be still seen as reasonably valid indicators.

Table 4.37 : Services in MMA ranked in ascending order (1 very bad - 5 very good).

	Mean score	Standard deviation	N (valid sample)
Cooum & waterways	1.25	0.62	122
Mosquito control	1.49	0.82	146
Storm drains	1.93	1.13	147
Tree planting	1.95	1.16	65
Sewerage	2.19	1.08	109
Roads & Traffic	2.34	1.07	148
Solid waste management	2.47	1.31	148
Water supply	2.70	1.14	141
Bus transport	3.17	1.23	143
Electricity	3.18	1.13	142
Telephones	3.31	1.20	85
Beaches	3.33	1.18	123
Fire service	3.48	1.08	82
Suburban Trains	3.71	0.97	109

Break-up of scores for each of the 14 items discussed above are shown in figure 4.5. The ratings or scores given to different services are fairly stable across income groups though there are a few exceptions. (A simple test of analysis of variance - ANOVA using Fisher's F ratio for the 14 services indicated that only in case of three items, namely, beaches, electricity and storm water drains, the null hypothesis is rejected at 5% level). The lowest income group households rate (the present level of maintenance of) beaches to be very good -- an average score of 4.19; the highest income group households consider it be less than moderate -- an average score of 2.78. As the standard deviations in the above table indicate, River Cooum (and water ways) and mosquito control programmes are rated to be 'very bad' across the board; trains, fire service and electricity get better scores (3 and above).

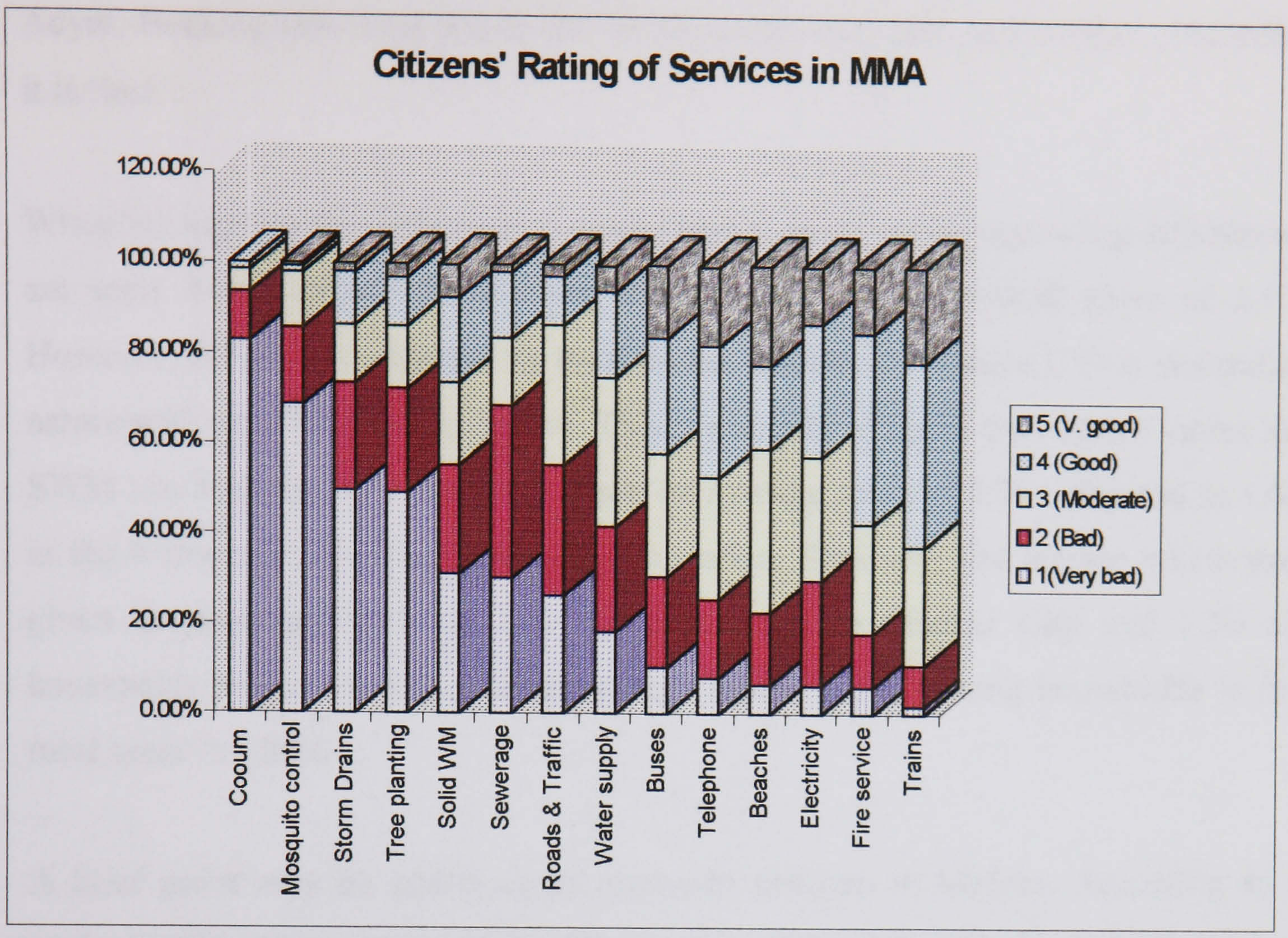

Figure 4.5 : Citizens' ratings for the 14 services.

It can also be seen from table 4.37 that solid waste management has the highest standard deviation : this is partly due to Exnora effect, namely, due to formation of local waste management units (called Exnoras) by households voluntarily. This issue is examined in detail in chapters seven and eight.

The percentage of households giving different scores for each of the 14 services indicates that there are seven services in whose cases more than 50% of the respondents think the performance is either very bad or bad : these are Cooum, Mosquito control, storm drainage, tree planting, solid waste management, sewerage and roads & traffic management (in that order). For instance, more than 80% of households in MMA think that the condition of waterways in Madras (Cooum, Adyar, Buckingham canal and Otteri Nalah) to be 'very bad' and another 10% think it is 'bad'.

When we analyse this information across spatial units, some interesting differences are seen. For instance, solid waste management gets an overall score of 2.47. However, the service provided by local bodies outside the Madras City is skeletal in nature with very little infrastructure. This is also picked up by the relative scores for SWM : in Madras City, this service gets an average score of 2.74 compared to 1.58 in the 9 towns in Madras Urban Agglomeration. Similarly, fire service which was given an average score of 3.56 by households in Madras City and 3.50 by households in the 9 towns gets an average score of 1.67 among households in the rural areas in MMA.

A brief point may be added about mosquito problem in Madras. According to a study by the entomologist of the Corporation of Madras, the city has the highest incidence of malaria out-breaks in India. The Corporation has a limited budget for mosquito control (mainly fumigation and larvicide spraying). However, as studies have shown the A-Stephensi mosquito has adapted very well to urban conditions, in particular, breeding in open wells and roof-top water tanks. In a sense, I would conjecture that very high incidence of malaria in Madras is highly associated with Madras being a city with chronic water scarcity (and hence the need for individual households to store up fresh water).

The analysis so far can be summarised : (a) On the whole, in MMA, none of the services is excellent; some of the services are clearly perceived to be better and some to be worse; (b) Madras Metropolitan Area seems to be relatively better endowed with transport, electricity and communications compared to the 'basic' services of water supply, sanitation and waste management : a vision of Madras with world-class automobile plants in one part of the metropolitan area while annual cholera outbreaks kill some people elsewhere in the city is not far from reality; (c) among the households covered by a voluntary waste collection system (known as

Civic Exnora), the relative ranking of waste management is considerably higher than those not covered by such systems.

4.5 Differences in the Environmental Priorities of the Rich and the Poor :

By combining the information in terms of quality of living index and the household perceptions about the various services, it is possible to see if there are significant similarities and differences between the rich and the poor. The quality of life score is like a wealth score as many of the items contributing to the score have linear relationship with income. Further, the scores given to different services were examined by dividing the sample households into quintiles based on the quality of life index (which can get values from 0 to 12) and examining the scores of the lower 40% households (broadly considered as the poor) with the remaining 60% households (middle and higher incomes). The quality of service with a score of 2 or below was coded as 'bad' and that of services with 3 or above was coded as 'good'. The resulting picture is shown in table 4.38. Irrespective of incomes, households are unanimous about River Cooum and Water ways, mosquito control and storm drainage (*bad-bad*). Similarly, all income groups view in a positive light the level of service of trains, fire service and electricity (*good-good*). However, the considerable scope for differences of opinion and how it may affect what should be policy priorities is evident.

Table 4.38 : Quality of services - Perceptions of the rich and the poor in MMA

		Perception of the ***poor***	
		Service delivery **Bad**	Service delivery **satisfactory/good**
Perception of the ***rich***	Service delivery **Bad**	▪ Cooum ▪ Mosquito control ▪ Storm Drainage	▪ Tree planting ▪ Sewerage ▪ Roads & traffic ▪ Beaches
	Service delivery **satisfactory/ good**	▪ Solid waste management ▪ Water supply ▪ Bus transport ▪ Telephones	▪ Electricity ▪ Fire services ▪ Trains

While the poor think that waste management, water supply, bus transport and telephones as being 'bad' (and, perhaps feeling that they need to be improved), the better-off think that beaches, road traffic, sewerage and tree plantation activities are unsatisfactory and implying their preference for these services. The rich are likely to have adequate sources of water supply (an issue discussed in chapter five) and are also likely to have developed institutional arrangements to take care of waste management (discussed in chapters seven and eight). Similarly, the rich and middle classes have private modes of transport (mostly two-wheelers) and hence it is understandable that bus transport is not their priority though road traffic is. Therefore, it is easy to see that they want to emphasise on other aspects. This distinction seems to be of interest in the context of environmental policy discourse in India's cities. The richer groups, because of their access to information and ability to organise themselves, have greater influence on policy making. Analysis and approaches like the discussion above can contribute by juxtaposing the likely preferences of the poor and the rich. Further, they can contribute to making transparent the likely domination of the local environmental agenda by the priorities of the rich at the expense of meeting the needs of the poor.

4. 6 Summary :

Though the focus in this chapter has been mainly on material dimensions of housing and various services, some aspects of quality of life in Madras are evident. In some cases, I have attempted a comparison of the data from the household survey of this research (from 1996 Madras survey) and the data from the 1991 Census. As already mentioned, given the rather small sample size of this survey, it is likely that sample variability is the main reason for the difference between distributions of this sample and that of the Census. In addition, in some cases differences in definition could contribute to a difference. If these comparisons can be trusted, compared to 1991, in Madras, more people had access to water and sanitation, and electricity in 1996. However, the average household sizes have increased and density in terms of number of persons per room has increased as well.

What is clear without doubt is that the quality of services is much better within Madras City than in many of the peripheral areas (referred to as 9 towns and Rest of MMA in this study and as MUA in Census). In terms of citizens' rating of 14 local services (figure 4.5), both waste management and water supply are neither top performers nor are they worst performers. However, there is an interesting dichotomy between the rich and the poor. It was seen (table 4.38) that both water supply and waste management are considered by the rich to be satisfactory or good whereas the poor think these services are bad.

Chapter Five

An Analysis of Water Supply in Madras

5.1 Introduction :

There is an interesting dichotomy in water supply. In the developed North, two main areas of focus in the discourse on water supply (if it can be called a discourse) are : (a) engineering aspects of water supply (for instance, McGhee, 1991; Viessman and Hammer, 1998; Twort et al., 2000); and (b) the issues of privatisation and economics of regulation of water utilities (Glaister,1996; Cowan, 1997; Robinson, 1997; OECD, 1999). The discourse on water supply in the developing world, initially started as a component of development discussions (though it has been a relatively small sector in terms of the share of funds allocated[1]). Over a period of time, this discourse has changed from an exclusively engineering and technology focus (as seen in Dangerfield, 1983) to a wider discussion based in social sciences[2]. A widely-cited strand of literature (Wade, 1978; Ostrom, 1991; 1993; Shah, 1993; Bardhan 1995; Uphoff, 1996; Wood, 1999) has focused on institutions of irrigation and conditions (and incentive-structures) affecting their functioning. Some aspects of institutional design may be relevant in the context of drinking water supply as well. While some discussion on social dimensions of water supply has concentrated mainly on community water supplies in rural areas (Kerr, 1989; Davis et al., 1993), others have criticised that real participation requires a deeper understanding of social institutions (for example, Cleaver, 1999 with special reference to gender dimensions). Some studies of urban water supply have focused mainly on the water markets in developing countries and the extent of water vending activities (for example,

[1] As of 1997, out of World Bank's total portfolio of US$ 118 billion, approximately 6.6 per cent was allocated to water and sanitation sector projects (The World Bank, 1997). About 4 to 5 per cent of DAC aid goes to water and sanitation. In terms of domestic resources, from India's national accounts for years 1991-1996, gross domestic capital formation in 'electricity, gas and water supply' was in the range of 2.5 to 3.0 per cent of GDP (EPWRF, 1997).

[2] Black, 1998 provides a summary of how approach to water supply and sanitation in international co-operation has changed in the last 3 decades.

Whittington, et al., 1991; Cairncross and Kinnear,1992; Fass, 1993) and whether there is considerable mark up in prices and rent-seeking behaviour by some agents (Lovei and Whittington, 1993; Crane,1994). While in the rural context, water vending is seen as a part of the solution to poor water supply (Wood et al., 1991), in the urban context, vending is sometimes portrayed as a symptom of shortage and as a justification for increasing public investments in water supply (The World Bank, 1995b : 23).

Against this background, this chapter aims to examine the institutional context of water supply in Chennai. The remainder of this chapter is arranged as follows: section 2 provides a backdrop of policy discourse concerning water supply in Madras; section 3 provides details of the water supply system in Madras; section 4 discusses the construction of a water balance sheet for Madras based on data from the household survey as well as other secondary sources. Water markets in Madras and the role of regulation are discussed in sections 5 and 6; sections 7,8 and 9 focus on inequality in water supply and entitlements aspects. Section 10 focuses on water quality aspects and section 11 presents details of household expenditures on water supply. Section 12 briefly discusses some recent changes in the policy of Metro Water Board and its initiative to publish a citizens' charter; and section 13 summarises the conclusions.

5.2 The Backdrop : Water Supply Policy Discourse in Madras:

Water policy discourse in Madras focused mainly on two dimensions : how to increase the total quantity of water available; how to use the water more efficiently.

With regard to the former, various schemes have been considered from time to time to bring water to Madras from far off sources. As far back as 1881, a scheme was conceived by Colonel W. Ellis to bring water to Madras from the river Krishna. In 1951, the Planning Commission of India set up a committee (known as the Khosla committee, after its chairman) to look into the development of Krishna-Pennar river projects. Supplying water to Madras was also considered by this committee. In 1963, an announcement was made in the Parliament to the effect that Krishna river's riparian states, namely, Maharashtra, Karnataka and Andhra Pradesh, were willing to allocate 15 thousand million cubic feet[3] (TMCft) to Tamil Nadu. However, it remained as an intention rather than a commitment. In 1976, when the state was under the President's rule and state elections were impending, the then prime minister of India, on a visit to Madras, made a public announcement that the three riparian states have agreed to release 5 TMCft of water each (Government of Tamil Nadu, 1983). An agreement was signed two months later. Though the three riparian states agreed to this, the actual transfer of water would be between Andhra Pradesh and Tamil Nadu. The details took another seven years before another agreement was signed in 1983 by the then chief ministers of these two states. Since 1983, whenever water shortages were experienced, Krishna water project was evoked as a panacea. Out of 15 TMCft, Madras is supposed to get 12 TMCft (the remainder being losses and leakage). As a result, Madras is supposed to get an additional quantity of 930 million litres a day (MLD) when the entire project is completed (in 2011) (see Government of Tamil Nadu, 1993; MMDA, 1995 : 95-96).

After 13 years of time since the 1983 agreement and an estimated expenditure of Rs. 21.9 billion[4], in September 1996, the first phase of the scheme was officially inaugurated by the chief ministers of the two states, in a function in Madras. It may be a coincidence that the local government elections for Madras Corporation (after a long period without elected local government) were only ten days away and that the chief minister's son was a contender to become the elected mayor of Madras. In April 2001, when the opposition coalition came to power in the state legislature

[3] 1 cubic foot = 28.316 litres. 1 TMCft per annum works out to 77.58 MLD.
[4] According to Ramakrishnan (1996), the original cost estimates in 1983 were of Rs 7.6 billion. When adjusted for inflation between 1983 and 1996, this comes to Rs 21.6 billion for the entire project. As compared to this the figure of Rs 21.9 billion for stage 1 alone, suggests that there has been significant cost over-run.

elections, other schemes to bring water from far off sources (Veeranam and Neyveli) are being proposed.

An illustration of this dimension of policy discourse is the often-repeated statistic that per capita water supply in Madras is the lowest for any metropolitan city[5]. Inequality between different households or between different parts of Madras are seldom discussed. The following paragraph from the World Bank (1995b: 24) staff appraisal report of Second Madras Water Supply Project sums up the belief :

> "The project will benefit all consumers directly and indirectly....The poor will benefit particularly since they suffer most from the adverse impacts of health and inconvenience due to inadequate water supply at present... Thus, although benefits of the project will be widely distributed in Madras, there will be particular benefits to the poor...".

With regard to the second dimension, namely, conserving water or using it more effectively, in the late 1970s, UNDP commissioned several studies to augment the use of ground water in Madras. From these studies, some ground water sources in northern parts of the metropolitan area (Minjur,Panjetty, Tamaraipakkam and Poondi) were identified (see MMDA, 1995 : 90-91) and these became important sources of water supply by Metro Water Board. Over-extraction of ground water by private individuals posed a threat to these sources and also posed the risk that sea water ingression will take place. Hence, the state government enacted the *Madras Metropolitan Area Groundwater (Regulation) Act, 1987*, giving additional regulatory powers to Metro Water Board. More recently, during 1998-99 and 2000, Metro Water Board has been attempting to encourage rain water harvesting. On the

[5] For instance, the World Bank (1986 : 3) states : "Madras city remains the lowest supplied metropolitan area in India with an average 78 lpcd...The corresponding figures for other cities are Bombay 253, Delhi 220, Calcutta 190 and Bangalore 125 lpcd.". A decade later, MMDA (1995: 94-95) provides a similar statement is made. The figures used this time are: Madras(70 lpcd) with Bangalore (90 lpcd), Bombay (150 lpcd), Calcutta (190 lpcd), Delhi (160 lpcd) and Pune (275 lpcd). Similar statement is also found in the World Bank, 1995b:2.

recommendation of the Metro Water Board, the state government introduced in planning regulations that all new plans for multi-family apartments will need to include arrangements for rain water harvesting.

5.3 Various Sources of Water Supply in Madras :

Accounts of the water supply sector predominantly reflect the 'formal' or 'documented' view of the system, based on information readily available. For instance, the water supply chapters in an earlier study in which I was a co-author (Dattatri and Anand,1991), or the draft Master Plan for Madras (MMDA, 1995) are limited to such documented view. Information on water markets in cities in developing countries is scarce and often such information (when available) is of dubious validity, though that need not be an excuse. This study is one of the first attempts to collate and understand the different components of water markets in Madras.

5.3.1 Institutional Arrangements for Water Supply in Madras

In terms of institutional arrangements, four distinct systems of water supply can be found in Madras :

a) Supply of water by Madras Metropolitan Water Supply and Sewerage Board (in short Metro Water Board) -- mainly for Madras City;
b) Municipal supply -- in 9 towns adjoining Madras ;
c) Self-provision by many households and industries -- by drilling of shallow wells or deep tubewells;
d) Private market -- (a) bulk supply by means of tanker trucks of 12,000 litres capacity and (b) retail distribution of 'mineral water' in jerry cans of 10 or 12 litres capacity.

With regard to the generic forms of institutional arrangements for water supply considered in chapter 1 (figure 1.1), Metro Water Board can be described as shown in figure 5.1.

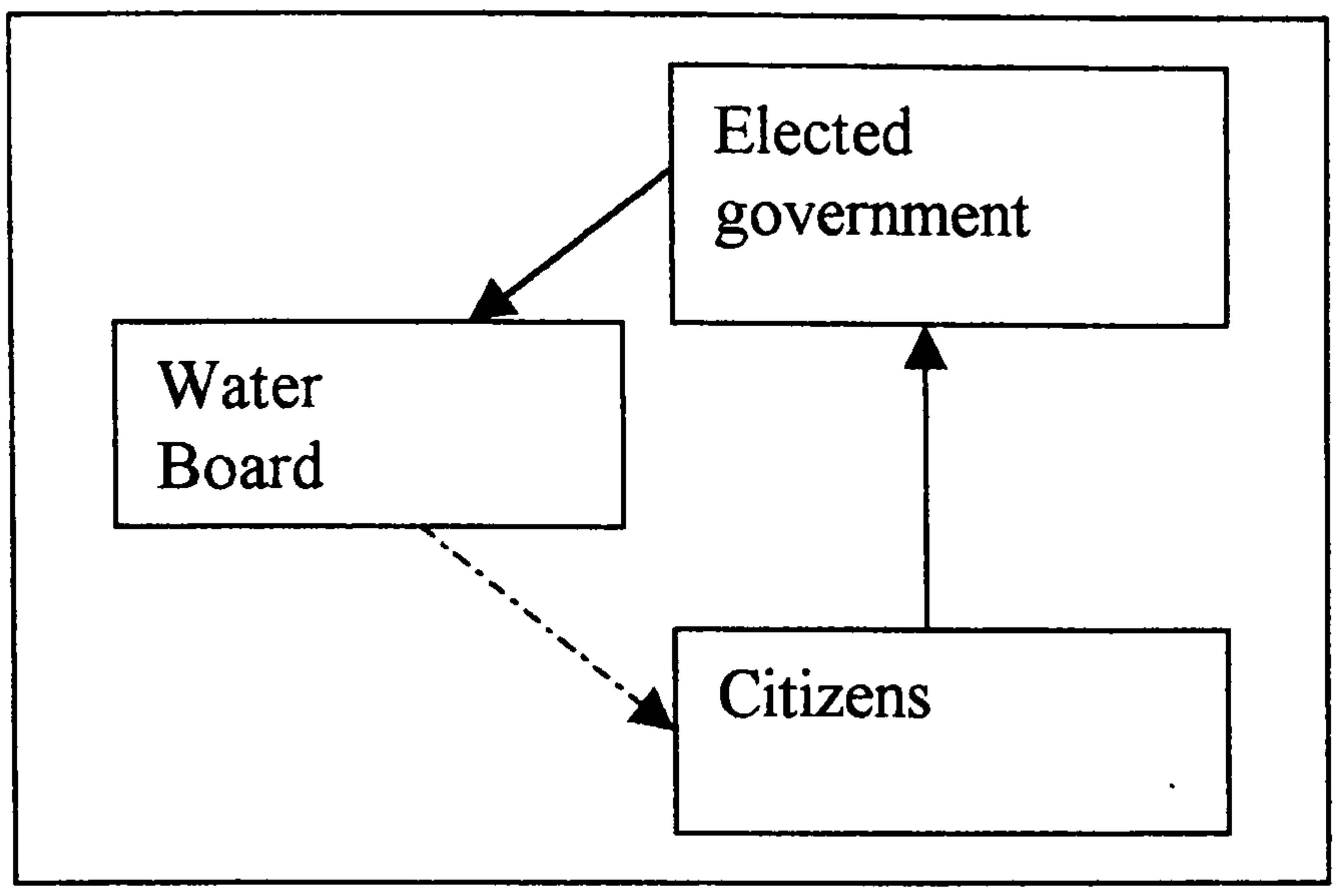

Figure 5.1 : A conceptual view of Metro Water Board in relation to its customers.

While in theory it may not be problematic, the elected government in question is one of the *state* government rather than elected *local* government. The state government appoints the chair-person, (usually the minister in charge of local administration); a civil servant of the state cadre is appointed as the managing director. The policy decisions are, thus, made by the state government rather than a local government.

5.3.2 Households as per the main source of Water Supply : Census 1991

Distribution of households in Madras Urban Agglomeration according to the main source of water as per Census 1991 is given in table 5.1.

Table 5.1 : Number of households in Madras Urban Agglomeration (MUA) as per main source of water : 1991

	Within the premises		Outside the premises		Total		
	Madras City	Rest of MUA	Madras City	Rest of MUA	Madras City	Rest of MUA	Entire MUA
Well	125,775	153,005	40,760	55,650	166,535	208,655	375,190
Tap	205,765	26,925	129,360	44,525	335,125	71,450	406,575
Handpump/ Tubewell	126,040	19,300	79,925	15,480	205,965	34,780	240,745
River/Canal	180	65	90	105	270	170	440
Tank	105	60	50	880	155	940	1,095
Others	8,195	340	44,390	3,780	52,585	4,120	56,705
All Sources	466,060	199,695	294,575	120,420	760,635	320,115	1,080,750

Source : Census of India, 1991

About 35% of all households in Madras depend on a well as their main source of water. Another 22 % of the households depend on a tubewell or a handpump, which draws water from deep ground water aquifers. Within Madras City, only 44% of all households draw water from a tap. On the other hand, according to Metro Water, the figure relating to 'population covered by water supply' is 92% (which is the area of the City 'covered' by Metro Water)[6]. The share of people drawing water from a tap in the urban agglomeration area (outside the City) is even lower.

5.3.3 Households using various sources of water : 1996 Survey

Many households in metropolitan cities such as Madras often depend on more than one source of water, depending on access to such sources, the water needs of the household, opportunity cost of labour (determined by number of members in the household and labour market participation rates), dimensions of quantity and quality of water from different sources and so on. Table 5.2 presents information from the

[6] See MMDA,1995, page 92.

Madras household survey on the distribution of households having access to various sources of water.

Table 5.2 : Households in Madras as per various sources of water : 1996

		Madras City	9 Towns	Total for MMA
1	No source within the premises	19.3%	16.1%	17.6%
2	Shallow well	16.5%	54.8%	29.1%
3	Tubewell	6.4%	--	4.7%
4	Shared Municipal Tap Connection	8.3%	--	6.1%
5	Municipal Tap Connection	4.6%	6.5%	4.7%
6	Well and Connection	15.6%	16.1%	14.9%
7	Tubewell and Connection	27.5%	3.2%	20.9%
8	Well, Tubewell and Connection	1.8%	3.2%	2.0%
9	Sub-total for households with connection categories (4+5+6+7+8)	57.8%	29.0%	48.6%
	Total for all categories	100.0%	100.0%	100.0%

Source : Madras household survey, 1996.

It can be seen that about 42 % of households in Madras City and more than 70% of households in the Rest of MMA are <u>not</u> covered by the piped water supply system. These figures suggest that actual coverage figures of water supply could be much lower than the figures suggested by the 'documented' view (which states that 92% of the population is 'covered'). The main reason for this difference is that the official coverage figures include many households belonging to rows 1,2, and 3 above (i.e., those not having a connection) because they may be drawing water from public fountains, stand posts or in case of Madras, static tanks. Hence, they are counted in the category 'covered by water supply'.

5.4 Towards a Water Balance Sheet for Madras

Estimating a water balance sheet for any metropolitan city is difficult -- Madras is no exception. However, such a balance sheet can provide an indication of the sources of water *vis-à-vis* the uses to which water is being put and contribute to increased transparency in making decisions about water use and conservation. During the field work, it was observed that in Madras, a numerous sources of information (including the interviews with households and vendors) give different pictures of water supply and management situation. However, reconciling these different view-points is important to understand the policy priorities. A water balance sheet, the first of its kind for any metropolitan city in India, is attempted in this research. Five sources of information have been used in this exercise : (a) Housing tables from Census 1991, giving information on number of households with the principal source of water; (b) household survey conducted by me during June-October 1996 giving details of all the sources that a household has; (c) Annual Report of Metro Water for 1994-95 containing financial statistics; (d) Madras Metropolitan Development Authority's Draft Second Master Plan; and (e) MMDA-TRF research study reports, mainly Srinivasan,1991 and Dattatri and Anand,1991. This estimate relates to the period prior to September 1996, (i.e., before the release of 200 MLD from the Krishna Water project in October 1996).

Prior to October 1996, the total supply of water from Metro Water Board was 433 MLD (MMDA,1995). This was drawn from 6 sources:

a) About <u>200 MLD</u> comes from the Poondi - Sholavaram - Red Hills system. This is mainly from surface sources, namely Arniar and Kortaliayar rivers.

b) Another <u>148 MLD</u> is pumped from a number of well-fields in North and North West Madras.

c) South Coastal Aquifer provides about 10 MLD .

d) Metro Water has been maintaining some local sources and wells in Urur, Thiruvanmiyur, Porur, Kattupakkam etc., which together contribute 20 MLD.

e) There are 35 Municipal wells whose potential has been assessed as 5 MLD. These are not connected to the Metro Water distribution system.

f) In addition, there are 7,141 India Mark II pumps and 1884 tubewells (total : 9025). The total yield of these pumps is estimated to be 50 MLD (MMDA Master Plan).

Of this, about 71 MLD (i.e., about 16%) is supplied to metered customers. Remaining supply is unmetered.

The water balance sheet for Madras Urban Agglomeration is presented in Figure 5. 2. (The details of the estimate are contained in Appendix 4). My estimate is based on quantities for the period upto September 1996. As mentioned earlier, on September 29, 1996, the first phase of Krishna Water Project was inaugurated. As a result, the supply is supposed to have been augmented by 200 MLD[7]. However, subsequent information from Metro Water Board (2000) indicated that the total water supply has remained at 440 MLD[8]. Therefore, the water balance sheet is still useful, especially in relation to the end uses.

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[7] Towards the end of Appendix 4, a revised water balance sheet taking into account additional 200 MLD is shown.

[8] The first stage of 3 TMCft translates to 233 MLD. However, official statements have put it as 200 MLD. While Krishna project brought in 200 MLD, supply from local sources is said to have dwindled to 240 MLD (http://www.chennaimetrowater.com accessed on January 24, 2001).

Figure 5.2 : Water Balance Sheet for Madras Urban Agglomeration : 1996

(figures in MLD)

		Surface	*Ground Water*				
Madras City	Poondi, Red hills	200		Metro Water 383	Metered 71	Industry	37
	Well fields South		148			Commercial	4
						Public Authorities	16
	Coastal Aquifer		10			Bulk consumer	10
						Non residential	4
	Porur, Thiruvan -miyur Wells		20		Unmetered 302	Industry	47
						Commercial	9
	Mun. wells		5			Public Authorities	25
						Dom. non-residential	5
						Residential	*97*
						Public fountains	*4*
						Unaccounted for Water	115
					Static tanks (filled by tankers) 10	*Residential*	*10*
	India Mark II Hand pumps		50	....	(Metro Water)	*Residential*	*50*
	Private Wells		10			Residential	10
	Private Tubewells		79			Residential	79
Rest of MUA	Palar Sub-surface	26		Total Municipal Supply 32		*Residential*	*32*
	Local bore wells		6				
	Private wells		15			Residential	15
	Private Tubewells		22			Residential	22
	Others		1			Residential	1
Entire MUA	Borewells		8	....	Used by Private tankers	Residential	4
						Commercial	4
	Mineral water		0.1			Residential	0.1
	Total	**226**	**374.1**				**600.1**

According to the water balance sheet, in 1996, Madras consumed above 600.1 million litres of water per day (MLD) or roughly 111 lpcd.

With regard to sources, we see that, 226 MLD (or 37.6% of 600.1 MLD) came from surface sources and the remainder came from ground water sources. According to the Institute for Water Studies (1994 :pp.15), the ground water levels in Madras have been falling by about 1 metre per decade or approximately 10 cm per year. If we assume that the area consisting of entire Madras City and MUA formed one continuous groundwater table, the total quantum of water drawn excluding the recharge portion can be calculated, crudely, as shown in Table 5.3 :

Table 5.3: Groundwater abstraction in Madras : An estimate from falling water tables

	Area sq.km.	Quantum of water in cum/annum	Quantum in MLD
Madras City	172	17,200,000	47.12
Rest of MUA	400	40,000,000	109.59
Total	572	57,200,000	156.71

The estimate in Table 5.3 can be compared with the estimates made in the water balance sheet in figure 5.1. Many of the well-fields of Metro Water lie beyond the MUA area. Hence, if they are excluded, then the ground water drawal estimated in the balance sheet (374 minus 148) comes to about 226 MLD, whereas the above table indicates a drawal of about 157 MLD, implying that the gap between the two (nearly 70 MLD) may be attributed to the net recharge from precipitation[9]. Given the density of population in Madras City, the recharge there is likely to be much smaller.

[9] According to Central Ground Water Board,1993, annual rainfall recharge in Madras is estimated to be 55.34 million cubic metres per annum. That works out to about 120 MLD, but according to that study the recharge is equivalent to abstraction (i.e., no net fall in water tables).

With regard to end-uses, from the water balance sheet, it is possible to summarise (a) how much water is supplied by Metro Water board to various uses; and (b) the total quantity allocated to residential use (i.e., consumed by households – shown in italics in the water balance sheet) from both public and private sources. The total quantity of water supplied by Metro Water Board was 433 MLD. This comprised (a) 71 MLD of metered supply (to non-residential users); (b) 302 MLD of unmetered supply of which 101 MLD was supplied to residential use (including 4 MLD for public fountains); (c) 10 MLD of water is supplied to static tanks by tanker trucks of Metro Water Board. This is summarised in table 5.4 below:

Table 5.4 : End uses of water in million litres per day (MLD)

	By public sector	Private sources	Total
Residential[10]	193	131.1	324.1
Industrial	47	?	47
Commercial	9	4	13
All other uses	101	?	101
Unaccounted for water	115	?	115
Total[11]	465	135.1	600.1

Note: Question marks indicate that we have no data on these items.

In the above table, the expression private sources includes supplies from wholesale water sellers, mineral water and also self-provision by households (from wells and tubewells).

[10] The calculation is explained as follows. Numbers are quantities in MLD from water balance sheet. Description is given in brackets. For public sector 193 = 97 (unmetered residential supply from Metro Water board) + 4 (public fountains) + 10 (from static tanks) + 50 (from India Mark-2 pumps) + 32 (from municipal supply in rest of MMA). For private sources 131.1 = 10 (from private wells) + 79 (private tubewells) + 15 (private wells in rest of MUA) + 22 (tubewells in rest of MUA) + 1 (other sources) + 4 (supply by tankers) + 0.1(mineral water).

[11] This is given by 433(from Metro Water) + 32 (from municipal sources in MUA).

5.5 Water Vending and Market Structure :

According to a survey of water utilities in Asia and the Pacific (McIntosh and Yniguez, 1997 : 85), 24 out of 48 utilities reported water vending to be present. 11 of the 24 utilities (including Delhi, Mumbai and Calcutta) described the situation as "some water vending but not common". Madras is included in the category "no significant water vending". From the water balance sheet, it appears that the extent of water vending in Madras is quite insignificant indeed (about 8.1 MLD by tanker trucks and mineral water out of 600.1 MLD). However, this can be misleading. Almost anywhere in Madras, one comes across tanker trucks carrying water; shop keepers stacking up mineral water cans and retail water vendors supplying water to residents etc. In this section, I will describe the various elements of water vending in Madras.

Tanker Truck Operators

In conditions of scarcity, a water market reflects an oligopolistic structure with scope for super-normal profits. While technology is not an entry-barrier, the minimum efficient scale of operations and legal requirements act may as the entry barriers. If there are no entry-barriers, then the market structure would be that of monopolistic competition, with a large number of firms (operators) providing water supply. (During the dry season, many tanker trucks generally used for transport of petroleum or edible oils can be easily put to use for transport of water). Panic reaction in the form of regulation (limiting the number of tanker trucks, for example) could act as entry barrier and actually could be counter-productive (from an efficiency point of view). Such regulation benefits the large operators (who can incur the legal costs of compliance and get the necessary permits, for instance). The market structure changes to that of an oligopoly.

Section 5 of the *Madras Metropolitan Area Groundwater (Regulation) Act, 1987* requires everyone extracting[12] or transporting groundwater to have a license. Local news papers reports and interviews with water tanker operators indicated that from time to time, tanker trucks not having a license are impounded with the help of the police. The regulators believe that this is in public interest. They argue that the effect of regulation is seen in stabilising the ground water levels in the villages on the south coastal aquifers where over-pumping could otherwise have caused salinity ingress[13]. All the tanker truck operators that were interviewed consider this legislation and the licensing requirements to be unnecessary hurdles.

In this case, it appears that regulation has a significant impact on the market structure for water. When the regulators are active, water market becomes oligopolistic. Scope for collusion (pricing by leadership) and for some extent of price wars does exist in such a case. When the regulators are lax, the market structure quickly comes back to monopolistic competition where the number of operators is large and there is freedom of entry (and exit). Though all of them supply water (a homogeneous product), they differ in terms of information, consumers' perceptions about quality of water and the reliability of the operator. Hence, there is some degree of product differentiation - the product being 'the transport and supply of water' and not water *per se*.

There are about 150 tanker trucks operating in the private sector. There are no statistics on concentration ratios, but the top five firms have a market share of about 50%. In order to break even, each truck must make at least 5 to 6 trips per day. On this basis, the total supply by this sector is estimated to be 8MLD. However, the operators pointed out that they may make up to 10 trips during the peak demand

[12] For any purpose other than domestic use.

[13] Discussions with Senior Hydrogeologist of Metro water Board; also opinion expressed in Ramakrishnan (n.d.), pp. 45 where he says : "After the implementation of the ground water regulation act, the indiscriminate extraction by private agencies has been controlled efficiently and the extraction has been reduced considerably by the Board".

period (i.e., summer months). At least half of the demand is from non-residential users (offices, factories, construction sites, hotels, hospitals, marriage halls, etc.).

The price charged per 12,000 litres (known locally as 'one load') varies considerably depending on the season. However, during the survey period (June- October 1996), it was around Rs. 350 or roughly Rs. 29.17 per 1,000 litres.

Mineral Water Market :

With regard to the mineral water markets, the overall size of the market is put at 0.1MLD, though Madras is one of the fastest growing markets for mineral water consumption. Information about this market was very difficult to obtain. Several attempts to contact the market leaders in this field, M/S Apollo, have been unsuccessful. M/S SAS Enterprises who own Water Vendee brand of mineral water supply (and the second largest firm in terms of market share) were interviewed. Two of their directors and several senior managers were interviewed and also field visits were made to a few of the water vending facilities[14]. As of 1996, mineral water market size in Madras was estimated to be about 2.5 million litres per month. There were at least 19 different brands. However, the top 6 firms had a market share of about 80 per cent. All of them sell mineral water in jerry cans of 12 litres through retail distributors and street-corner shops. Retail price per can varies from Rs. 12 to Rs. 15, or roughly, Rs. 1 to 1.25 per litre. Though there are standards that are to be met, regulation is a bit grey area : Metro Water Board does not have regulatory powers concerning these; the Tamil Nadu Pollution Control Board comes into picture only if there is a case of pollution in violation of norms; the health authorities come into picture only if an explicit health risk or epidemic has been linked with mineral water consumption. There are some Indian standards concerning the use of

[14] Unlike other mineral water or bottled water manufacturers in Madras, the SAS Enterprises use a decentralised approach where they give a franchise to different retailers. A mineral water plant is then set up in the premises of the retailer.

the term 'mineral water' and also regarding the material to be used for containers of drinking water. However, who enforces them is not clear.

Control of Public Water Static Tanks :Rent Seeking or Co-operation ?

A third type of response is in the form of rent seeking behaviour for the water supplied through static tanks. In 1996, these numbered about 3,400. Each such tank has a capacity of 3,000 litres. These static tanks are owned and provided by the Metro Water Board. A majority of these are welded steel tanks, though in some streets masonry and concrete tanks have been constructed and in others high-density poly-ethelene (HDPE) tanks are being used. These are placed along-side a public street and are filled every day (in many cases once, but in some cases twice) by tanker trucks contracted by the Metro Water Board. This is a free supply for slum dwellers and others not having yard tap connection. However, it was observed that a majority of these tanks are regulated by local individuals who collected Rs.0.25 per kudam (a container of 20 litres capacity) from the consumers. When the households were asked as to why they were paying for a public water supply (supposed to be available free of charge), this payment was described as 'tips' for the driver and cleaner of the tanker trucks for making sure that water reaches their static tank. Assuming that such payments are made in all locations in Madras, the following calculation is made for a typical day in 1996:

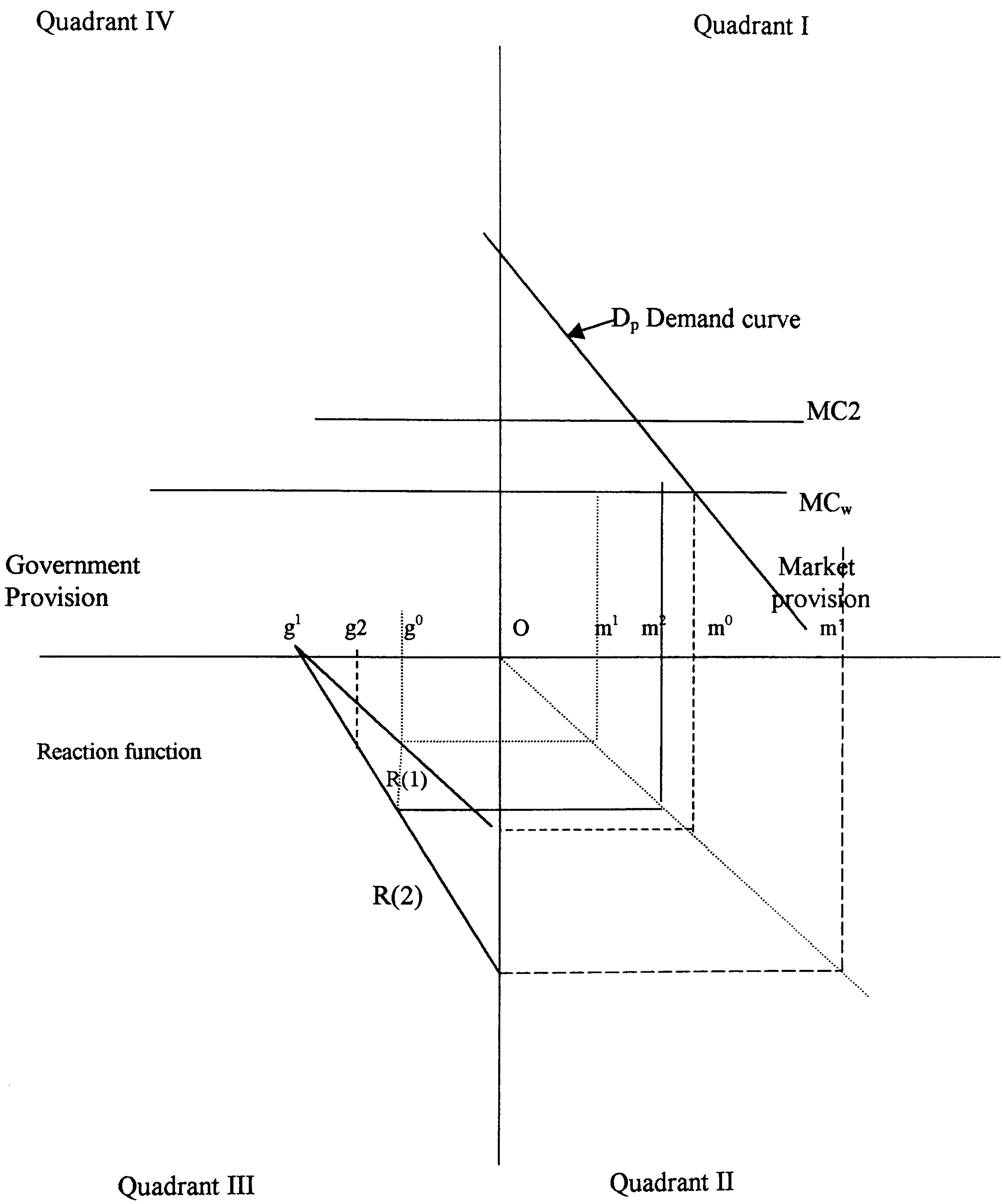
Capacity of one static tank	:	3,000 litres
Number of kudams supplied	:	3000/20 = 150
Charge per kudam	:	Rs. 0.25
Total amount collected per static tank	:	150*0.25 = Rs. 37.50
Amount 'supposedly' given to tanker driver	:	= Rs. 10 to 15
Capacity of tanker truck	:	10,000 litres
Number of static tanks filled per trip	:	3
Number of trips per day	:	8 to 10
Total amount per driver per day	:	Rs. 10 * 3 * 9 = Rs. 270 (L)
		Rs. 15 *3*10 = Rs. 450 (U)
Total number of tankers in operation	:	150
Total amount of 'extra' income per day	:	150*270 = Rs. 405,000 (L)
		150*450 = Rs. 675,000 (U)
(L – lower estimate ; U – upper estimate.)		

Assuming that such payments occur mainly during the summer months (4 months), the total amount so being paid by consumers is roughly Rs. 1.6 to 2.5 millions. Are such payments an indication of rent-seeking behaviour? In the collection of these charges, horizontal equity is maintained (i.e., everyone is charged the same amount per kudam) making it similar to a user charge in some respects.

An extension of supply from static tanks is the retail water vending. In this research, interviews were conducted with 6 different water vendors. All the vendors collect water from a public source. In case of Madras City, this is from the static tanks in one of the streets; in case of MUA Towns, this is from one of the municipal water tanks/water works stations. Also, a majority of vendors use ordinary bicycle for transporting water; about 30% of the vendors however, use purpose built vehicle - to be hauled by the vendors or in a small number of cases, drawn by a bullock. When the water is delivered in this fashion, they charge Rs. 1 per kudam (20 litres) or roughly Rs. 50 per 1,000 litres. Most households who are buying such water from vendors, buy 2 kudams per day (or incur Rs. 60 per month).

5.6 Impact of Government Policy on Private provision of water :

From the water balance sheet we saw that while the Metro Water Board and municipalities were supplying 189 MLD, this was supplemented by individuals from private supplies or from market purchase (to make the total consumption 324 MLD). Given that urban water supply has the property of rivalry in consumption, it is possible to examine some likely effects that government policy may have on private provision of this good and final consumption by individual consumers. An illustration given by Cullis and Jones (1992 : 399) can be adapted for this purpose. This is shown in figure 5.3.



R(1) – reaction function with a slope of 45 degrees suggested by Cullis and Jones;
R(2) – more plausible reaction function in Madras

Figure : 5.3 : Impact of government policy on water markets in Madras

Quadrant I relates to market provision of water. Quadrant IV indicates the public sector provision. The assumptions here are : good G (water per capita per day) is a rival good and both public and private sectors can produce this at a constant marginal cost of MC_w If there were no public provision, the market outcome would have produced a quantity where the marginal cost equals the private demand D_p, that is, quantity equal to Om^0. If the government considers it to be a merit good it could produce $Og^1 = Om^0$. However, let us assume[15] the government only produces Og^0. To trace the impact of this on market provision, a reaction function is shown in quadrant III. According to Cullis and Jones, the slope of this reaction function depends on two factors (explained below). In the simplest case, this reaction function has a slope of -1 (water produced by government and the market are substitutable).

If government provides Og^0, the impact on market can be traced by reading the reaction function and the market provision now decreases from Om^0 to Om^1. Total provision of the good is such that $Om^0 = Og^0 + Om^1$. Following Cullis and Jones, total provision of the water ($G_t = Om^0$) is the sum of water provided by the government (G_g) and water provided by the market (P_m) :

$$G_t = G_g + P_m$$

$$P_m = Om^0 - a\,G_g + b(G_g - T_g) \qquad 5.1$$

Cullis and Jones point out that 'a' here measures the extent of closeness of substitution between the market and government produced goods; G_g is the value of water provided by the government and T_g is the financial impact (water charges) of the provision of the good by government. Coefficient 'b' represents the marginal propensity to consume good G out of income. Slope of the reaction function :

[15] If it were a pure public good or if there is natural monopoly, government may produce the entire quantity. However, as in case of many other public goods, there is scope for market provision. Government takes this into account and hence, decides to produce Og^0 which is $< Og^1$.

$$\frac{d\,P_m}{d\,G_g} = -a + b \qquad 5.2$$

The reaction function R(1) is one where a=1 and b=0. For a case like water, product differentiation is limited and hence 'a' can be assumed to be 1; however, because of other likely benefits from having a water connection or perceived superiority of quality of water supplied by Metro Water Board , people of Madras may have some positive 'b' value (rather than zero). Therefore, the reaction function in Madras for water is likely to have a slope of more than –1 (i.e., a steeper R(2)). The implication of steeper R(2) can be explained as follows:

a. If the government does not provide this service, market will need to provide Om'. However, market equilibrium is Om^0. Hence, if it is entirely left to the market, shortage (equal to Om' – Om^0) will result.
b. Planners assume that water supplied by public sector and private sector are perfectly substitutable (hence, slope of reaction function = -1). Using R(1), planners calculate total quantity to be $Og^1=Om^0$. Government decides to provide Og^0 and the planners calculate the amount that market needs to supply (Om^1 = Om^0 - Og^0). Hence, they issue licenses limiting the total quantity from market to Om^1.
c. However, in consumers' view, water supplied by public sector and private sector are not substitutable. They use a steeper R(2). Given Og^0, they require Om^2 from the market.
d. As the regulation limits the market to supply Om^1 a water shortage occurs.
e. This may result in 'grey' market for water in the short run and/or a political pressure from consumers to increase government supply from Og^0 to Og^2.
f. Grey market activities may result in over-extraction of water in nearby sources pushing the marginal cost of extraction to MC2.

g. This will result in a new equilibrium quantity (not shown in the figure, but let us say is Om'') which is lower than Om^0. Since government is already supplying Og^0, market will supply a quantity that is even lower than Om^1 (equal to Om'' minus Og^0). The amount of shortage increases, further increasing grey market activity and political pressure to increase government supply.

This is a very static view but it seems to pretty much sum up what has been happening in Madras. To resolve this, water planners need to understand the true reaction function (and hence knowing customer preferences for water supplied by Metro Water Board versus water supplied by market). Another implication is to deregulate market. At present, as already mentioned, the licensing requirements to transport water have the effect of restricting market response to Om^1 assuming the reaction function to be Og^0. The focus of regulation should shift from controlling the number of tanker trucks to protecting aquifers and limiting water extraction to be within the recharge capacity.

An alternative approach may be to analyse the water market in Madras in a partial or general equilibrium framework (Devarajan, 1997; Gunning and Keyzer, 1995; Goldin and Roland-Holst, 1995). This lies beyond the scope of this work but it is felt that the water balance sheet developed in this chapter can contribute to the development of a general equilibrium model for water markets in a metropolitan city with multiple sources of water.

5.7 Distribution equity : Who gets how much water in Madras:

The share of water available to different income groups cannot be worked out without detailed consumption surveys. From the limited data available, I have worked out the average water consumption rates for different users (Table 5.5). For instance, from the Water Balance Sheet we know that unmetered residential consumers get about 97 MLD. According to the Census 1991, we know that the number of households having a water connection within their premises is 205,765, and the average household size is 5. Therefore, per capita consumption comes to 94 lpcd. Another example can be of those using public fountains. According to Metro Water, there were 7,879 public fountains. From the Census, we know that 129,360 households were getting water from a 'tap outside their premises' and if we assume that this entire groups of households get water from a public fountain that works out to roughly 16 households or 80 persons per stand post (assuming all stand posts are functioning). The stand posts get water from the same mains that are supplying to residential consumers. If we use the same statistic of 880 litres per connection (total quantity of water supplied divided by total number of connections including public fountains), that works out to 11 lpcd.

Table 5.5 : Per capita water supply for different sections of population

Households having a tap in house	152
Tubewells in the house	125
India Mark II pumps	125
Households having a tap in house (after adjusting for unaccounted for water)	94
Others : Static tanks	38
Shallow wells within the house	16
Shallow wells outside	12
Households using public fountain	11

One limitation of these estimates is that we use 1991 figures of number of households (in 1996). If the population growth is taken into account, all the per capita figures could be even lower. However, that does not affect the main argument here which concerns inequality in water distribution. These figures indicate one aspect of inequity i.e., differences in the quantity of consumption. Another aspect of equity relates to who is paying how much.

5.8 Differences in Cost of Water from Different Sources

In 1994-95 Metro Water's total expenditure was about Rs 840 million (or about £15.5 million in 1995 prices). However, this includes expenditure on water supply as well as sewerage. In the absence of break-up, if we assume that half of this amount is allocated to water supply, the average cost per thousand litres works out to Rs 2.66. In comparison, the tariffs charged for metered consumers and effective average cost for others are shown in table 5.6.

Table 5.6 : Average cost of water faced by various users in Madras

User category	Cost in Rs.	Quantity	Units	Average cost Rs. per 1,000 litres
A. Metro water : metered				
Industrial				25.00
Commercial				10.00
Public authorities				10.00
Bulk Consumers				20.00
B. Metro Water --Unmetered				
Industrial	1,771,670	47	MLD	0.10
Commercial	24,255, 755	9	MLD	7.38
Public authorities	701,275	24	MLD	0.08
Domestic Non-Residential	5,775,520	6	MLD	2.64
Domestic residential	64,660,930	97	MLD	1.83
C. Static tank users	0.25	20	Litres	12.50
Vendors (from static tanks)	1.00	20	Litres	50.00
D. Private Sector				
Private tankers	350	12,000	Litres	29.17
Mineral water	15	12	Litres	1250.00

Sources :1. Cost details : (a) For metered users of Metro Water, tariffs from Metro Water regulations; (b) For unmetered users of Metro Water, cost details from Metro Water annual report, 1994 (schedule H).

2. Quantity details from Water Balance Sheet in figure 5.1.

3. For C and D, data collected from field work and interviews .

From the above table it appears that the low income households without any entitlements to water other than from self regulated sector of static tanks may face an average cost of water that is nearly 7 times that faced by an average household having a yard tap connection (or more than 4 times the average cost of supply by

Metro Water). Unmetered industrial users paying Rs.0.10 per 1,000 litres while average cost of supply for Metro Water is Rs. 2.66 per 1,000 litres i.e., less than 4% of cost is a disconcerting finding.

A payment made for obtaining water forms only one aspect of costs of water supply. The time spent by households in collecting and transporting water, and any efforts to improve its quality (for instance, by filtering) must be included in an analysis of costs. This issue is examined in section 5.10.

5.9 Water Entitlements : Exploring property rights issues:

Access to many of the water supply sources is either through private or communal property rights. Consumers obtain water under different arrangements including :

- Private property rights : In most cases, a connection from municipal piped network is possible only if the title to land is legally recognised and protected. Both riparian and ground water rights are also seen as inalienable rights attached to land.

- Communal rights : In some cases, when the source has open access character, access to water is regulated and it is provided by being a member of a community or a co-operative unit. (However, this is more likely to prevail in rural context. In urban context, some wells and public fountains are seen as communal property).

- Traded good : As mentioned earlier, water vending becomes the only source to households or consumers who do not have either of the above two sources.

Property rights issues can be brought into the discussion using Sen's entitlements concept. The amount of water that a person actually consumes depends on the entitlement set E_i of person i. This E_i "can be characterised as depending on two parameters viz., the endowment of the person and the exchange entitlement mapping". (Sen,1981:pp.45). The entitlements approach has been largely applied in the context of food, though its potential for application to other commodities is recognised. Two points need to be mentioned :

- The term 'entitlement' in case of water as used by Winpenny (1993), is used in a different meaning than it is used here. Winpenny's use of the expression entitlement (and hence his criticism of such approach) is that of a state enforced legal right - that every citizen is entitled to get some water. Here, the expression is used following Sen's definition and usage as a broader expression for rules of [legal] acquirement - a bundle which depends on several factors including legal and institutional framework, social norms, property rights and so on.

- There are several critiques of Sen's entitlements concept. (Sen acknowledges some of them in Sen, 1990; also see Gore, 1993 and Leach et al.,1999). Gasper (1993) discusses several aspects concerning entitlements analysis and its applications and points out the likely confusion in using the expression entitlements with different definitions. In particular, he draws attention to three different meanings in which entitlements has been used in the context of resources : 'present rights to resources, or rightfully held resources, or a set of possible titles arising from the use of rights and resources'. Here, the expression entitlements is used in a rather narrow 'every day language' - to borrow Gasper's expression - the most [amount of water] that people might become entitled to. I am aware that there could be problems with such interpretation, specially if people are unable to or fail to make good use of their opportunities (see Gasper, pp. 705).

Given that water is a bulky commodity and given the limitations for households to engage in day-to-day retail trade in water, it is the endowment portion rather than exchange entitlements component which determines the amount of water that a person gets in a system. One can construct a water endowment function as the amount of water that a household has access to from the various sources. Since it was not possible to collect details of actual water consumption in the Madras survey, the average figures from the metropolitan-level as estimated in Table 5.5 are used in conjunction with the responses that households gave to the questions on (a) the various sources from which they presently draw water, (b) whether the ground water drawn by the household is saline/brackish. The calculation of water endowment[16] of person i is then done as follows :

$$E_i = \sum_j m_{ij} * Q_j \qquad 5.3$$

where

m_{ij} is 1 if household i has access to source j and 0 otherwise

Q_j is the average quantum of water available from source j (from table 5.5).

However, some of the households may have a well but if the water from the well is saline/brackish, whether it should be included in the endowment or not is a moot point. Depending on this the endowment can be modified[17] as :

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[16] It is also possible to distinguish between private property rights and communal property rights. Such distinction may be necessary because : private property rights (having a well or borewell within the premises) may offer additional convenience and may require less time and labour in collecting water (though there could be exceptions). Then, one can decompose the right hand side in equation 1 into public (1 to j) and private (1 to k) components.

$$E_i = \sum_j m_{ij} * Q^{Pub}_j + \sum_k m_{ik} * Q^{Prv}_k$$

[17] Instead of salinity, if one wants to incorporate seasonality of a source as in case of wetlands or in case of arid regions, similar variables can be defined and the endowment function can be so extended.

$$E_i = \sum_j m_{ij} * Q_j * (1 - Sal_j) \qquad 5.4$$

where Sal_j is 1 if source j is saline or brackish and 0 otherwise.

The distribution of households as per water endowment levels taking salinity into account[18] is shown in table 5.7.

Table 5.7 : Water endowment levels of households in Madras

Water Endowment In lpcd	Mean Monthly Income Rs.					Entire sample
	2,000	3,000	4,500	8,000	20,000	
0	40.0%	34.1%	9.4%			17.6%
16	35.0%	31.8%	18.8%	36.4%	15.8%	28.4%
94	10.0%	13.6%	18.8%	6.1%		10.8%
110	5.0%	15.9%	18.8%	9.1%	31.6%	15.5%
125	10.0%	2.3%	6.3%	6.1%		4.7%
219		2.3%	28.1%	33.3%	52.6%	20.9%
235				9.1%		2.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

Source : Madras Household Survey, 1996.

Note : Shaded cell refers to median class (of endowment) in each column.

The water endowment of households in different income levels is made up of either ground water or water from tap (Metro Water or municipal supply in towns in MMA). This is seen in table 5.8.

[18] Information on salinity was available only for a sub-sample of 94 households within the sample. However, of the 44 households who were not asked this question, 26 households did not have any source in their premises; another 16 had only Metro water connection and no well or tubewell. Therefore, only in case of 2 households who should have been asked this question, we have no information. Therefore, these results need not be treated as those from a truncated sample.

Table 5.8 : Mean water endowment levels litres per capita per day

	Mean Monthly Income Rs.				
	2,000	3,000	4,500	8,000	20,000
Endowment from ground water	14	30	62	54	79
Endowment from Metro water or tap	19	13	49	69	73
Total	33	43	111	123	153

In terms of location, we can see that households in Madras City have nearly twice as much water endowment as those living beyond the City limits in the 9 towns and in metropolitan area (table 5.9).

Table 5.9 : Average Endowment levels in litres per capita per day (lpcd) for households in different spatial units

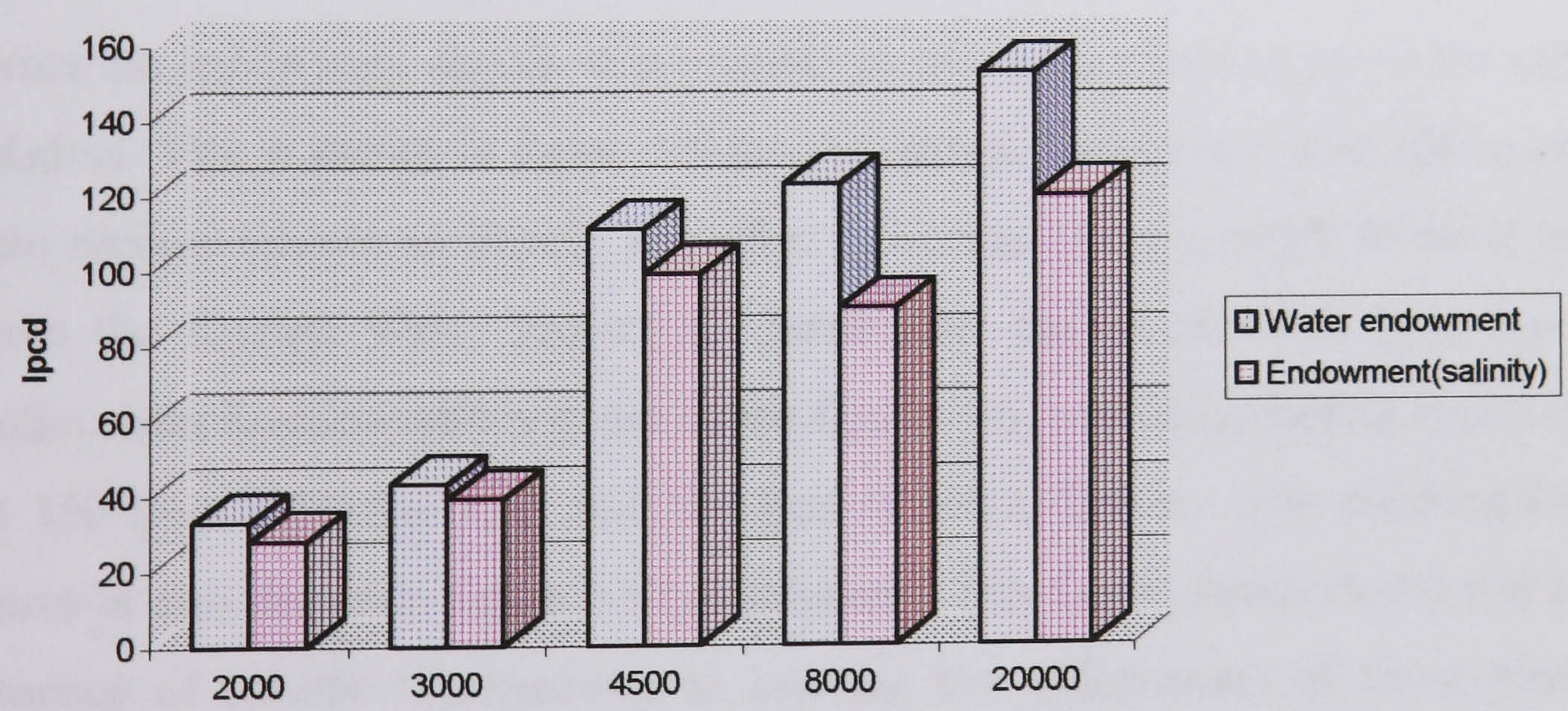
	Madras City	9 Towns	Rest of MMA	Entire sample
Endowment from ground water	55	27	16	42
Endowment from Metro water or tap	50	20	0	46
Total	105	47	16	88

Further, from table 5.10 and figure 5.4 it can be seen that salinity or brackishness affects a larger proportion of low income households : however, the quantity of water that they have access to is limited and hence, the water endowment is already so low that the impact of salinity appears to be small. This is from the reduction in water endowment level.

Table 5.10 : Impact of salinity on water endowment level

Mean Monthly Income Rs.	% of households in the income group reporting salinity	Mean Water endowment without salinity effect (Z1)	Mean Water endowment after discarding sources affected by salinity (Z2)	Percentage change (Z2 – Z1)/Z1
2000	66.7%	33	28	15%
3000	60.0%	43	39	9%
4500	47.6%	111	99	11%
8000	44.8%	123	90	27%
20000	33.3%	153	120	22%
Entire sample	48.9%	88	72	18%

Figure 5.4 : Change in endowment due to salinity



It appears therefore that salinity is a bit complex problem and nearly a half of the population in Madras seems to be affected by it. However, it needs to be reiterated that for the poorest (who do not have any entitlements to water within the premises of their homes), the water endowment levels are 0 and hence salinity effect on them cannot be easily measured.

Though water endowment increases with income (as seen from tables 5.7 to 5.9), income alone does not sufficiently explain the differences. A linear regression analysis yielded the following result (t- ratios shown in parenthesis) :

$$\left.\begin{array}{l} \text{WATENDOW} = \underset{(4.986)}{43.438604} + \underset{(4.357)}{0.004437} * \text{MEANINC} \\ \\ \qquad\qquad \text{R square} \; : \; 0.115 \end{array}\right\} 5.6$$

There seem to be structural and institutional reasons affecting endowments rather than incomes alone. For instance, if a household wants to increase their endowment by drilling a tube-well, they may need to have property rights (either as owner or as a tenant). Similarly, the present policy is that a household cannot get a water connection unless the household is located in an area of the metropolis where such connections are possible and the property is assessed for property tax[19].

From the endowment details, it is possible to construct a Lorenz curve for water in Madras. This is shown in figure 5.5 for the current endowment level taking salinity into account (shown as 'Now'). The effect of increasing the quantum of water supply from the Krishna Water Project on distribution can be estimated by a modified endowment function with new per capita figures (m_{ij}) for those having access to tap at 150 lpcd in Madras City and 100 lpcd in MUA Towns. The resulting Lorenz curve is also shown in figure 5.5 (as 'Krishna'). This figure shows clearly that in the absence of specific interventions to increase the endowments of those presently having little or zero endowments, a city-wide programme of increasing the water supply will disproportionately benefit only those who already have access to the system and have high endowments.

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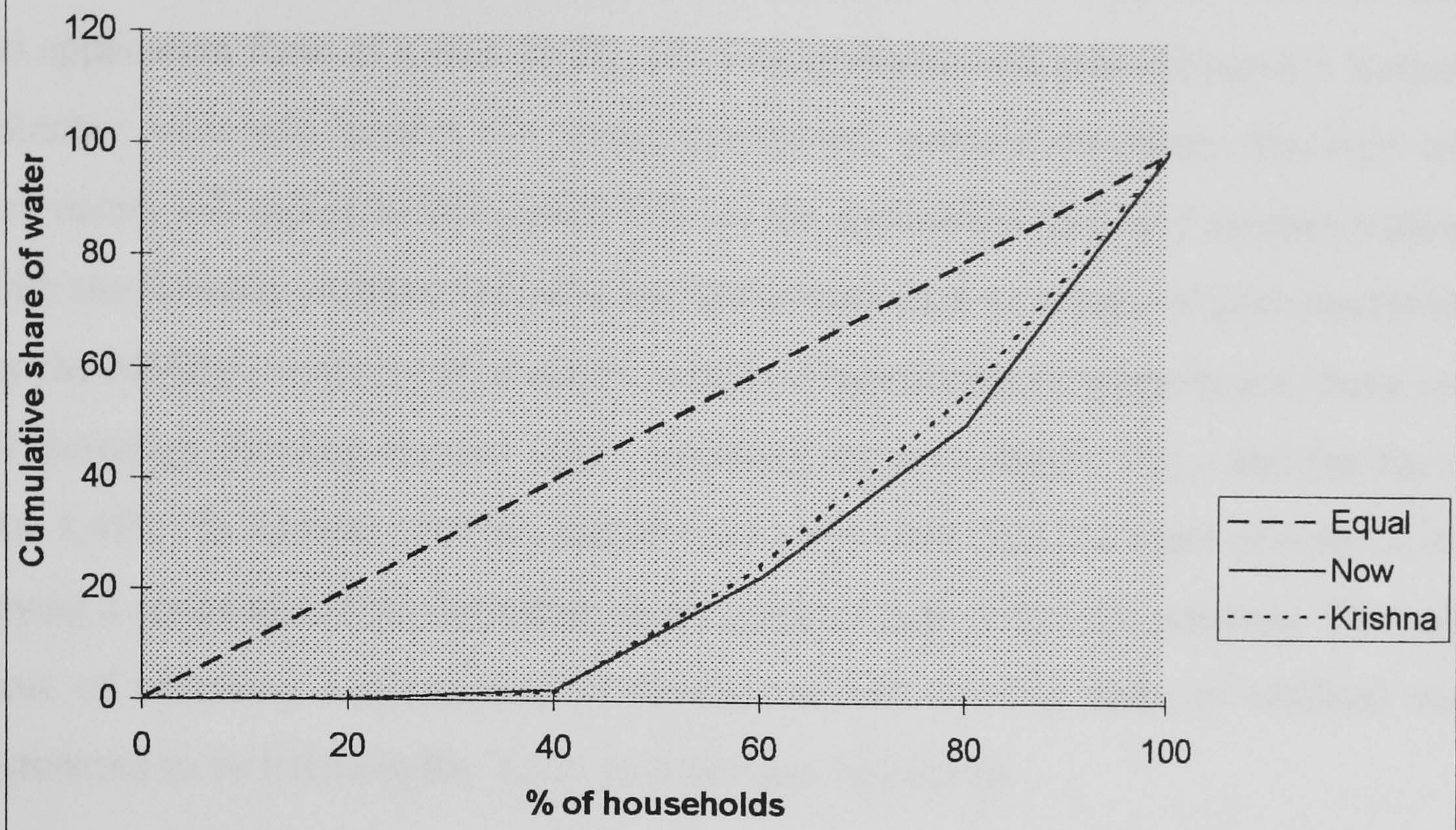
19 This seems to have been relaxed in 1998. See discussion on citizens' charter in section 5.11.

Fig. 5.5 Lorenz Curves for Water Endowments in Madras



Completion of a project to increase the total quantum of water supplied to the city *per se* does not affect those who do not have endowments related to piped water (first two rows of the table 5.7 - households with endowments of 0 and 16). Given that 75% of lowest income group and 65% of the next income group do not have a connection, any water project that does not provide them with a connection, does not affect their endowment. Hence, building projects to increase total amount of water available in Madras does not automatically lead to an outcome to say that 'the poor would particularly benefit'.

The poor will benefit only if specific steps are taken to improve their water endowments[20]. This may require a policy-overhaul with regard to how connections

[20] The calculation of water demand of different segments of population in Madras and the assumptions used in those calculations are a cause for concern. With regard to supply to low income households, a master plan for water supply (1991) has assumed that the number of households living in slums and low income settlements will not increase. This is based on the policy that no

are given and whether legal tenure of status is essential. Even if the policy is changed, whether the low income households can afford the capital costs of a new connection is another issue. As of 1996, a prospective applicant for a connection will first obtain an application form at a cost of Rs. 50. The applicant will then approach a licensed plumber who will inspect the house concerned, prepare necessary drawings and estimated; the applicant then jointly fills up the application form and submits it along with the licensed plumber and attaches documents such as a copy of plan sanctioned by the MMDA or the local authority, notice of assessment of property tax, three sets of drawings showing internal water plumbing network details, etc.., and the fee of Rs. 1,450. In addition, the household concerned must bear the costs of material for laying a connection from the mains to the sump or tank within the premises. The total cost of obtaining a connection (assuming no rent seeking exists in Madras) was estimated to be between Rs. 3,500 to 5,000 per household.

5.10 Water Quality Dimensions :

So far the focus has been on the quantity of water supply and inequality related to that. Water quality is another dimension. Table 5.11 provides information on steps taken by households to improve water quality. About 37.2% of all households drink water without substantially improving its quality[21].

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new slums will come up in Madras and that the slum clearance board will build tenements at a rate that equals new household formation rate for low income households. Further, the quantity of supply assumed for low income households is 37 lpcd.

[21]Total of first three rows in Table 5.11. As candle filter is not effective against micro-organisms, health risks for those who use candle filter and those who do not use candle filter are assumed to be the same.

Table 5.11 : Water quality and household responses in Madras

Water quality Response	Mean Monthly Income Rs. 2,000	3,000	4,500	8,000	20,000	Entire sample
Drink as it is	85.0%	34.1%	25.0%	3.0%	5.3%	28.4%
Boil some times		11.4%	12.5%	3.0%		6.8%
Candle filter				9.1%		2.0%
Boil always	15.0%	50.0%	31.3%	30.3%	21.1%	33.1%
Boil & candle filter			28.1%	30.3%	15.8%	16.2%
Ultra-violet filter			3.1%	18.2%	36.8%	9.5%
Mineral water				3.0%	10.5%	2.1%
UV filter & mineral water					10.5%	2.0%
Sample %	13.5%	29.7%	21.6%	22.3%	12.8%	100.0%

Improving the water quality involves some allocation of resources by the household (capital costs, fuel, time). Hence, as can be expected, response to water quality indicates a strong correlation with income : higher the income, higher is the expenditure incurred on improving water quality. Boiling of water takes time and consumes energy. A candle filter can cost around Rs. 500 i.e., about 2.5% of annual income for lowest income group. An ultra-violet ray filter costs up to Rs. 6,000 and requires electricity, an over-head tank and plumbing. The observed association between income and responses in terms of water quality is also supported from other socio-economic characteristics as shown below :

Table 5.12: Water quality versus education and crowding.

Water quality Household response	Years of schooling	Density Persons per room
Drink as it is	7.0	2.99
Boil some times	8.0	2.51
Candle filter	10.2	1.06
Boil always	13.0	2.17
Boil & candle filter	13.2	1.65
Ultra-violet filter	14.0	0.93
Mineral water	17.0	1.33
UV filter & mineral water	15.7	0.79

It is very interesting to see from the survey data regarding the nature of fuel used and boiling of water as a household response to quality. This is shown in table 5.13.

Table 5.13: Water quality versus availability of gas connection.

Water quality	Households as per gas connection available		Of all households
Household response	No	Yes	
Drink as it is	76.2%	23.8%	28.4%
Boil some times	50.0%	50.0%	6.8%
Candle filter		100.0%	2.0%
Boil always	34.7%	65.3%	33.1%
Boil & candle filter	4.2%	95.8%	16.2%
Ultra-violet filter		100.0%	9.5%
Mineral water		100.0%	2.1%
UV filter & mineral water		100.0%	2.0%
Of all households	37.2%	62.8%	100.0%

Having a gas connection seems to be the most significant parameter for people to boil water (to reduce the risk of water borne diseases).

5.11 Expenditure on Water incurred by households : Some Estimates

Household expenditure on water comprises three elements : direct payment (such as water charges, payments made to vendors or water sellers); expenditure in terms of time spent collecting water (applicable to households not having a source of water within the premises or those having a well but not having pumping facility); expenditure to improve the quality of water. The estimated expenditures[22] are shown in Table 5.14. These figures are averages for households in each income group.

Table 5.14 : Household expenditures on water

	Average Costs Rs. per month per household in the income group			
Mean monthly income Rs. Pm	Direct costs	Cost of time	Cost of quality improvements	Total : Actual Expenditure on water
2,000	11.50	24.47	6.30	42.27
3,000	16.14	27.19	18.20	61.53
4,500	40.94	16.97	27.56	85.47
8,000	50.30	5.77	69.03	125.11
20,000	60.53	0.00	123.11	183.63
Entire sample mean μ	34.19	16.35	43.42	93.95
Standard deviation σ	26.97	24.83	64.72	73.53
μ/σ	1.7704	0.6585	0.6709	1.2777

[22] Details of the estimation are shown in Appendix 5.

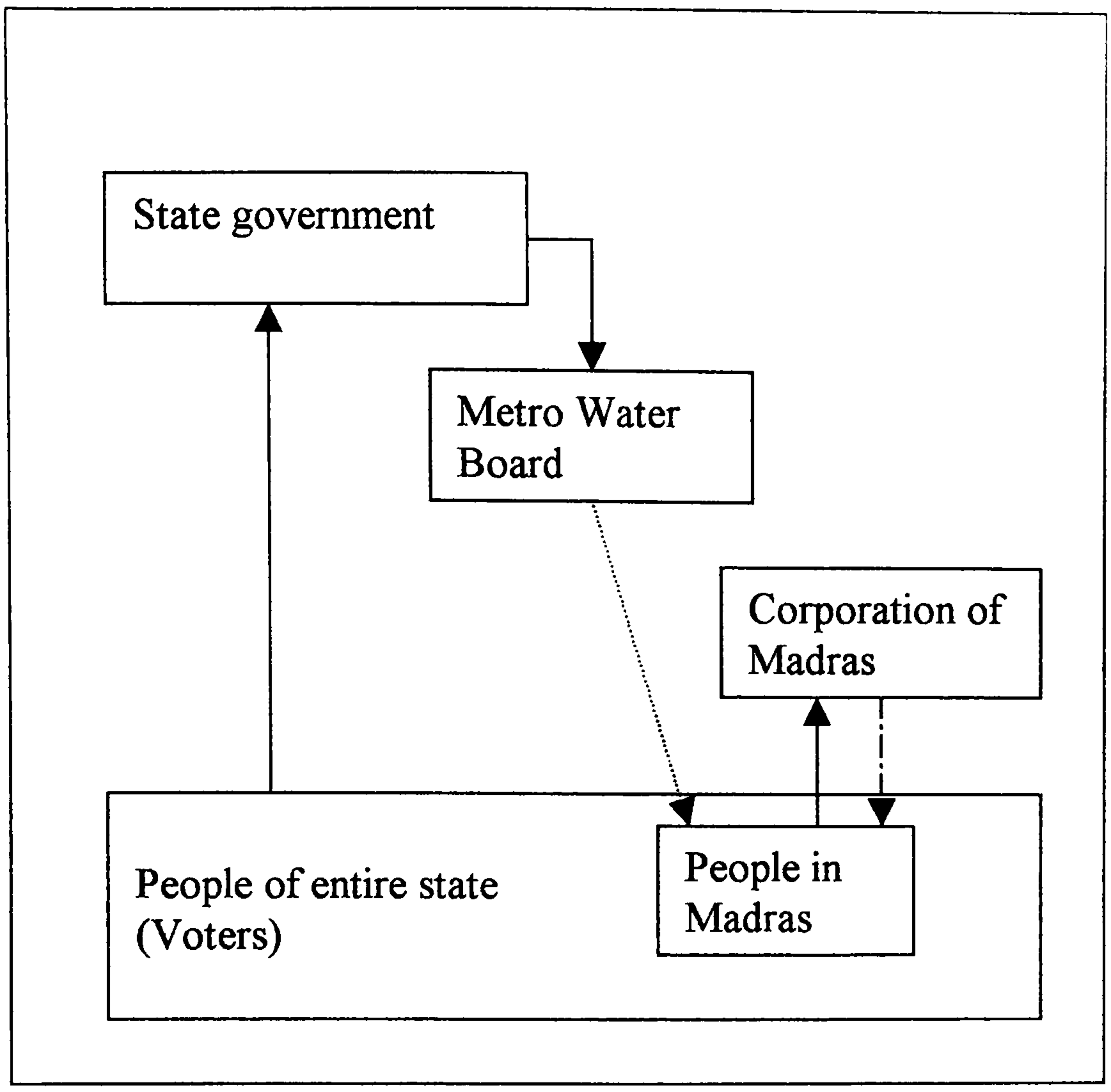
Though there is quite variation in expenditures towards water quality, highest variation (as seen from μ/σ) is in expenditure on quantity. However, it is evident from the table that for the lower income groups, the value of time lost is the main cost component. For higher income households, improving water quality is the main cost item. Similar information is also presented in table 5.15 below according to households in various water endowment levels.

Table 5.15 : Expenditures on water by households as per water endowment

Water endowment lpcd	Average Expenditures by households per month Rs.			
	Direct cost	Time Cost	Quality cost	Total cost
0	9.89	32.55	16.02	58.46
16	18.57	13.65	46.33	78.56
94	45.73	10.24	51.44	107.41
110	50.77	14.07	79.23	144.07
125	40.00	0.00	15.00	55.00
219	70.00	0.00	81.76	151.76
235	100.00	0.00	33.00	133.00

5.12 Recent Institutional Changes at Metro Water Board:

As mentioned earlier, Metro Water Board functions like a state government department. Though it is accountable to the people through the elected state government, this model can be criticised for the 'distance' between Metro Water Board and its consumers. While many other 'local' public goods are provided by local government units, water and sewerage are being provided by a state government undertaking. This is shown in figure 5.5.



This model was created (on the advice of the World Bank) in late 1970s, to implement projects quickly without much delay in discussions. However, this model can be criticised that Metro Water Board is not directly accountable to its ultimate users (people of Madras). Voters in the entire state elect 234 members to the state legislature. Of these, 14 are elected from constituencies contained within Madras City and another 6 constituencies contained in the rest of MMA. The party having a simple majority in the state legislature forms the state government. As a creature of state government, Metro Water Board (through accountability to legislature) is accountable to the entire population of Tamil Nadu state (approximately 50 million) rather than to people of Madras Metropolitan Area (approximately 5 million) though it supplies water only to people of Madras City and a few adjoining areas (and not even the whole of MMA).

In the light of discussions about democratic decentralisation and right to information movement, the Tamil Nadu government introduced the Tamil Nadu Right to Information[23] Act, 1997. Further in April 1998, the Metro Water Board published a citizens' charter – the first of its kind for any water utility in India. Through this charter, Metro Water Board has made several commitments : (a) to ensure that water quality meets the standards laid down; (b) to provide a connection wherever water main is available; (c) to supply water by tanker trucks in areas where there is no pipe network; (d) limiting interruptions to service to specific lengths of time; (e) to respond to customer complaints and enquiries promptly; (f) keep a record of all customer complaints and action taken and make these available to an independent audit. The charter also states that application forms for water and sewerage connections will be available free of cost.

At the time when I started this research, Metro Water Board was an inaccessible organisation (as seen in their response to my requests for information – Appendix 2). Now, their annual report and various other details are available on the internet. These are tremendous changes in any organisation.

However, citizens' charter approach is not a substitute for making Metro Water Board directly accountable to its consumers. It can be criticised that there exists no ombudsman for consumers to take their appeal to. Metro Water Board has both executive and regulatory powers in a single organisation. Though the citizens' charter mentions of the scope for external audit, no ombudsman has been created.

An alternative is to make the Metro Water Board accountable to elected local government. However, local government units are not entirely blame-less. Critics

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[23] Though in principle such an Act is considered to be empowering citizens, a reading of section 3 of the Act (containing a long list of items that are excluded) makes one wonder whether a citizen at all needs the help of such an Act to access the remaining information. One of the items on which the government need not divulge information is : "projections and assumptions relating to internal

argue that corruption at local level is far more difficult to control than at state and central government levels. Even if one chooses to place Metro Water Board under municipal government, a problem remains. There is no single local government unit for the entire metropolitan area; Madras City Corporation has jurisdiction only for Madras City. In that case, placing a metropolitan water supply organisation under a local government unit covering only part of the metropolitan area is problematic.

5.13 Conclusions :

A basic service such as water supply, something taken for granted in the western world, can be a complex issue in any city in the developing world. People in such cities seem to face various different sources. If they are among the lucky ones to have a connection, they face a regulated monopoly of the state, where the prices are politically determined without relation to costs. The others face a market that varies from an oligopoly to a monopolistic competition depending on how active the regulators are and how powerful the law is. The need for understanding the functioning of water markets and the need to avoid 'excessive' regulation, which could be counter-productive, is clear.

This chapter has also presented some information on the nature of inequality in distribution of water and the relative prices faced by different categories of households. A policy that focuses mainly on increasing water availability per capita without altering the entitlements would not improve the well-being of the lowest income groups but in fact increase the inequality in distribution. Entitlements need not necessarily mean only private ownership of the water tap connection. There can be community-based institutions with collective ownership.

policy analysis, analysis of alternative policy options, and information relating to rejected policy options".

With its citizens' charter, Metro Water Board has attempted to make public commitments towards its service standards. However, it remains a state government organisation and the newly elected state government can easily change the policy. Whether Metro Water Board remains a state government organisation or whether it is placed under elected local government, it will need to communicate with its consumers. Accountability without transparency in planning and policy-making will remain ineffective. A right to information law can help in making a democracy effective; however, an effective democracy should be one where citizens do not have to invoke the right to information law.

Chapter Six
Consumer Preferences for Alternative Sources of Water Supply in Madras

6.1 Introduction :

This chapter aims to examine some issues in relation to household preferences for different sources of water. As each source of water has various attributes, the object of analysis is to understand consumer preferences for these different attributes on the basis of information from the survey. My belief is that such information can be useful for water policy makers to target the resources more effectively.

A small number of studies have explored household preferences for water using discrete choice modelling approach. Some of these studies have essentially focused on the probability of households choosing an improved water source, if such source is provided. For example, Mu et al.,1990, examine a conditional logit model of households' source choice decision, based on data from 69 households in Ukunda, Kenya. In Kerala, India, (by Singh et al., 1993) and Punjab, Pakistan (by Altaf et al., 1993), willingness to pay surveys were used to estimate (a) the proportion of households likely to connect to improved water systems; and (b) whether such improvement schemes would be economically viable. Griffin et al. (1995) revisited the Kerala households and found that households who were predicted from the first survey to connect to water sources, did indeed connect when such connections were offered. Madanat and Humplick (1993) approach the problem by using "..a system of inter-related models to represent the different decisions made by a household in response to pipe water deficiency". In their model, households have different decisions to make : connection decision; storage decision; and source choice decision for usage 1, for usage 2 and so on (i.e., whether to use the water source for a given function, such as, cooking, bathing, washing etc.). In this model, "...lower-level decisions are conditional on the predicted choices of higher-level models…[;]… feedback in the form of composite variables from the lower-level models is included in higher-level models..". They use a sequential maximum likelihood approach. Though they recognise that such an approach yields parameters that are consistent but not efficient they ignore the alternative of a full specification (such as a nested multi-nomial logit model) on the grounds that ".. such an exercise would be extremely time consuming".

All the above-mentioned studies have focused on rural water supply. Lovei and Whittington (1993) have examined water markets in Jakarta (though no models are discussed in that paper). Other studies have examined demand for sanitation in urban areas (for example, Altaf and Hughes, 1994 on Ouagadougou; Whittington et al., 1992 on Kumasi, Ghana). In these studies the regressors included both household characteristics and some of the attributes of the alternatives. Household preferences for individual attributes were not examined.

In a study of assessing environmental values associated with water supply options in the Australian Capital Territory, the Centre for International Economics (1997) used a discrete choice modelling approach to analyse the trade-off between different features (attributes) of various water supply options. Their final sample consisted of 294 interviews. Each person was given a number of options. First, they asked respondents to rank 6 attributes in the order of importance. The attributes used were (p.112) : (a) keeping restrictions on residential water use to a minimum; (b) keeping the need to use recycled water to a minimum; (c) keeping the increase in household costs to a minimum; (d) keeping risks to river flows [from diverting water to supply in Canberra or as a receptacle of waste flows] to a minimum; (e) keeping risks to uncommon wildlife species to a minimum; and (f) keeping adverse effects on Canberra's green appearance to a minimum. CIE study notes that ranking task did not force respondents to make trade-offs (p.115). To understand the relative valuations (marginal rates of substitution) between different attributes, they also used conditional logit analysis to examine the choices. They found that the impact on the flows in rivers was considered by the households to be the most important attribute (p.119). Other attributes (in that order of relative importance) were the household cost of water, the quantity of water (or the level of restrictions), the protection of species, and the impact on the appearance of the urban area. The impact on the quality of water came out as the least significant attribute.

Against this background, this chapter considers an analysis of household choices for water sources in Madras.

6.2 Attributes and Options in Choice Set for Water :

A source of water is considered to have separable attributes. As discussed in chapter 2, following the random utility theory, it is assumed that the consumer chooses that option which yields maximum utility. The consumer may be taking into account the attributes of the choices and also other factors that cannot be observed by the researcher. In the absence of prior information about parameters of attributes, exogenous sampling approach is used in this research. I have decided to use a small number of options, reflecting different combinations of some of the attributes of interest. For example, a policy maker or planner may be interested to know the following:

a) given that resources are scarce, which aspect of water supply should be improved first, i.e., in consumers' view, which attributes are more important and which are less important;

b) whether water supply plans should be based on giving yard tap connections to all households or whether the policy should limit itself to providing communal water sources such as shared connections (which would require some households to haul or carry water);

c) whether consumers prefer water supply provision by a government agency or whether they are ambivalent as to who provides the service; and

d) whether consumers have preferences for conservation and recycling aspects and whether consumers support a policy that requires them to engage in water harvesting and using recycled water for non-drinking purposes[1].

In order to examine some of these issues, in this study, the following seven attributes were considered, namely : monthly charge for the household (PRICE); quantity of water to be supplied (QUANT); whether such water is treated to meet with standards or not (WQUAL); whether it will be delivered via a yard tap (YARDTAP); and whether it will require the connection to be shared among designated households (SHARED); whether it will be delivered by private sector (PRIVATE); and whether an option requires the household to engage in rain water harvesting and recycling of sullage (ENVIRON). The first two are ordinal variables whereas others are binary variables.

Based on field observations and focus group work, I have used seven options in the household survey. These were developed from various combinations of these attributes. Two of these were in-house (IH) or yard tap connections to the public water distribution network (IH-1 for residents in Madras City and IH-2 for those in peripheral areas). The two out-house (OH) connection options are very similar to the IH options (i.e., same amount of water, also by public sector provider) with the only difference that ownership is to be shared among five designated households (i.e., a common property resource but not an open access resource as in the case of a stand post). Other options were : a yard tap connection from a network of water mains to be provided by the private sector (PP), supply of water by private tanker trucks (TS) and one that requires the participant to indulge in rain water harvesting and recycling of sullage for flushing purpose, which we label as the 'environmental option' (ENV). The values of the various attributes (other than PRICE) of these

[1] Relevant in the light of recent thrust in Madras towards rain water harvesting (discussed briefly in the last chapter).

seven options are shown in Table 6.1. The option to choose 'none' was not included in the description. However, during the interview if the respondent did not choose any of the options, the response was coded as 'none'. The universal choice set, thus, has 8 options in all. All the attributes in the 'none' option are coded as zeroes.

Table 6.1 Values of various attributes for the 7 options in Madras survey

ATTRIBUTES	IH-1	IH-2	PP	OH-1	OH-2	ENV	TS
YARDTAP Convenience of yard tap connection (1 = yes; 0 = no)	1	1	1	0	0	0	0
QUANT Quantity of water In lpcd	150	50	150	150	50	30% saving[2]	150
WQUAL Quality of water : Treated water = 1 Otherwise = 0	1	1	1	1	1	0	0
PRIVATE Private Sector =1 Otherwise = 0	0	0	1	0	0	0	1
ENVIRON Whether a commitment to recycle water and rainwater harvesting needed Yes= 1; No =o	0	0	0	0	0	1	0
SHARED Connection to be shared with others No =0 ; Yes =1	0	0	0	1	1	0	0

From the respondent's point of view, each option comes with a monthly user charge (PRICE). However, the capital costs of obtaining a connection (for those who do not have this facility) were not included. For the ENV option, participants were told that the capital cost of installing a rain water harvesting system would be amortised

[2] In the last chapter, average water endowment for entire sample was seen to be 88 lpcd. Therefore, QUANT attribute for this option is the average saving which is 30% of 88 = 26.4 litres.

and converted into a monthly instalment. The prices used in the interviews were randomly selected from a range covering Rs. 1 to Rs. 350 (i.e., up to nearly twelve times the then prevailing monthly tariff of Rs 30 for unmetered connections). The distribution of prices used in the survey is shown in table 6.2 (also figure 6.1).

Table 6.2 : Price ranges used for each option

Price range Rs.	IH1	IH2	PP	OH1	OH2	TS	ENV
0-30	2	0	0	1	1	0	0
31-60	3	6	1	12	8	0	6
61-90	11	8	2	10	3	0	3
91-120	24	11	7	2	0	0	11
121-150	17	6	13	1	1	0	14
151-180	6	2	7	0	0	0	7
181-210	19	2	4	0	0	122	18
211-240	2	1	2	0	0	0	5
241-270	3	1	2	0	0	0	5
271-300	7	0	1	0	0	0	3
301-350	0	1	0	0	0	0	1
N	94	38	39	26	13	122	73
Mean	153	122	153	65	58	210	168
Standard Deviation	66	63	48	22	25	0	64

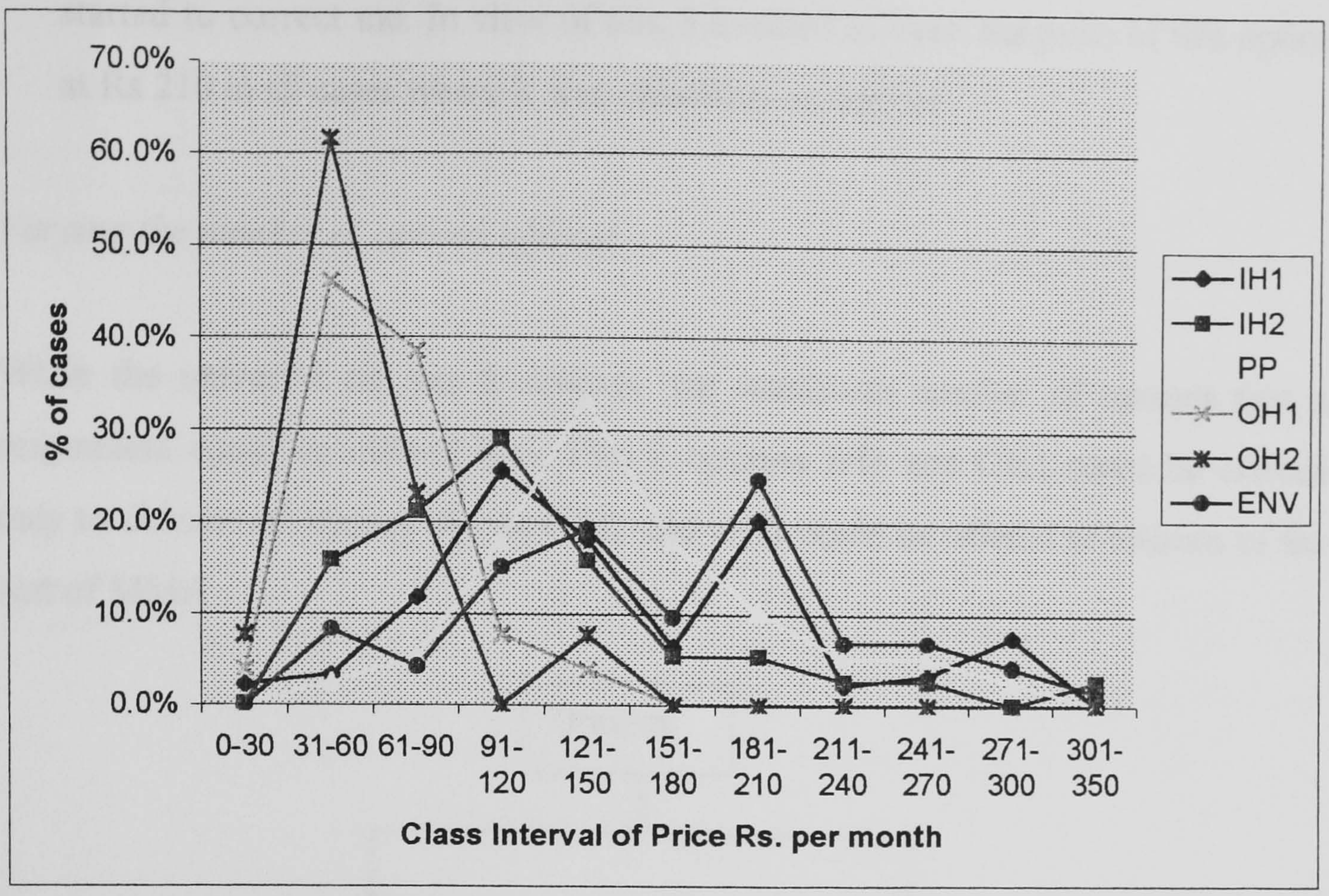


Figure 6.1 : Price ranges used for 6 of the options for water in Madras survey.

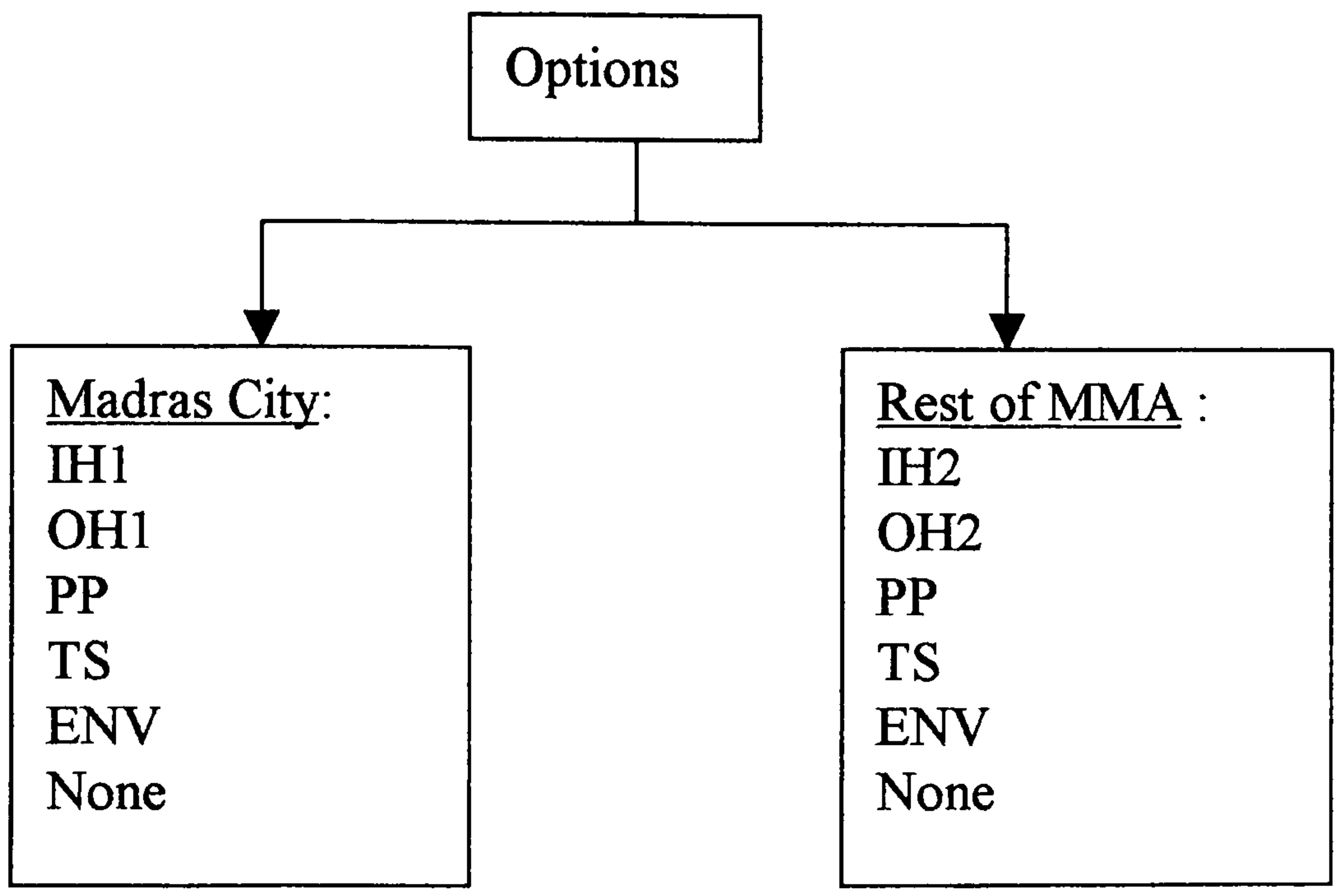
The following points need to be highlighted :

a. For OH1 and OH2, a majority of cases are concentrated within the price range of Rs 1 to Rs. 120. Since this is monthly charge to be paid by each of the 5 households sharing the OH option, the implied total monthly charge is in the range of Rs 5 to 600 (as compared to Rs 0 to 300 for IH1 which is a yard tap connection without having to share it with anyone else.)
b. I faced a problem in selecting a price range for the TS option. While all other options had some hypothetical element in them, the TS option is entirely based on (the then) existing situation concerning tanker trucks. The market price worked out to Rs.210 per month. In the pre-tests, I found that most households were aware of this market price for water supplied by tanker trucks. In these pre-tests, when I offered this option at a price that was different from the market price, respondents thought that I was ignorant of its true price and

started to correct me. In view of this, I decided to keep the price of this option at Rs 210 in all cases where it was offered as an option.

Varying the number of options offered :

While the universal set has 8 options, the maximum number of options that a respondent could be offered is 6. This is because IH1 and OH1 could be offered only to citizens of Madras city and IH2 and OH2 could be offered to citizens of the rest of MMA.



It took about 5-6 minutes to explain each option. If 5 options were offered, describing them would have taken about 25 minutes. In the pre-tests, I could notice that participants were beginning to get restless when I describe more than 3 options. To avoid boredom and consequent lack of interest, I decided to restrict the number of options offered to a maximum of 4. Participants were randomly assigned to one of three treatment groups with 2, 3 or 4 options (other than 'none') as shown in table 6.2 below. In more than 95% of all cases, respondents received either 2 or 3 options (plus the option to choose 'none').

Table 6.3 : Choice sets used in Madras Survey

Number of options[3]	Choice sets for Respondent as per location				Total
	Madras City		MMA		
2	IH1 + TS	18	IH2 + TS	6	
	IH1 + OH1	5	IH2 + OH2	2	
	OH1 + TS	1	OH2 + TS	1	
	PP + TS	10			
	IH1 + PP	2	IH2 + PP	1	
	Sub Total	*36*		*10*	46 (31.1%)
3	IH1+TS+ENV	45	IH2 + TS + ENV	19	
	IH1 + OH1 + TS	6			
	IH1+PP+TS	5			
	IH1+ PP + OH1	6	IH2 + PP + OH2	10	
	PP + OH1 + TS	2			
	PP + TS + ENV	2			
	Sub Total	*66*		*29*	95 (64.2%)
4	IH1+TS+ENV+OH1	6			
	IH1+PP+TS+ENV	1			
	Sub Total	*7*		*0*	7 (4.7%)
Total		109		39	148

6.3 Item non-response – Those who did not choose any of the options:

About 12.2 per cent of the respondents, i.e., 18 respondents, did not choose any of the options offered (*item non-response* : see Mitchell and Carson, 1989 : 269; Arrow et al., 1993). While there are specific guidelines on survey response rates, those relating to item non-response are less specific. Mitchell and Carson (1989 :

[3] When the option to choose 'None' is included, effectively, the number of options is 3,4, and 5 respectively.

267) point out that non response rate of 20 to 30 per cent is not uncommon in CV surveys where the sample is random and the scenario is complex. In this light, the item non response rate of 12.2% in Madras survey can be considered to be within acceptable limits.

The main reasons given were : not interested in any changes (3 respondents); satisfied with the existing system (3 respondents); do not believe it can be changed by individual action (3 respondents); it is government's responsibility to provide water supply (2 respondents); we are already paying taxes (2 respondents); we have to consult others - family members (1 respondent); other community leaders (1 respondent); landlord (1 respondent); other reasons (2 respondents).

Another aspect of concern is whether the non-responders were predominantly from one social or economic group, resulting in a biased sample. Two related concerns are: (a) since the task was to be interviewed by (me) a male researcher, whether women were more likely to be non-responders; and (b) whether there is any sign of 'information overload' that is whether non-response rate increases as the number of options being described increases. From the data in table 6.4, we can investigate these concerns.

Table 6.4 : Non response v. respondent's gender and number of options offered

Number of options	Distribution of responses					
	All respondents			Respondents choosing 'None'		
	Female	Male	Total	Female	Male	Total
2	15	31	46	5 (33.3%)	5 (16.1%)	10 (21.7%)
3	44	51	95	3 (6.8%)	5 (9.8%)	8 (8.4%)
4	5	2	7	0 (0%)	0 (0%)	0 (0%)
Total	64	84	148	8 (12.5%)	10 (11.9%)	18 (12.2%)

Note : Figures in parenthesis are non-response rates for each category.

The above table does not indicate any systematic difference between male and female respondents[4]. With regard to the second concern above, there are contrasting signals. On the one hand, response rates seem to increase as the number of options offered increases. However, 13 of the 18 non-responders were from the two lowest income groups (table 6.5). It is possible that some of these households may have found the interview and the task complicated and unfamiliar.

[4] Pearson Chi-square test statistics are: 1.759 (for 46 respondents receiving 2 options); 0.273 (for 95 respondents receiving 3 options). Number of degrees of freedom in both cases is 1. All 7 respondents receiving 4 options did choose one of the options. Hence, Pearson test statistic is not applied.

Table 6.5 : Distribution of responders and non-responders as per income

Mean monthly income Rs.	Responders	Non responders	Entire sample
2,000	10.8%	33.3%	13.5%
3,000	28.5%	38.9%	29.7%
4,500	23.8%	5.6%	21.6%
8,000	22.3%	22.2%	22.3%
20,000	14.6%		12.8%
Entire sample	87.8%	12.2%	100.0%
N	130	18	148

Note : Figures are column percentage (exception – last 2 rows).

Tests of analysis of variance using F test and comparison of means using independent samples t-test (table 6.6) indicated that in terms of gender, age group, years of schooling, the non-responders and responders were not systematically different.

Table 6.6 : t-test for difference in means between responders and non-responders.

	t-ratio	Degrees of freedom	Significance
Gender of respondent	-0.109	146	0.913
Age of respondent	-1.314	146	0.191
Years of schooling	1.109	144	0.269
Mean income	2.148	146	0.033
Water endowment	2.116	146	0.036

Difference between responders and non-responders in terms of income (and water endowment which is somewhat linked to income) is probably capturing the difference in terms of familiarity with the task of listening to descriptions of options, remembering the details and indicating the response[5].

6.4 Modelling Household Preferences :

In this section, first the multi-nomial logit (MNL) model is considered. Its specification issues are examined using a log-likelihood ratio test. The independence from irrelevant alternatives property is considered. The question of hierarchical elimination by attributes is examined with nested MNL models. While all these models focus on attributes of the alternatives, the issue of socio-economic characteristics is considered first by including some alternative-specific constants (ASCs). Lastly, probit models which include both attributes and some socio-economic characteristics are also discussed.

6.4.1 Multi Nomial Logit (MNL) Models :

In chapter 2, using the random utility maximisation model, a multi-nomial logit was shown (equation 2.23) as :

$$\log\ (P_j / (1 - P_j)) = \beta'(Z_j)$$

As mentioned in chapter 2, the left hand side is the log of the odds that a particular choice is made. The RHS is a function of attributes. For example, we can write :

$$\begin{aligned}\log\ (P_j / (1 - P_j)) = {} & \beta 1 * PRICE_j + \beta 2 * YARDTAP_j + \beta 3 * PRIVATE_j \\ & + \beta 4 * ENVIRON_j + \beta 5 * WQUAL_j + \beta 6 * QUANT_j + \beta 7 * SHARED_j\end{aligned} \qquad 6.1$$

[5] A large majority of non-responses, i.e.,15 of the 18, were the ones where interview was conducted in Tamil. Again, language of interview has relationship with level of education. The more educated respondents opted for the interview to be held in English.

Some results from MNL models are reported in table 6.7 below. In table 6.7, for each model, the following details are given :

a. Estimated model parameters (and whether they were significant);

b. Value of the log likelihood function when it is maximised, $L(\beta^*)$; and value of the log likelihood function when all coefficients are set to zero, $L(0)$;

c. Goodness of fit measure :

Ben-Akiva and Lerman (1985 : 167) and Pindyck and Rubinfeld (1991) discussed a goodness of fit measure defined as :

$$\rho \text{ square} = 1 - [L(\beta^*) / L(0)] \qquad 6.2$$

where $L(\beta^*)$ is the value when log likelihood function has been maximised and $L(0)$ is the value of log likelihood function when all the parameters have been set to zero. Of course, as Pindyck and Rubinfeld (1991:269) point out, "...any particular numerical value of ρ [square] is difficult to interpret. Nonetheless, the value of ρ [square] does give us some indication of how much is to be gained by the addition of new variables to a model". Ben-Akiva and Lerman point out that (like R square) ρ square will always increase or stay the same whenever new variables (regressors) are added. They suggest the calculation of rho-squared bar (which is similar to adjusted R square in case of ordinary least square regression):

$$\rho\text{-squared bar} = 1 - \{[L(\beta^*) - K] / L(0)\} \qquad 6.3$$

where K is the number of parameters (regressors). For example, for model D-6, the value of $L(\beta^*)$ is –83.29; the value of L(0) is –307.75; the number of regressors (K) is 6. Hence,

$$\text{rho squared bar} = 1 - (-83.29 - 6)/(-307.75)$$
$$= 1 - 0.290138 = 0.709862$$

d. A likelihood ratio (LR) test for comparing two alternative specifications.

Following Ben-Akiva and Lerman (1985: 166), a log-likelihood ratio test can be used to compare a model that is specified with K_U number of attributes (the unrestricted model U) with another model that includes K_R attributes (the restricted model R). The test statistic is :

$$\xi = -2\{L(\beta_R^*) - L(\beta_U^*)\} \qquad 6.4$$

where, the two $L(\beta^*)$ are the values of the log-likelihood function when it is maximised; β_R denotes the restricted model and β_U denotes the unrestricted model. This test statistic has a limiting Chi-square distribution with degrees of freedom equal to $(K_U - K_R)$. In the table, the following details are reported : (i) the numbers of the two models being compared; (ii) LR test statistic (shown in equation 6.2 above); and (iii) the degrees of freedom for the Chi square test $(K_U - K_R)$; and (d) the critical value of Chi square.

For example, model D-6 has 6 attributes ($K_U = 6$); we want to impose a restriction that the parameter of QUANT attribute is zero. Hence, we want to estimate a restricted model (D-5, with K_R being 5). We have, $L(\beta_R^*)$ i.e., the value of log-likelihood function maximised from the restricted model (D-5) = -88.44; $L(\beta_U^*)$ from model D-6 is = -83.29. The LR test statistic is :

$$= -2*(-88.44 + 83.29) = 10.3$$

The degrees of freedom for chi-square test is 1; the critical value from chi square table for 99% significance was found to be 7.88. Since the test statistic is larger than critical value, we can reject the null hypothesis that model D-5 is a better specification. Hence, we accept the alternative specification that model D-6 is a better specification than D-5.

(It may be noted that for convenience, in table 6.7, I have identified models with a number which indicates the number of attributes included in the specification. Thus, a model with 6 attributes is called D-6; one with 5 attributes is called D-5 and so on. This notation is adapted purely for convenience.).

Table 6.7 : Results of Discrete choice (MNL) models

	Model D-6	Model D-5	Model D-4
PRICE	-0.0049	-0.0081*	-0.0066*
YARDTAP	1.9451**	2.2023**	1.1545**
PRIVATE	-0.8915*	-1.6232**	-1.1829**
ENVIRON	-2.4428**	-1.7323**	-1.0786*
WQUAL	-0.6633	-1.6643*	
QUANT	-0.0152*		
SHARED			
L(β*)	-83.29	-88.44	-93.10
L(0)	-307.75	-307.75	-307.75
Rho squared bar	0.7099	0.6964	0.6845
LR : models being compared	--	D5,D6	D4,D5
LR statistic	--	10.3	9.32
Degrees of freedom	--	1	1
Critical Chi square	--	7.88**	7.88**

	Model D-3	Model D-2	Model D-1
PRICE	-0.0077**	-0.011**	-0.0081**
YARDTAP	1.5621**	1.7978**	
PRIVATE	-0.9474**		
ENVIRON			
L(β*)	-96.08	-100.28	-141.27
L(0)	-307.75	-307.75	-307.75
Rho squared bar	0.6781	0.6677	0.5377
LR : models being compared	D3,D4	D2,D3	D1 , D2
LR statistic	5.96	8.4	81.98
Degrees of freedom	1	1	1
Critical Chi square	3.84*	7.88**	7.88**

Note : Parameters t-ratio: ** significant at 1%; * significant at 5%.

Chi square : ** significant at 99% : * significant at 95%.

The following observations can be made from the results in table 6.7 above :

a) It was not possible to specify a model with all 7 attributes. It was resulting in singular Hessian. Therefore, I start with 6 attributes. Anomalous results arose when the attribute SHARED was used. It appears that the way the choice set has been specified, the attributes SHARED and WQUAL were somehow inter-related. Since WQUAL and QUANT were more interesting from the policy point of view, I decided to concentrate on them and omit SHARED attribute from the analysis. In model D-6, we find that two of the parameters were highly significant (at 1% level) and another two were significant (at 5% level). Rho squared bar indicates that goodness of fit is quite high.

b) Model D-5 is specified with 5 attributes (and dropping QUANT and SHARED attributes). Three attributes were highly significant (1%) and the other two attributes were significant (5%). As compared to model D-6, rho squared bar has slightly decreased. A LR-test indicates that the null hypothesis that model D-5 is a better specification than model D-6 can be rejected at 99% level.

c) On the similar lines, the remaining columns in table 6.7 impose further restrictions on the number of attributes. However, both rho squared bar and LR tests indicate that as we go on decreasing the number of attributes, there is a reduction in goodness of fit and some loss is model specification.

On the whole, the above regression results seem to indicate that consumers consider a number of attributes. Since we do not have any information on attributes from other studies[6] in Madras, it is difficult to say whether the models meet prior

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[6] In the Kerala study by Singh et al. (1993), probit regressions included the following attributes: monthly tariff (-0.0605); connection charge (-0.0010); improved service (-0.0582). They also included the attributes of existing source such as distance to current source (0.0002); time taken in minutes in the queue at current source (0.0028). In their case, the attribute 'improved service' was expected to have positive sign.

expectations. While PRICE and YARDTAP attributes have the signs as expected, for the other attributes, the expectation is that sign of attributes such as quality (WQUAL) and quantity (QUANT) should be positive. The negative sign of ENVIRON attribute is probably indicating two things : (a) consumers may be sceptical how far individual efforts to engage in water harvesting and recycling of sullage is a solution to water supply shortage; (b) they may be indicating that such schemes may not work in a crowded metropolitan area. The parameter of attribute water quality (WQUAL) was not significant in model D-6. In the previous chapter, we have seen that many consumers already engage in boiling or filtering it. Many of them have already invested resources to buy water filters etc. Hence, we can understand that WQUAL is not significant. With regard to SHARED, it has a negative sign as expected (a negative preference for sharing water connection) though it was not significant in model D-6A.

6.4.2 The IIA property :

In chapter 2, a mention was made of the independence from irrelevant alternatives (IIA) property of MNL models. I attempted to test for the IIA property in the various specifications of MNL model discussed here. For this, a model is specified with all the alternatives (unrestricted model); then one of the alternatives is dropped and the model is re-specified (restricted model). Hausman-McFadden test statistic (equation 2.24 discussed in section 2.3 of chapter 2) could not be calculated. In all the cases that I have tried, the matrix [$CovB_u$ - $CovB_r$] was not positive definite. Hausman and McFadden (1984 : 1226) note this possibility in case of small samples. They suggest comparing the probabilities and ratios of probability of selecting two options when a third option is omitted from the choice set. Table 6.8 below summarises the predicted probabilities from the models discussed above. Actual probability is based on which option was chosen by sample respondents. The other columns are probabilities predicted by the MNL model.

Table 6.8 : Predicted probabilities from model D-6 (unrestricted case) and when one of the alternatives is dropped

		Probability of selecting an option			
		Actual	Predicted from model D-6	When OH1 omitted	When IH1 omitted
1	IH1	0.4797	0.4595	0.4722	0.0000
2	IH2	0.1486	0.2095	0.2153	0.3377
3	PP	0.1351	0.0946	0.0972	0.2078
4	OH1	0.0270	0.0270	0.0000	0.0390
5	OH2	0.0203	0.0203	0.0208	0.0519
6	TS	0.0203	0.0608	0.0625	0.0779
7	ENV	0.0473	0.0473	0.0486	0.0909
8	None	0.1216	0.0811	0.0833	0.1948
9	Total	1.0000	1.0000	1.0000	1.0000
Some Ratios of probabilities					
10	IH2/PP		2.2143	2.2143	1.6250
11	TS/ENV		1.2857	1.2857	0.8571
12	TS/PP		0.6429	0.6429	0.3750

From the above table, looking at rows numbered 10,11 and 12, the IIA property is evident when comparing predicted probabilities from model D-6 with the case when OH1 was omitted. For example, all the three ratios (of probabilities) shown above match to 4th decimal place. However, the ratios of probabilities for model D-6 and a restricted model when IH1 is omitted (shown in the last column) were quite different. The impact of dropping IH1 does, however, seem to be far more significant. Note that dropping IH1 makes the sample size smaller[7]. More importantly, it affects the information available from the remaining respondents. As we saw earlier, YARDTAP is a significant attribute in all models. By dropping IH1, we are losing quite a lot of information about this attribute and how consumers

[7] This is because the choice variable Y_{ij} should get the value of 1 at least once for every valid observation (that option j has been chosen by individual i). However, when the all lines of data

perceive it. The above result may also mean that the specification of model D-6 is not very good. As already mentioned, I could not include all 7 attributes. Hence, I have settled for the next best option, that is to specify a model with 6 attributes (D-6). This choice seems to have come with some loss in model specification (which is what the failure of IIA property in table above also seems to indicate).

6.4.3 The Issue of hierarchical decision making :

A brief mention was made in section 2.4 in chapter 2 of non-compensatory preferences and lexicographic rules. Do consumers consider attributes in a hierarchical manner or consider some attributes to be more important than others? If households do consider attributes in this way, any amount of increase in one attribute may not make an option preferable if it lacks in the attribute that they consider to be important. Following McFadden (1984) and Ben-Akiva and Lerman (1985), I have attempted to explore this issue with the use of nested multi-nomial logit models. As noted in chapter 2, any conclusions from such models will have a limited scope.

Nested MNL models explore whether options are being considered in a hierarchical manner (but within the compensatory framework of utility). If we find the presence of such hierarchical decision making, then a nested MNL (NMNL) model will be a better specification than an ordinary MNL model, specially in relation to estimated probabilities. If some evidence of hierarchical decision making is found, further research can then explore lexicographic preferences and whether a non-compensatory decision framework is being used by consumers. There can also be policy implications. If attributes are considered in a hierarchical manner, the planner can consider the hierarchy of priorities in allocating investments.

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relating to IH1 are omitted, many observations (where the respondent indeed chose IH1) will become invalid observations and drop out of computation.

The null hypothesis is that MNL model specification (model D-6) is correct. The alternative hypothesis is that a NMNL model is a better specification. To test this, the options offered in Madras survey can be seen in terms of various tree structures depending on how the attributes are considered. For example, if the consumer considers options having the attribute of YARDTAP first, before considering other aspects, we have a tree structure as shown is figure 6.2 below.

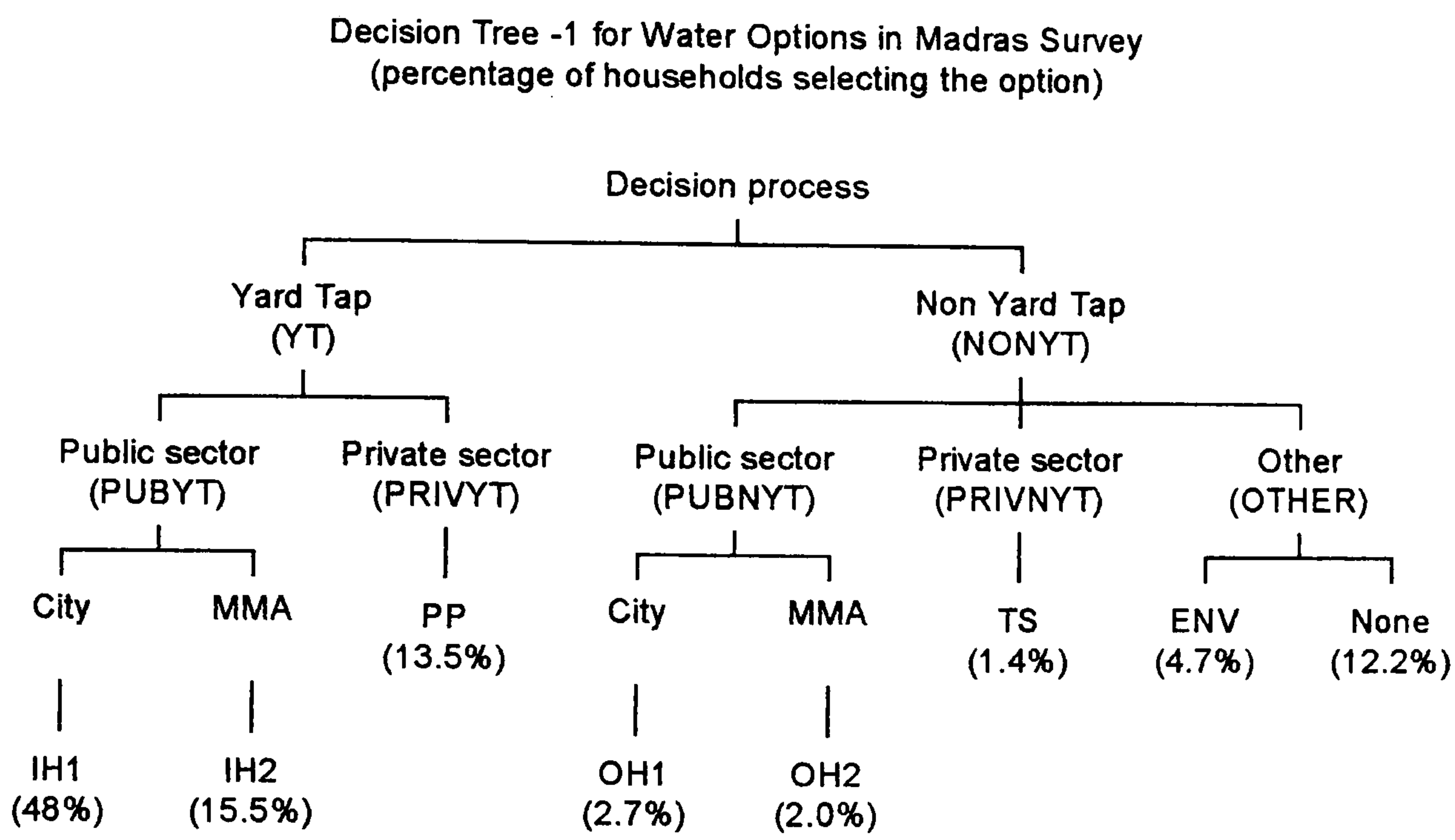

Figure : 6.2 : Decision tree where 'YARDTAP' is considered first

Such a tree structure can be analysed with the help of a nested multi-nomial logit (NMNL) model. The model relating to the above tree is shown in table 6.9 as N-1. In a nested model, in addition to attributes, inclusive values have to be estimated[8]. The number of inclusive values depends on the number of branches and twigs in the tree. The tree structure in figure 6.2 implies that there are 2 inclusive values at level 1 (YT, NONYT); at the next level we have inclusive values relating to whether the service provider is public sector or private sector or other (in case of a YARDTAP

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We can see that the critical value of Chi-square for even 90 per cent level for 2 degrees of freedom is 4.61. Hence, we cannot reject the MNL specification in favour of a NMNL specification based on a Wald test.

Similarly, Wald statistic for model N-2 is :

$$W = (1- 0.934)^2/ 1.2832^2 + (1-0.814)^2/2.246^2 = 0.0095$$

Again, we cannot reject the MNL specification based on a chi square test.

On the basis of these points, it appears that the MNL model specification can be accepted rather than a NMNL model. Therefore, households in Madras do seem to attach a lot of importance to YARDTAP attribute but there is no evidence to say that they approach the decision in a hierarchical manner eliminating all options that do not have that attribute.

6.4.4 Including Respondent Characteristics in the model :

So far in the discussion, the probability of selecting an option has been considered to be a function of the attributes of the alternatives and random variations in tastes and preferences. It is possible that the socio-economic characteristics of the respondents also have an impact on the decision. As mentioned earlier, the Singh et al. (1993) and Griffin et al. (1995) studies of rural water supply in Kerala included some characteristics of households. There are two possible approaches to including household/respondent characteristics in MNL models :

a. by creating a number of dummy variable or alternative-specific constants (ASCs); or

b. by dividing the sample into categories based on values of a chosen characteristic and examine if there are any systematic differences between such categories[12].

Creating ASCs is a frequently used approach. For example, if we want to include the gender of the respondent as a relevant characteristic in model D-6, seven alternative specific constants need to be created[13]. The resulting model is shown in table 6.10 (compared with D6).

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[12] The second approach is both cumbersome and does not tell us anything about interactions between a variable of interest and other variables. Out of academic curiosity, I tried to divide the sample into two groups : those within Madras City (109 respondents) and those outside the City (39 respondents) and re-estimated model D-6 for each group. None of the coefficients was significant.

[13] ASC must be dropped for one of the alternatives to avoid a problem known as the 'dummy variable trap'.

Table 6.10: MNL model with ASCs for gender of respondent

	Parameters from Model D6	Parameters when ASC for gender are included
PRICE	-0.0049	-0.00094
YARDTAP	1.9451**	1.6345**
PRIVATE	-0.8915*	-0.9588
ENVIRON	-2.4428**	-2.966**
WQUAL	-0.6633	0.2052
QUANT	-0.0152*	-0.0241**
IH1-FEM		-10.258
IH2-FEM		-13.798
PP-FEM		-9.466
OH1-FEM		-10.210
OH2-FEM		-23.353
TS-FEM		-10.334
ENV-FEM		-10.667
L(β *)	-83.29	-71.75
L(0)	-307.75	-307.75
LR test statistic		23.08
DF for Chi square		7
Critical Chi-square		18.48**

None of the alternative-specific constants in this case were significant. However, for the LR test (comparing model D-6 with the new model which also contains 7 ASCs), the statistic is higher than the critical Chi-square value at 99%. Hence, we can reject the null hypothesis (that model D6 is the correct specification) and accept the above specification that includes alternative specific constants.

This example shows that inclusion of socio-economic characteristics of respondent improves the model specification. While there is no limit on the number of such ASCs, Greene (1995 : 495) points out : "There are many different possible configurations of alternative specific constants and alternative specific variables. In estimating a model, it is not possible to determine a priori if a singularity will arise as a consequence of the specification.". Because, my choice set has 8 options (including 'None'), for every socio-economic character (e.g. FEMALE or OWNER), 7 ASCs will be added to the model. Table 6.11 below reports only the predicted probabilities of selecting various alternatives from models with different sets of ASCs.

Table 6.11 : Predicted probabilities from Model D6 and some alternative specifications with ASCs for some respondent characteristics

		Predicted Probabilities			
	Actual probabilities	From Model D6 (no ASCs)	Model M-1 :Extending model D-6 with ASCs for 'FEMALE'	Model M-2 : with ASCs for 'FEMALE' and 'OWNER'	Model M3: with ASCs for 'FEMALE', 'OWNER' and 'CONNECTED'
IH1	0.4797	0.4595	0.4730	0.4797	0.4797
IH2	0.1486	0.2095	0.1824	0.1622	0.1622
PP	0.1351	0.0946	0.1081	0.1216	0.1216
OH1	0.0270	0.0270	0.0270	0.0270	0.0270
OH2	0.0203	0.0203	0.0203	0.0203	0.0203
TS	0.0203	0.0608	0.0405	0.0270	0.0270
ENV	0.0473	0.0473	0.0473	0.0473	0.0473
None	0.1216	0.0811	0.1014	0.1149	0.1149
Total	1.0000	1.0000	1.0000	1.0000	1.0000

From the above table, we can see that inclusion of socio-economic characteristics improves the model performance in terms of predicted probabilities. However, to include 3 demographic characteristics, the number of parameters of the model has become 27 (6 attributes as in model D6 plus 21 ASCs). In all these cases (not reported here), none of the parameters of ASCs was individually significant though collectively they contribute to improving the specification.

6.4.5 Probit Models :

As mentioned in chapter 2, the multi-nomial logit models are formulated by assuming that error terms are independently and identically distributed. Instead, if one assumes that errors are multi-variate normal[14] distributed, probit models can be used[15]. As compared to MNL models, probit models have two advantages: (a) The probit model does not have the restriction imposed by the IIA property; and (b) socio-economic characteristics can be included in the model without having to go through the (cumbersome) route of ASCs. However, the probit models also have a disadvantage is that computationally these models are more cumbersome. Maddala (1983:63) points out that for more than four alternatives, the computation of multinomial probit model are almost impractical.

Table 6.12 reports results from some probit models[16]. In Model P1, besides the attributes of options, the following respondent characteristics are included:

a. *Demographic:*

FEMALE	= 0 if respondent was male; 1 if respondent was male
CHILDR	= number of children in the household.

b. *Economic:*

INCOME	= mean monthly income Rs.
OWNER	= 0 if respondent is not the owner of the house; 1 otherwise.
ROOMS	= number of rooms in the house

[14] In the binary case, the errors will be bivariate normal distributed; in case of three options, the errors are trivariate normal distributed; and in case of m options, the errors are multi-variate normal distributed.
[15] See Maddala, 1983 : 62-64 for modelling details.
[16] See Greene (1995:426) for details on using random effects panel approachfor probit models.

HUTMENT = 0, if respondent's house is not hutment; 1 otherwise.

c. *Spatial:*

MMA = 0, if respondent lives within Madras city; =0 otherwise.

d. *Water related* :

WATENDOW = water endowment in lpcd (discussed in chapter 5).

CONNECTED = 0 if respondent does not have yard tap connection; 1 otherwise.

WACOST = Total current expenditure on water(Total cost) Rs. Per month

In other models, we impose some restrictions. Model P-4 is similar to model D-6 discussed earlier: i.e., it contains parameters of 6 attributes.

Ben-Akiva and Lerman (1985) suggest that in addition to "...evaluating how well coefficients reflect our own a priori expectations, it is also desirable to compare them with analogous values from similar models calibrated for other places, times and even other choice contexts". I have shown in the last column of table 6.12, some parameters from Singh et al.,(1993) study of Kerala.

Table 6.12 : Results from Probit models : panel data with random effects

	Model P-1	Model P-2	Model P-3	Model P-4	Singh et al., 1993
PRICE	0.0012	0.0013		0.00112	-0.0605**
YARDTAP	1.4781**	1.4775**		1.5757**	
PRIVATE	-0.9027**	-0.8733**		-1.0948**	
ENVIRON	-1.5063**	-1.4764**		-1.3886**	
WQUAL	-0.1874	-0.1573		-0.5159	
QUANT	-0.00719**	-0.0072**		-0.0041*	
INCOME	0.000001	0.0868	-0.000006		0.00002
MMA	-0.4649	0.000008	-0.1569		
FEMALE	0.08124	0.1514	-0.1529		-0.2749
OWNER	0.1618	-0.4885	-0.03500		
CHILDR	0.0012		0.00224		
CONNECTED	0.0852		-0.09035		
ROOMS	0.00495		-0.0177		0.0861*
HUTMENT	-0.0588		-0.17022		
WATENDOW	0.00039		0.00015		
WACOST	0.00011		-0.00049		
Rho[17]	0.20751	0.20751	0.000	0.0000	
L(β *)	-180.8461	-181.3831	-272.6889	-181.5394	
L(0)	-273.8390	-273.8390	-273.8390	-273.8390	
Rho squared bar[18]	0.2811	0.3010	-0.032	0.3151	0.28
Percentage correctly predicted	81.32%	81.02%	65.01%	78.25%	

[17] Rho here is not related to the goodness of fit measure rho squared bar. Greene (1995:426) points out that rho here relates to random effects. If no random effects are present, the value of rho will be negligible. For estimation, a starting value of about 0.29 is used by LIMDEP programme.

[18] Rho square as per equation 6.2, works out for model P-3 to be 0.004. Rho squared bar for model P-3 is negative because in spite of having 10 variables, the change in log-likelihood function is small. See equation 6.3.

The following points can be identified from the table:

a. First, in all the probit models, the sign of PRICE attribute is not negative, though in none of the models was it significant at all. In all the MNL models, we found that PRICE had the expected sign.

b. From rho squared bar, model P-4 seems to be better than model P-1. On the other hand, from the percentage correctly predicted, model P-1 is better than Model P-4.

c. However, the rho values in models P-1 and P-2 suggest that there may be some random effects present. However, the parameters of all the socio-economic variables and those of Rho are not significant.

d. With regard to Singh et al., study, many of the variables used by them are different from the ones I have used. The four variables that are common to these two models are shown in the table. Two of these (PRICE and ROOMS) were significant in Singh et al., study. In my models, these were not significant. The parameters of number of rooms and income in the two studies seem to be in the same direction.

By no means, the ten socio-economic characteristics considered here are exhaustive. However, it appears that including them would improve our insight. However, including them in MNL models via alternative specific constants is cumbersome. Using probit models is an alternative, but in case of Madras data, we saw that MNL models were better in terms of goodness of fit measure (0.71 for model D-6 compared to 0.29 to 0.31 for models P-1 to P-4).

6.4.5 Welfare estimates :

Estimating implicit prices can help in making point estimates of willingness to pay (WTP) for a change in one of the attributes. Morrison et al (1998 : 10) point out that "...implicit prices are the marginal rates of substitution between the attribute of interest and the monetary attribute". From the various betas estimated in the MNL model D-6, these implicit prices are estimated. These are shown in table 6.13.

Table 6.13 : Point estimates of implicit prices Rs. (1996)

	Betas from Model D-6	Implicit prices[19]
PRICE	-0.0049	---
YARDTAP	1.9451	-396.94
PRIVATE	-0.8915	181.94
ENVIRON	-2.4428	498.53
WQUAL	-0.6633	135.37
QUANT	-0.0152	3.10

The implicit prices are based on *ceteris paribus* assumption. In interpreting the implicit prices, it must be remembered that the co-efficient of YARDTAP was positive whereas all other attributes have a negative sign. Morrison et al. (1998) consider the absolute values of the implicit prices but not their signs. However, if we consider the sign to be relevant, we may interpret the implicit price as willingness to pay or willingness to accept compensation depending on the sign of the parameter of interest as compared to the sign of the coefficient of monetary term (PRICE). Thus, a negative implicit price can be interpreted as willingness to

[19] In a compensatory framework (as in a utility function), the ratio of the parameters of two attributes indicates the rate at which the consumer will be willing to trade off one of these attributes for the other. See Ben-Akiva and Lerman (1985 : 160). By taking a ratio of the parameter of an attribute with the parameter of monetary attribute, we arrive at implicit price. Thus the parameter for YARDTAP is 1.945. The implicit price for YARDTAP is : 1.945/0.0049 = 396.94.

pay; and a positive implicit price of an attribute as compensation. In this light, it appears that households in Madras are willing to pay Rs. 396.94 for the convenience of a yard tap. As compared to this, all other attributes are considered inferior and changes in them will be preferred only if compensation is given. For instance, to persuade a household to adapt the 'environment' option, it appears that they should be compensated by Rs 498.53. Similarly, to accept a yard tap connection from private sector, they need to be compensated by Rs. 181.94.

Though the above implicit prices give only a partial picture, some important points do emerge :

a. While water supply policy debate in Madras has centred on the quantity of water supply (as discussed in the previous chapter), quantity of water seems to have the smallest impact.

b. The preference for yard tap connection seems to be mainly because of the convenience and property rights and all other benefits that a yard tap offers and not solely because it offers good quality water or because it offers sufficient quantity. (This can be deduced by comparing the implicit price for yard tap which is Rs. 396.94 with the implicit prices for quality and quantity, i.e., 135.37 and 3.10. Thus, the implicit net benefit from a yard tap seems to be : 396.94 – (135.37 + 3.10) = 258.47 which may be an indicator of other benefits from having a yard tap.)

c. Households are not averse to private sector so long as it is in the form of yard tap connection. The benefits from a yard tap (equivalent to the implicit price, Rs. 396.94) are in excess of the losses in terms of private sector providing this (Rs. 181.94; and another 135.37 for the water quality and 3.10 for the quantity.). The implicit net benefits from a yard tap provided by private sector are : 258.47 – 181.97 = 76.50.

d. The very high implicit price (Rs. 498.53) of environment attribute seems to signal household demand for compensation because instead of providing an improved supply, they are being asked to conserve water and engage in water harvesting and recycling.

e. Even if one were to provide a yard tap and then ask people to engage in water harvesting and recycling, the implicit net benefits could be negative (i.e., some net welfare loss rather than welfare gain) : +258.47 – 498.53 = 240.06.

With regard to welfare estimates, a brief note was made of compensating surplus in chapter two (equation 2.27):

$$CS = (-1/\beta_M)(V_0 - V_1)$$

Each of the indirect utility functions can be estimated using :

$$V = \beta1*PRICE + \beta2*YARDTAP + \beta3*PRIVATE + \beta4*ENVIRON + \beta5*WQUAL + \beta6*QUANT \quad 6.6$$

I have shown these calculations in table 6.14. The parameters estimated in model D-6 are shown as betas in the first row in table 6.14.

Calculating V_0 : In the second row in table 6.15, estimation of V_0 is shown. This is based on mean values from the sample households for variables that correspond to the attributes. For example, from table 5.14 in the last chapter, we know that on average, households spend Rs. 93.95 per month on water supply. We can use this as the value of attribute PRICE. Similarly, in table 5.2, we saw that 57.8% of respondents have a yard tap (i.e., YARDTAP = 0.578); no one presently depends on 'private' sector alone (PRIVATE = 0); no one already engages in water harvesting and recycling of sullage (ENVIRON = 0); 57.8% of people also get treated water (and so WQUAL = 0.578); the average water endowment in Chennai is 88 litres per capita per day (QUANT = 88) and so on.

$$V_0 = -0.0049*93.95 + 1.9451*0.578 - 0.8915*0 - 2.4428*0$$
$$-0.6633*0.578 - 0.0152*88 = -1.05707$$

Calculating V_1 : V_1 can be estimated for each alternative based on the mean values of the attributes and the parameters from D-6. For example, for IH1, the average price is Rs. 153 (see table 6.2); the values of other attributes for IH1 (table 6.1) were : YARDTAP = 1; PRIVATE = 0; ENVIRON = 0; WQUAL = 1 (treated water); QUANT = 150 litres. Therefore :

$$= -0.0049 * 153 + 1.9451*1 - 0.8915*0 - 2.4428*0$$
$$-0.6634*1 - 0.0152*150 = -1.7479 \qquad 6.7$$

Therefore,

CS = (-1/(-0.0049)) (-1.05707 + 1.7479) = Rs. 140.98.

For IH2 this works out as :

CS = (-1/(-0.0049)) (-1.05707 + 0.076) = Rs. –200.21.

The compensating surpluses for the various options are calculated on the same lines and these are shown in table 6.14.

Table 6.14 : Compensating Surplus estimation for various options

	PRICE	YARDTAP	PRIVATE	ENVIRON	WQUAL	QUANT	V	CS
Betas	-0.0049	1.9451	-0.8915	-2.4428	-0.6633	-0.0152		
V_0	93.95	0.578	0	0	0.578	88	-1.05707	
							V_1	
IH1	153	1	0	0	1	150	-1.7479	140.98
IH2	122	1	0	0	1	50	-0.076	-200.22
PP	153	1	1	0	1	150	-2.6394	322.92
OH1	65	0	0	0	1	150	-3.2618	449.94
OH2	58	0	0	0	1	50	-1.7075	132.74
TS	210	0	1	0	0	150	-4.2005	641.52
ENV	168	0	0	1	0	26.4	-3.66728	532.69

Morrison et al (1998:12) point out that a negative value of CS is equivalent to a reduction in income and hence, is interpreted as willingness to pay. It is very interesting to see that CS is positive for all categories except IH2. We would expect CS to have negative sign if the option concerned (R_1) is an improvement from current situation (R_0). Positive sign indicates that to maintain the same level of utility, income must be increased by the amounts shown. For example, if everyone is compulsorily needed to adapt 'environment' friendly measures of water conservation and recycling, they must be compensated by Rs. 532. Two inferences can be drawn from this :

a. Though water is perceived to be a common problem in Chennai, because of the various entitlements and negotiated processes, people seem to resist any major changes in their water supply. They may be apprehensive that they will lose out from any significant change. The CS values may be reflecting this 'inertia' to change.

b. The exception is that of IH2 that is providing YARDTAP connections in the rest of metropolitan area where such connections do not exist. Clearly, this seems to be an important priority.

For the water planner, estimating CS for households in different groups as per water endowment level may be of use[20]. This is estimated for households in different endowment levels in the following manner :

a. The equation for indirect utility is as shown in 6.6 earlier. The parameters estimated from model D-6 are used.

b. Current utility level V_0 is calculated by using mean values for the existing arrangements for the attributes for the households in a given endowment level. With regard to PRICE, the total monthly expenditure on water (shown in last column in table 5.15 in the last chapter) is used. These are shown in table 6.15 below.

Table 6.15 : Calculating V_0 for households having different levels of endowment

Endowment	PRICE	YARDTAP	PRIVATE	ENVIRON	WQUAL	QUANT	V_0
0	58.46	0	0	0	0	0	-0.28645
16	78.56	0	0	0	0	16	-0.62814
94	107.41	1	0	0	1	94	-0.67331
110	144.07	1	0	0	1	110	-1.09614
125	55	0	0	0	0	125	-2.1695
219	151.76	1	0	0	1	219	-2.79062
235	133	1	0	0	1	235	-2.9419

c. For V_1 the values already calculated by using the mean values for each option (in table 6.14 earlier) are used.

d. The compensating surplus calculations for each alternative for households with different endowment levels are thus shown in table 6.16 below.

[20] See table 5.7 for details on various levels of endowment.

Table 6.16 : CS estimates for households in different endowment levels[21]

		IH1	IH2	PP	OH1	OH2	TS	ENV
	V_1	-1.7479	-0.076	-2.6394	-3.2618	-1.7075	-4.2005	-3.66728
Endowment	V_0	Compensating Surplus CS						
0	-0.28645	298.25	-42.95	480.19	607.21	290.01	798.78	689.96
16	-0.62814	228.52	-112.68	410.46	537.48	220.28	729.05	620.23
94	-0.67331	219.30	-121.90	401.24	528.26	211.06	719.83	611.01
110	-1.09614	133.01	-208.19	314.95	441.97	124.77	633.54	524.72
125	-2.1695	-86.04	-427.24	95.90	222.92	-94.29	414.49	305.67
219	-2.79062	-212.80	-554.00	-30.86	96.16	-221.05	287.73	178.91
235	-2.9419	-243.67	-584.88	-61.73	65.29	-251.92	256.86	148.04

For example, for the category of households having 0 endowment, from table 6.15, we find that V_0 = -0.28645. In table 6.15, V_1 for IH1 was given as –1.7479. Therefore, CS for households with 0 endowment choosing IH1 is :

$$CS = (-1/(-0.0049))*(-0.28645 + 1.7479) = \text{Rs. } 298.25$$

Another example can be of households having an endowment of 110 lpcd and choosing PP option. For these households, the value of V_0 = -1.09614. In table 6.14, V_1 for PP was found to be –2.6394. Therefore, CS for households having an endowment of 110 lpcd and choosing PP is :

$$= (-1/(-0.0049))* (-1.09614 +2.6394) = \text{Rs. } 314.95$$

Some important conclusions can be drawn from the above table :

a. From the values of CS for IH2 option, we find that improving the water supply in the rest of the metropolitan area, by providing yard tap connections will

[21] Values of V1 are from table 6.14; values of V0 are from table 6.15. CS is estimated using equation CS = $(-1/\beta_M)(V_0 - V_1)$. The value β_M is assumed to be the same as the value of parameter of attribute PRICE i.e., -0.0049.

improve the welfare of households in all categories in those areas. If such improvement is mainly done through communal stand posts (OH2), the welfare of those with high water endowment (125 lpcd or above) will improve but those of others will worsen.

b. Interestingly, options such as IH1 are predominantly welfare improving mainly for those who already have high level of water endowments (as the negative CS values indicate willingness to pay). In the last chapter we saw that increasing water quantity from projects such as Krishna River, will mainly benefit households with high level of water endowments. The above figures in the table further corroborates this point.

c. Similarly, welfare gains from private sector involvement for providing yard tap connections also accrue mainly to those who have very high level of water endowment (from the negative CS amounts for PP option for households with endowment of 219 and 235 lpcd).

d. The households with low water endowment in Madras City, seem to expect 'compensation' or subsidy even for a yard tap option (such as IH1). Those expecting such 'compensation' include households who have no source (0 endowment); those depending on well only (endowment of 16 lpcd); those depending only on a connection and not having any other source (i.e., endowment of 94 lpcd) and those having a connection plus a well (endowment of 110 lpcd).

e. Though promoting water conservation has its merits, it appears that there may be little welfare gains from such a policy. The welfare loss from such a policy are disproportionately large especially for households with low levels of water endowment. Hence, a policy to enforce environmental conservation may actually worsen the income distribution.

6.5 Summary and Conclusions :

This chapter has examined the data from Madras household survey concerning alternative sources of water supply. These sources have been described in relation to a set of seven attributes. From the analysis presented in this chapter, the following conclusions can be drawn :

a. From the multi-nomial logit (MNL) models, we find that YARDTAP was highly significant. This is probably indicating the preference of consumers for an individual connection.

b. From the two nested logit models we do not find evidence to suggest that households in Madras consider the alternatives in a hierarchical manner. Though YARDTAP is an important attribute, consumers seem to take the various attributes into account simultaneously rather than hierarchically.

c. From the MNL models with alternative specific constants (ASCs) and from the probit models, we find that socio-economic characteristics could improve our insight. However, the MNL models using only attributes of options had better goodness of fit measures as compared to probit models using both attributes of options and respondent characteristics. Within MNL models, inclusion of socio-economic characteristics via alternative specific constants did not significantly improve the predicted probabilities.

d. From the discussion on welfare changes, we find that only those with very high water endowment levels have willingness to pay for water improvements (for example, providing 150 lpcd of water with a yard tap connection) in Madras City. Interestingly, even those having a Metro Water connection (i.e., endowment of 94 lpcd) as the only source or as one of two sources (endowment of 110 lpcd) are not willing to pay for improved water supply. These results are not surprising, considering that water scarcity is an endemic problem in Chennai and the policy of rationing water imposes significant costs to households.

e. It appears that there will be welfare gains from a policy of giving yard tap water connections to those living in the peripheral areas. This policy seems to have benefits across the board to households in all categories of water endowment.

f. The discussion on implicit prices indicates that a policy of forcing households to adapt environment-friendly measures such as rainwater harvesting and recycling may lead to substantial welfare losses. There is also an indication that such a policy will lead to greater welfare loss for those with low levels of water endowment (i.e., the poor) and hence worsen the income distribution.

g. There is also an indication that households may accept private sector's role so long as it is in the form of yard tap connections. The implicit price of 'private' sector attribute may also be useful in considering the welfare implications of privatising Metro Water board or other such utilities and how such utilities are valued. All other things being the same, the results here seem to indicate that a decision to privatise the Metro Water Board may have a welfare loss of about Rs. 182 for each of the 1 million households of Madras or about Rs. 182 million in aggregate.

Chapter Seven
Co-operation and Waste Management : An Exploration of Civic Exnora Model in Madras.

7.1 Introduction :

This chapter examines the case of solid waste management in Madras and a co-operation based approach to solving the problem. Much of recent discussion on solid waste management in developing countries has focused on the role of private sector in waste management (Cointreau-Levine,1994); on the issues of waste pickers, strategies to integrate them in waste management systems (Furedy, 1992); and the health impacts of waste picking specially on children (Hunt, 1996). Some studies have focused on valuing the benefits (of shifting dump sites) to those directly affected by the nuisance (Blore, 1996) and more generally household demand for improvements to solid waste management (Altaf and Deshazo, 1996). However, co-operation issues have not been examined in detail in these studies. One of the few studies on co-operation issues in the urban environment is by Lee (1998) which focuses on communal water supply with a case of three slums in Bangkok, Thailand. However, Lee observed that co-operation in case of water has not affected (the other) 'major free-rider problem - substantial amounts of uncollected waste found in the lanes, waterways and under the houses'. The collective action experience discussed in this chapter originally started with waste collection but in many cases the scope has increased to cover other issues including water supply.

7.2 Co-operation and Waste Management :

There is a rich literature on rural common property resource (CPR) institutions and co-operation based on commitment (Runge,1986; Jodha, 1990; Basu and Mishra, 1993; Seabright,1993; also Baland and Platteau,1996 and also 1997; Noronha, 1997). Issues of co-operation have been examined in several cases of irrigation and rural water resources (Wade,1988; Ostrom, 1990; Ostrom 1993; Bardhan,1993; Bardhan, 1995; Wood,1999) and in case of dairy co-operatives (Seabright, 1997). As White and Runge (1995) state : "...the question is no longer whether decentralised collective action can be effective, but under what circumstances it is appropriate, and how positive synergy between the state, market and civil organisations can most efficiently and fairly supply public goods". Baland and Platteau (1996 : 289) summarise some of the various conditions under which local management of CPRs may work :

> "....user groups must be small, live close to the CPRs, and be free to set access and management rules in their own way; the CPRs must be clearly defined and people must have a high level of dependence on them; rules as well as techniques of calculation and control must be simple and fair; there must be well-established schemes of punishment and these work best when they are graduated to fit the offence; costs of monitoring must not be too high; well-known and low cost conflict-resolution mechanisms must be available; crucial decisions must be taken publicly; and some record-keeping and accountability must be provided for."

Much work on CPRs relates to rural context[1]. Following the framework of Mancur Olson (1965), one might conclude that because of the large numbers of people in urban areas, collective action is unlikely to be successful there. Hence, urban dwellers are expected to 'vote with their feet' (in a Tiebout world) or exercise 'exit' as a strategy more often than use 'voice' (Hirschman, 1970). I feel that voting with feet is hardly an option for households in cities in the developing world. Exit i.e., not depending on the government and making one's own arrangements, seems to be an option in some cases. However, exit is not a viable solution for many local services which can only be provided by the government. In such cases, voice or collective action may be needed to influence public policy. In the 1990s, influential 'global

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[1] A search on the Web of Science database (home page URL : http://wos.mimas.ac.uk/. Access restrictions may exist) for the key words 'common property resources' produced 92 hits; another search for 'urban common property resources' or 'common property resources + urban' returned no hits. While this result needs to treated with caution (for instance, there could be papers dealing with

reports' highlighted community-based and participatory approaches as being central to improving the urban environment in developing countries (UNCHS,1996 : 424; World Resources Institute, 1996 : 131; Bartone et al., 1994 : 75) . However, while 'participation' and 'co-operation' have acquired the status of *mantra* for environmental managers, one finds few studies that examine the conditions under which co-operation or collective action works in the urban context and if so why.

The problem of filthy streets can be viewed as a co-operation problem. The well-known illustration is of glass bottles and the four alternative cases faced by an individual from Sen (1973 : 254) : 'Being generally interested in the environment but also being lazy about returning bottles (to the shop from where the soft drinks were purchased), this person may be best off if others return the bottles but not he, next best if all return bottles, next best if none does, and worst of all if he alone returns bottles while others do not'. If there are only two households having access from a street, if both of them co-operate to maintain it litter free, the street would be clean. (The issue can be expanded to a n-person case). However, that would require each of them to face some costs (to create appropriate storage or of leisure time lost in taking the garbage to the bin) while throwing the garbage on the street is cheaper. 'It is easy to see how each individual, acting atomistically, might prefer to throw litter on the street rather than go to the trouble of looking for a litter bin to dispose of it' (Basu, 1997 : 12). Therefore, rational behaviour by each of them leads to a socially undesirable outcome i.e., a filthy street or in fact a filthy city[2].

Against this background, I would like to examine the functioning of Civic Exnoras in Madras.

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urban common property resources without using these terms), it is a fairly reasonable description of the trend.

[2] Sen (1982 : 106) cautions against a narrow interpretation of economic rationality. The reality is not limited to a one-shot prisoners' dilemma model, where the central assumption preventing co-

7.3 Co-operation for waste management in Madras : The Civic Exnora model

Exnora has been recognised as one of the *100 Best Practices* in the second Habitat conference (United Nations Conference on Human Settlements, Istanbul, held in June 1996). However, Bardhan (2000 : 265) points out :"As in water management, so in other local public projects, such as environmental protection,...and public health and sanitation, local community-level institutions that can play a vital role in providing an informal framework of coordination in design as well as implementation are largely missing in most parts of India.....This local institutional failure is another example of the severity of collective action problems in India."

In almost all states in India, street sweeping and waste collection functions are provided by the local government[3]. A major share of local government spending is allocated to these services. In the case of Madras Corporation, as of 1994, out of a total revenue expenditure of about Rs. 2,200 million, approximately 18% was spent on solid waste management. In ideal conditions, the organisational structure for delivering this service would resemble a generic model mentioned in chapter 1. One such structure is shown in figure 7.1.

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operative behaviour is the lack of scope for communication and enforceable contract. See Dixit and Nalebuff,1991 :11-13 and chapter 4; also Taylor,1987.

[3] The Seventh Schedule to the Constitution of India lists the items for which the state governments have the power to make legislation. Item 5 in the list concerns local government and item 6 concerns public health. Chapter VIII of the Madras City Municipal corporation Act, 1919, contains provisions relating to scavenging, removal of rubbish and filth and powers of the Commissioner of the Corporation in this regard.

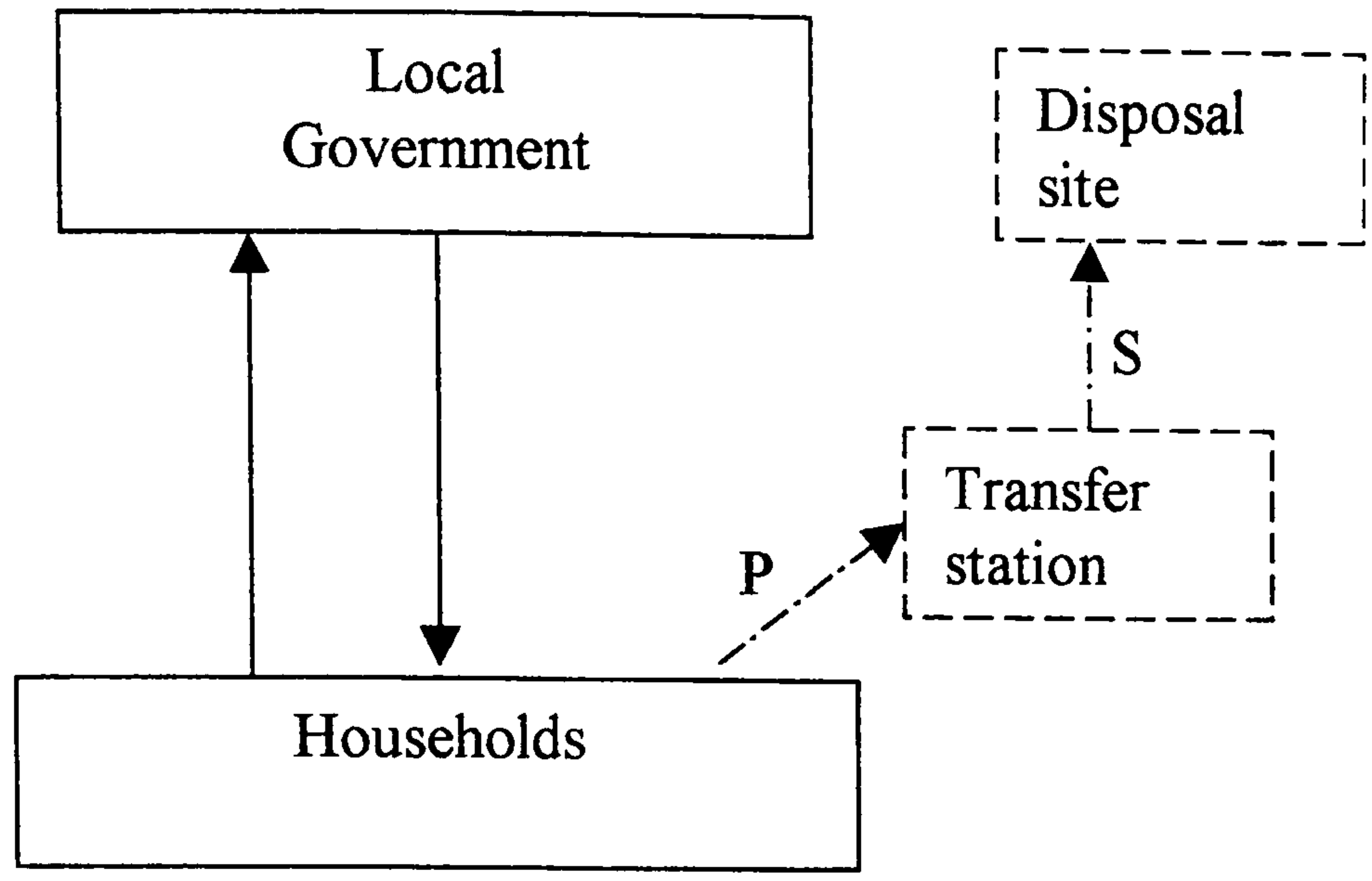

Figure 7.1 : Waste management (or any other local government) services
Solid arrows represent communication; broken arrows represent
flow of waste materials. P - primary collection; S-secondary collection

Street sweeping is a very labour intensive activity involving significant physical effort - and hence there is every incentive to avoid doing it unless supervision is exacting. Madras has a total of 2,202 km of streets/roads (Corporation of Madras, 1996) and 6,064 sanitary workers (ERM,1996a :16) making it roughly 3 workers per km., requiring each of them to sweep about 1,500 square metres of surface area every day. (If some of the sanitary workers are doing other tasks, the number available for street sweeping is even smaller and the area to be swept per person greater). The system had no checks to ensure that the waste collection vehicles were 'covering' all the streets that they were supposed to serve.

As in many cities in the developing world, the environmental quality of life in Madras suffered as the capacity of its local government units, the Madras City (Municipal) Corporation and other local municipalities, was severely constrained by the mismatch between their taxing powers and expenditure responsibilities[4]. By the

[4] By 1991, urban based activities were estimated to have contributed to 55 per cent of India's total Gross Domestic Product (GDP). However, the share of total municipal expenditure formed less than 1 per cent of GDP and about 3.5 per cent of total government spending (Jetha, 1992). Besides the 'urban fiscal crisis' (Mathur, 1986), there were several problems debilitating the municipal institutions : multiple organisations with overlap of jurisdictions and a vacuum of institutions to

1980s, even as some of the important functions of the Madras Corporation were already transferred to the newly created special purpose boards/organisations (such as the Metro Water Board), municipal expenditure was still in excess of municipal income and the gap was increasing (Dattatri and Anand, 1991). In 1993, some improvements were introduced (Poornalingam, 1993). One of these was to build masonry waste bins in all major streets and indicate the time of the day at which it is expected to be cleared. The other was to weigh each truck's payload, before the garbage is tipped in the landfill site and relate the actual amount of waste collected from each zone to the target.

Prior to the introduction of these reforms, in the late 1980s, a non-governmental organisation based in Madras by name Exnora International[5], promoted the idea of forming neighbourhood associations (called Civic Exnoras) for managing primary waste collection. The Exnora approach is based on voluntary co-operation for improving primary collection. Figure 7.2 shows the functioning of a Civic Exnora and the various relationships involved therein.

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take strategic or sector level decisions; numerous regulations but limited capacity to regulate; large but generally demotivated staff, limited accountability, poor and dilapidated capital stock and so on. See Sivaramakrishnan,1995 for an overview of urban management issues in India.

[5] Originally, EXNORA was formed as an acronym for 'ex non-resident Indians association'. One of its founders, M.B. Nirmal, a bank manager, returned to Madras around that time after having served in an overseas branch of the bank. However, after 1991, the acronym has been reinterpreted to mean 'Excellent, Novel and Radical' ideas for improvement.

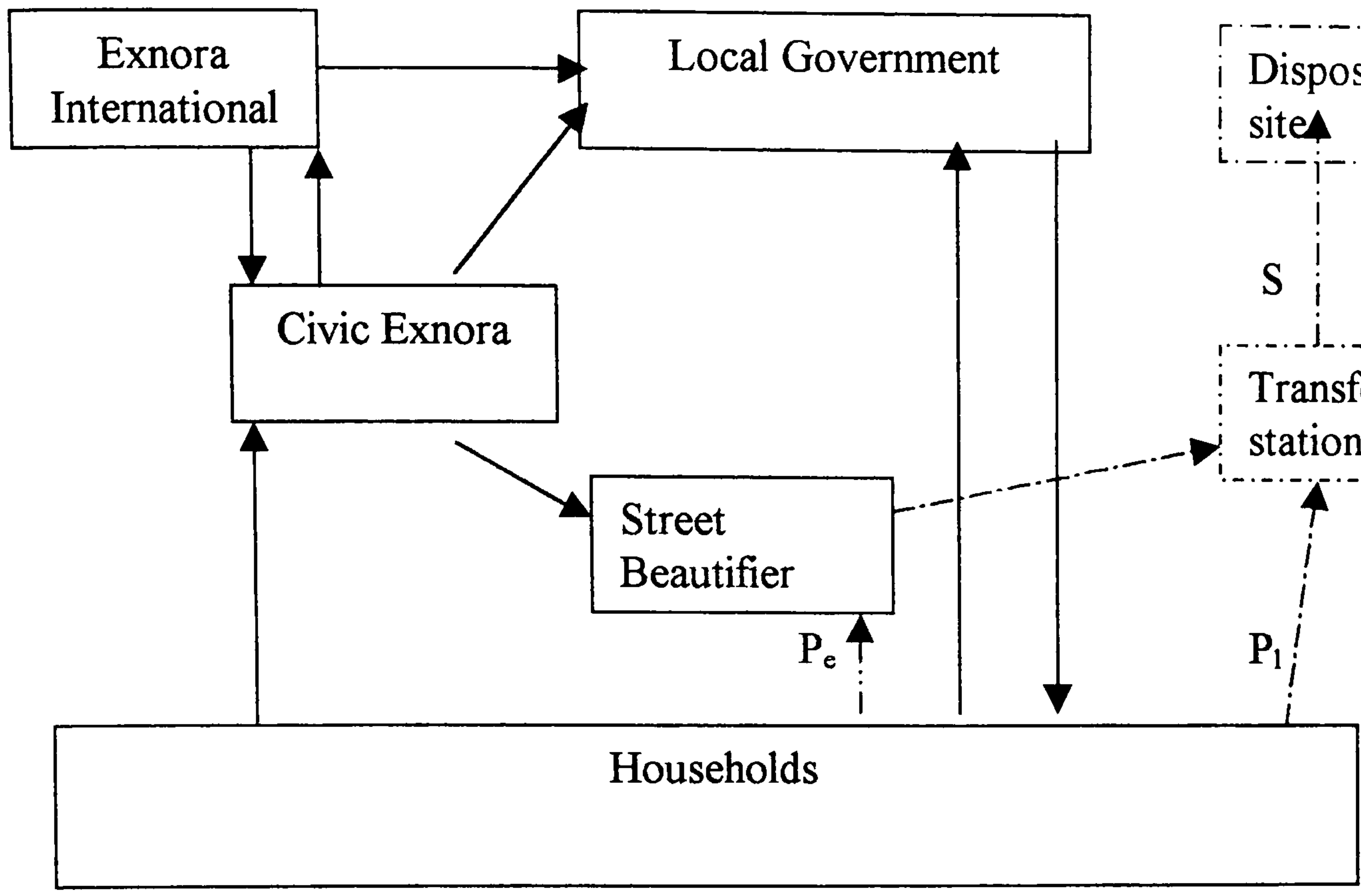

Figure 7.2 : Functioning of Civic Exnora :Various agents and relationships
Note : ——▶indicates communication; -indicates waste material flow.
P_e – primary collection provided by Exnora; P_l - Primary collection by local government; S – secondary collection.

The process of setting of a Civic Exnora in a neighbourhood involves the following steps :

a) A Civic Exnora unit is formed with the households of one street or a set of streets (by registering with Exnora International).
b) A committee of a small number of office bearers (either elected or more commonly filled by volunteers) is formed to manage the Civic Exnora.
c) A person responsible for collecting the wastes (called 'street beautifier') is appointed and trained.
d) A tricycle waste collection cart is purchased, often with a bank loan or funds from private sponsors.

e) The wastes are collected from each household once daily and the wastes are then taken to a municipal bin or (increasingly) to a transfer station of the Municipal Corporation.

f) Each household contributes a monthly fee to the Civic Exnora. From the amount collected, a monthly salary is paid to the street beautifier; and the remainder is used for repaying loan taken for the purchase of the tricycle and undertaking any other programmes.

Some estimates in the early 1990s mentioned that 'more than 60,000 people are now receiving waste services from some 500 roads in about 80 neighbourhoods, organised by 150 Civic Exnora units' (Furedy, 1992 ; Menon, 1993). A more recent estimate states that there are 1,500 Civic Exnoras covering approximately 0.45 million people (Ramkumar, 1996). With Exnora concept becoming well-established, step 2 may become step 1 (and vice versa) as a citizens' association of a neighbourhood wants to form a Civic Exnora and, therefore, approaches the Exnora International for ideas and leadership.

The concept of mobilising people's co-operation for tackling waste collection is fairly simple. Residents' associations in Calcutta are using the same concept; a similar programme in Hyderabad, India, where the Municipal Corporation is also contributing to share some of the costs is also reported (Chatterjee, 1995). However, the uniqueness of Exnora appears to be in the development of an institutional structure with a two-tier structure – one at local or neighbourhood level (Civic Exnoras) and the other at the apex level (Exnora International). Such structure enables a stronger voice for representing Exnoras in resolving issues with local government or even the state government (which controls other service providers such as the Metro Water Board).

Madras is one of the few Indian cities not to have had an elected local government for nearly 25 years (1973-1996). It is possible to argue that the absence of elected local government (where decisions are made by the local government bureaucracy not directly accountable to citizens) is the reason for the success of a co-operation based neighbourhood committee to tackle civic problems. Now that Madras has had the local elections (in October 1996), there should be no need for Civic Exnoras. On the contrary, my second field work visit in 1998 indicated that Civic Exnoras have attempted to adapt to the new situation. Some of them began to function as a bridge between elected councillors and the people who elect them, for instance by arranging meetings. A master plan for solid waste management for Madras prepared as a part of a World Bank funded sanitation programme proposed that 'primary collection will be arranged by community based groups' (ERM, 1996a: 108).

However, as seen in figure 2.2, Exnora system seems to be a parallel structure to local government. During my follow-up visit in 2000, I found that the Corporation of Madras took a decision that seems to have come as a surprise to many people in Madras. As per this decision, the waste collection services in three zones were contracted out to a private company called Chennai Environmental Services (CES-ONYX). In these three zones, new wheelie-bins have been installed and every morning the CES staff collect wastes from door-to-door by bringing the bins-bins to the door-step. Preliminary indications are that about Rs 700 million per annum will be paid to CES-ONYX for providing these services in these three zones. We do not know if this was done because Corporation started to perceive Exnora as a potential threat or not. My attempts to interview CES-ONYX executives were unsuccessful.

7.4 A sample survey of Civic Exnoras :

This part of the research is based on a random sample survey of 16 Civic Exnoras[6]. The sampling frame consisted of a list of all Civic Exnoras registered with the apex

[6] One of these is not a Civic Exnora. During the field work, an organisation called Madras City Clean Council (MCCC) was found in Triplicane area, providing services identical to any Civic Exnora. Hence, its office-bearers were interviewed. During the interview it was found that this

organisation. From this frame, Civic Exnoras were selected on the basis of location. In each case, a contact was established with the office-bearers or executive members managing the Civic Exnora concerned. Sample Civic Exnoras were selected without involving the Exnora International (to avoid any sampling bias). Depth interviews were held with the concerned individuals/committee members. In each case, a local household was contacted independently and the details given by the Civic Exnora office-bearers were cross-checked. A set of descriptive statistics is presented in Table 7.1.

Table 7.1 Descriptive statistics of some variables from the survey of 16 Civic Exnoras.

Variable	Description	Mean	Minimum	Maximum	Standard Deviation
HHTOTAL	Number of households served (group size)	189	90	400	106
HHPAYING	Number of households paying	175	75	400	102
FEES	Monthly charge per household Rs.	12.3	10	30	5.3
YEARS	Age of Civic Exnora (No. of years completed since start)	3.3	1.5	6	1.2
SERVICES	No. of services provided	3	1	8	1.8
CMTMBRS	No. of committee members	6.8	2	20	4.7
CMTRATIO	No. of households served per committee member	36	8	80	23

On average, each Civic Exnora has completed 3.36 years; each one is serving about 189 households of whom 175 (or 93% of) households are paying a monthly

organisation was not affiliated to Exnora International. F-tests indicated no significant difference between the Civic Exnoras in the sample and MCCC; hence, no distinction is made.

charge/fee and 14 are non-paying households. However, there is considerable variation in the number of households served by a Civic Exnora. Average household incomes could be an obvious explanatory variable, but population density also seems to matter (see Table 7.2). As population density in a zone decreases, the group size (i.e., number of households served) seems to increase, probably to off-set the increased costs of collection.

Table 7.2 : Number of households served by a Civic Exnora (or group size).

Zone number in Madras City	Area / Locality	Number of Civic Exnoras surveyed	Average number of Households served by each Civic Exnora	Average population density of the zone (persons per square km.)
6	Mylapore	1	250	381
6	Triplicane	7	127	381
8	T.Nagar	3	133	311
9	KK Nagar	2	400	153
10	Thiruvanmiyur	3	227	147

68% of Civic Exnoras have employed one street beautifier; another 25% of them have two street beautifiers and the others have 3 street beautifiers. What has motivated the forming of a Civic Exnora? 45% of the Civic Exnoras came into existence in response to a crisis - such as a public nuisance (an un-maintained public urinal/toilet). Another 27% were motivated by the demonstration effect after seeing the functioning of Civic Exnoras in neighbouring streets.

On average, each Civic Exnora is managed by a committee of 7 members, but there are substantial variations : nearly 70% of the Civic Exnoras have 5 members or less managing their affairs; there are a few that have 10 members in the committee and a very small percentage of them have a committee of 20 members.

All the Civic Exnoras provide primary waste collection service. Many of them undertake other activities as well (as can be seen from Table 7.3) : most of them take up civic grievances such as water supply problems, drainage overflow, faulty street lights etc.; some of them organise sports and cultural activity competitions and a few of them have taken up tree planting in their neighbourhoods.

Table 7.3 : Various services provided by Civic Exnoras

	Percentage of Civic Exnoras providing the service
Solid waste collection	100
Take up civic grievances	75
Arrange annual sports events	50
Arrange annual cultural events for women	38
Tree planting	31
Beautifying streets (painting exterior walls abutting street)	12
Running public library	6
Other services .	31

In this arrangement, some of the rules are : all households must store their garbage in their premises and dispose it of only in the waste collection cart when the beautifier brings it and sounds a whistle; street space must be treated as common property; every household must be charged equally.

Sanctions, relate to violation of norms and are essential to ensure smooth functioning of the co-operative arrangement and accountability[7]. Two types of sanctions may be needed - one concerning the discipline of disposing wastes; the other concerning payment of fees. As Civic Exnoras are voluntary arrangements and do not have any legal standing as far as the provision of service is concerned, the system of sanctions has to be fairly limited. Table 7.4 provides a summary of some of the norms, an indicator of their violation and possible sanctions.

Table 7.4 : Some norms and consequences of violation in Civic Exnoras

Norm	*Indicator of violation*	*Sanction*
All members must store garbage in their own premises, till collected by street-beautifier.	Garbage strewn around on the street adjacent to the house of Member X. Or member Y has seen member X dumping the garbage.	• Verbal instruction by one committee member • A more formal and credible expression – by a group of committee members • Naming and shaming approach • Withdrawal of service
All members must pay the monthly charge before due date	Payment not received	• Verbal (polite) reminder • Visit by a number of committee members • Withdrawal of service
Street beautifier must not be exploited with private tasks	Complaints from street beautifier	• Verbal expression of protest • The matter raised in the general meeting
The service is mainly for normal and reasonable level of waste arisings.	Extra-ordinarily high level of garbage from household X	• Refusal by street beautifier to take it. • Verbal discussion and service to be provided only after settling extra payment as negotiated by street beautifier.

[7] In the absence of a credible threat of sanctions, many of the norms become violable. The reference to accountability here is that the sanction must be known before hand, to ensure due process of law and the concept of *audi alterem partem* of natural justice.

Sanctions used by Exnora can be described as using peer group pressure and moral suasion. Even when a household does not pay the fee, Civic Exnoras are encouraged to collect waste from them. As long as the proportion of non-paying households is very small, the marginal cost of collecting wastes from them may be smaller than the benefit maintaining the street litter-free (and more importantly maintain loyalty from other paying members[8]).

All Civic Exnoras in the sample mentioned that the extreme measure of withdrawal of service was not used at all, even in case of persistent defaulters of monthly charges. There seem to be three reasons behind such a limited use of sanctions. Exnoras seem to want to highlight the positive aspects of co-operation and make violation (or defection) a morally repugnant option (thereby making enforcement costs very low in the long run). Secondly, Exnoras are aware that some individuals may be reluctant to join in the first instance, unless some track record is established. Over a period of time, Exnoras aim to win over such individuals. Thirdly, some households may have genuine affordability problem. To address this, some Civic Exnoras seem to have developed a two-tier fee structure, one a normal fee for most households and the second, much lower fee level for low income households.

7.5 Cost curves and Optimum group size :

In discussions on co-operation, group size is an important variable (Olson, 1965; Bardhan, 1995). Optimum group size depends on several factors, one of them being the relationship between group size and costs. For a Civic Exnora, (assuming that it is managed by volunteers and hence no administration costs are involved), the fixed

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[8] It appears that use of this strategy conceals information on number of non-paying households. On the other hand, if say, only 10% of households do not pay and Exnora stops collecting wastes from them, the visual effect of wastes dumped on the street by these 10 households may create doubts among other loyal members whether the system is working and whether they should continue to pay. This issue seems to be similar to the observation that 'if the proportion of black residents in an area rises above a critical level, it quickly increases further to nearly 100 per cent' (Dixit and

cost is that of the tricycle carts (which costs about Rs. 7,000) and wheel barrows (Rs. 1,000 each). Eight of the 16 Exnoras surveyed have received some grant to offset the cost of the tricycle cart (see Table 7.5).

Table 7.5 : Number of Civic Exnoras receiving grant to offset fixed costs

	Number of Civic Exnoras surveyed			
Number of street beautifiers	No grant	Upto 50% of cost as grant	100 % of cost as grant	Total
1	4	4	3	11
2	3	1		4
3	1			1
Total	8	5	3	16

The labour cost (salary of street beautifier) is the variable cost. On average each household generates about 2.9 kg of wastes (0.585 kg per capita, with an average household size of 5). Therefore, as the number of households increases, the weight to be hauled increases and this may affect the salary demanded by the street beautifier.

An attempt is made here to estimate the cost curves (cost per month) assuming that the tricycle cart or wheel barrow has a life of two years (a reasonable assumption given the condition of roads and the weight to be hauled). Linear, quadratic and cubic forms have been estimated by ordinary least squares (OLS) regression with the number of households (group size) as the independent variable. There were two outliers and regression models were re-estimated for a truncated sample by omitting the two outliers. These results are reported in Table 7.6.

Nalebuff,1991: 241). While we do not know what this critical percentage is, from experience, perhaps, Exnora knows this relationship and, hence, tries to avoid such outcome.

Table 7.6 : OLS Estimated cost curves of Civic Exnoras : Fixed cost (F.C.), Variable cost (V.C.) and Total Cost (T.C.) per household per month.

Model		Independent variables	B	Standard error of B	Adjusted R square	Standard error
Linear	F.C.	HHTOTAL	-0.003	0.0015	0.23	0.511
		Constant	2.810	0.3254		
	V.C.	HHTOTAL	-0.014	0.0037	0.56	1.226
		Constant	7.586	0.7801		
	T.C.	HHTOTAL	-0.017	0.0045	0.57	1.484
		Constant	10.396	0.9441		
Quadratic	F.C.	$HHTOTAL^2$	5E-05	6.3E-06	0.92	0.165
		HHTOTAL	-0.030	0.0031		
		Constant	5.368	0.3070		
	V.C.	$HHTOTAL^2$	6E-05	4.4E-05	0.60	1.158
		HHTOTAL	-0.045	0.0219		
		Constant	10.515	2.1560		
	T.C.	$HHTOTAL^2$	0.0001	4.3E-05	0.75	1.117
		HHTOTAL	-0.0756	0.0211		
		Constant	15.884	2.0796		
Cubic	F.C.	$HHTOTAL^3$	-8E-08	8.5E-08	0.92	0.165
		$HHTOTAL^2$	0.0001	6.0E-05		
		HHTOTAL	-0.0426	0.012		
		Constant	6.097	0.788		
	V.C.	$HHTOTAL^3$	-3E-07	6.3E-07	0.56	1.217
		$HHTOTAL^2$	0.0002	0.0004		
		HHTOTAL	-0.089	0.092		
		Constant	13.132	5.822		
	T.C.	$HHTOTAL^3$	-3E-07	6.3E-07	0.74	1.159
		$HHTOTAL^2$	0.0003	0.0004		
		HHTOTAL	-0.131	0.0882		
		Constant	19.23	5.543		

While both quadratic and cubic forms are plausible, cost curves for quadratic form (as standard errors are lower and goodness of fit better) are shown in figure 7.3.

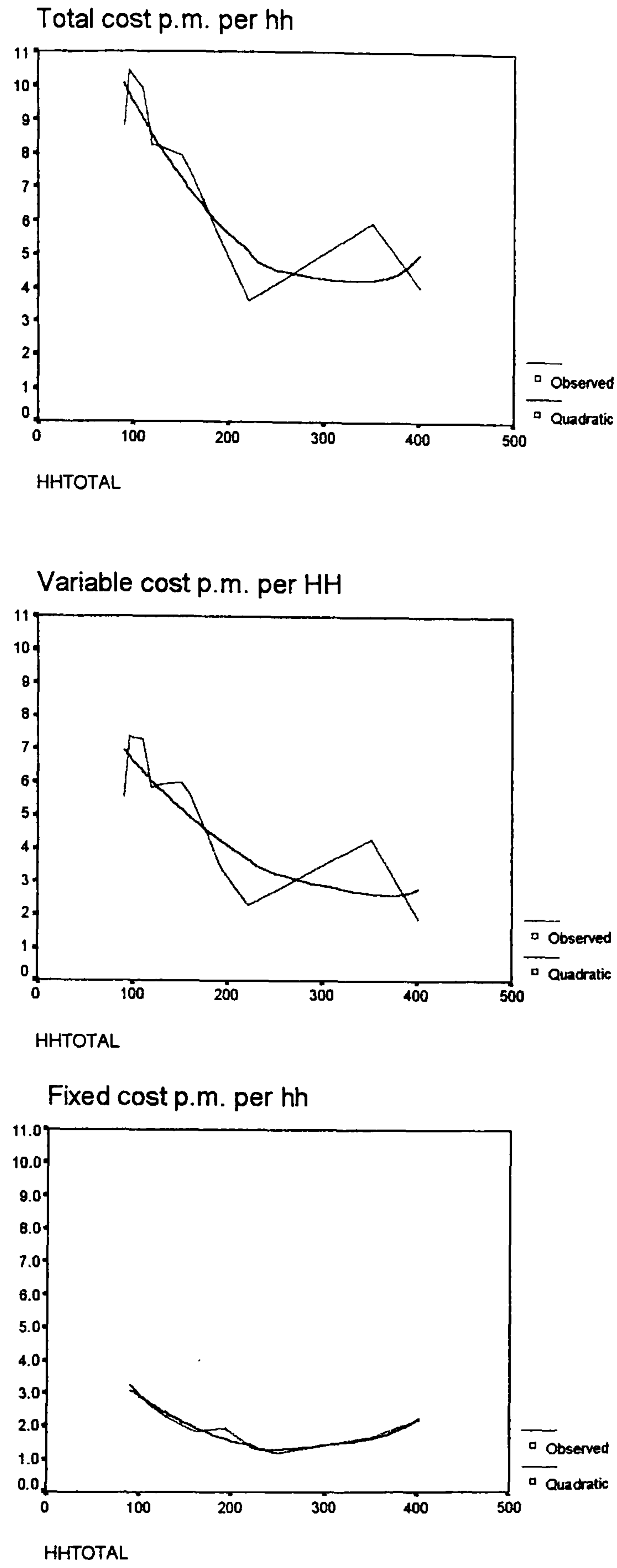

Figure 7.3 : Cost curves for Civic Exnoras
(Note : Group size i.e., number of households is shown on horizontal axis).

The fixed costs are falling with an increase in the number of households up to a group size of about 265 households and are beginning to rise again. The variable costs continue to fall till about 375 households and are beginning to rise thereafter. The total costs indicate the U shape of a typical long run average cost curve. However, the curve seems to indicate three clear situations : falling average costs up to a size of about 240 households; constant average costs between 240 and 360 households; rising average costs beyond a group size of 360 households (perhaps, congestion sets in and may require additional street beautifier or an additional vehicle or both).

If we define the difference between fee collected (FEES) and total cost as surplus (SURPLUS), we find that this SURPLUS is a function of number of households.

$$\begin{array}{lcccc} \text{SURPLUS} & = & 0.758 & + & 0.0157 * \text{HHTOTAL} \\ & & (0.569) & & (2.657) \end{array}$$

Figures in parenthesis are t ratios. R square is 0.468 (standard error of regression 2.027). Of course some of this surplus will be absorbed by : loan repayment; cost of providing other services; and management and administration costs (such as printing of stationery, providing tea at the meetings, etc.). However, there is no causal relationship between this surplus and the number of services provided (R square of 0.03).

7.6 Determinants of Co-operation: An exploration of some hypotheses

Bardhan (1995) has identified several issues with regard to co-operation in rural irrigation:

a) whether people want to co-operate following a norm of fairness (not wanting to free ride on others or co-operate when few others do - similar to Taylor's discussion of a chicken game requiring precommitment :Taylor, 1987 : 45);

b) whether flexible and graduated systems of sanctions are essential;

c) whether co-operation works better in small groups with similarity of (hydrological) needs;

d) whether there is a backward bending curve of co-operation depending on the extent of ecological stress;

e) whether, even in a highly conflict ridden situation, people leave behind their factional disputes when dealing with a co-operative arrangement in a functionally separate water user group.

To these we can add one more, following Seabright (1997:304) :

f) whether co-operation is habit forming i.e., whether 'co-operative action in the past can have significant effect on the prospects for co-operative action in the future'.

We cannot test for all of them from Civic Exnora survey. However, with regard to *c* above, we can see if co-operation in Madras is related to number households being served by a Civic Exnora. In a way, group size is also related to the ability to maintain flexible system of sanctions. Items *e* and *f* can be interpreted as : "once people co-operate for one service, is it easy to deliver other services" and "is co-operation less likely for new institutions". The former can be tested in terms whether there is any relationship between number of services provided and level of co-operation; the second one can be tested to see if older Civic Exnoras find more people co-operating than in case of recently formed Civic Exnoras.

In the survey, a question was posed to the committee members of the Civic Exnoras surveyed as to what percentage of households (being served by their Exnora) they thought were complying with the norms and rules of Civic Exnora (other than paying fee, i.e., storing the wastes as proposed and disposing them of as per arrangements; keeping the stretch of street abutting their house clean; attending meetings or functions, etc.). They were requested to place their answer in one of the five groups as shown in Table 7.7.

Table 7.7 :Responses to the question on co-operation

Share of households (members of the group) co-operating	Degree of co-operation	Co-operation level COOPERN	Distribution of Civic Exnoras surveyed (Per cent)
Less than 20 per cent of households co-operate	Very low	1	26.7
20 to 40 per cent of households co-operate	Low	2	20.0
40 to 60 per cent of households co-operate	Moderate	3	33.3
60 to 80 per cent of households co-operate	High	4	20.0
Over 80 per cent of households co-operate	Very high	5	--

At the time of collecting the data, my intention was to undertake ordinary least square regression. However, Maddala (1992 : 324) points out that in case of categorical dependent variable, OLS will be unbiased but inefficient. To use maximum likelihood procedure, a binary dummy variable called COOPDUM was created : If less than 40 per cent of households co-operated (i.e., degree of co-operation very low or low), COOPDUM was set to zero; if more than 40 per cent of households co-operated (i.e., degree of co-operation moderate or high or very high), COOPDUM was set to one.

The hypotheses that I wanted to test are :

(a) Co-operation is a function of group size i.e., H_0^1: COOPDUM = f (HHTOTAL);
(b) Co-operation depends on the level of fee charged by Civic Exnora, i.e., H_0^2: COOPDUM = f (FEES);
(c) Co-operation depends on the age of a Civic Exnora, i.e., H_0^3: COOPDUM = f (YEARS);
(d) Co-operation is a function of the number of services provided (due to economies of scope) i.e., H_0^4: COOPDUM = f (SERVICES)
(e) Co-operation is positively associated with the number of members on a committee, i.e., H_0^5: COOPDUM = f (CMTMBRS)
(f) Co-operation is negatively associated with the ratio of number of households represented by each committee members, i.e., H_0^6: COOPDUM = - f (CMTRATIO); and
(g) There is a positive relationship between co-operation and committee members working collectively, i.e., H_0^7: COOPDUM = f(WORKCLCT).

As a measure of goodness of fit, a pseudo R square is calculated for MLE models using $(1 - L(\beta^*) / L(0))$ where L (0) is the value of the log likelihood function with no coefficients; $L(\beta^*)$ is the value of log likelihood function when it is maximised. The results are shown in Table 7.8.

The first column in Table 7.8 gives the corresponding null hypothesis number mentioned above. For each hypothesis, if the maximum likelihood estimation shows a significant relationship, we accept the relationship; otherwise reject it. However, these results may be seen as preliminary indications, given that our sample size is small and that we are essentially testing pair-wise relationships rather than multi-variate relationships.

Table 7.8 : Testing hypotheses : Results of maximum likelihood estimation

	Independent Variable	Parameter	Constant	-2*L(0)	-2*L(β*)	Rho squared
H_0^1	HHTOTAL	-0.0019 (0.0050)	0.5005 (1.1114)	20.727	20.587	0.01
H_0^2	FEES	0.0594 (0.1198)	-0.4429 (1.542)	19.121	18.840	0.01
H_0^3	YEARS	0.0455 (0.45)	-0.157 (1.649)	19.408	19.398	0.001
H_0^4	SERVICES	0.813 (0.480)	-2.503 (1.627)	20.727	16.190	0.184
H_0^5	CMTMBRS	0.5122 (0.319)	-2.87 (1.778)	20.727	14.631	0.294
H_0^6	CMTRATIO	-0.058 (0.032)	2.252 (1.290)	20.727	16.257	0.216
H_0^7	WORKCLCT	+2.890 (1.354)	-1.099 (0.816)	20.727	14.739	0.289

Note : Figures in parenthesis are standard errors.
The dependent variable is COOPDUM.

In addition to pair-wise maximum likelihood estimations in Table 7.8, some multi-variate models were also attempted using the form :

$$\text{COOPERN} = f(\text{HHTOTAL, FEES, SERVICES, CMTMBRS, YEARS, CMTRATIO})$$

However, because of the small sample, such models were resulting in singularity of Hessian. After dropping some of the variables, the following model was estimated :

$$\text{COOPDUM} = -1.475 - 0.0017 * \text{HHTOTAL} - 0.185 * \text{SERVICES} + 0.036 * \text{CMTRATIO} + 1.646 * \text{WORKCLCT}$$

$-2*L(0) = 20.728$

$-2*L(\beta*) = 13.827$

Rho squared (or McFadden's R squared) = $1 - L(\beta*)/L(0) = 0.33$

None of the parameters had significant t-statistics. Group size (HHTOTAL) and whether members work collectively (WORKCLCT) have expected signs. However, the sign of number of services is coming out to be negative (while it was expected to be positive – if there are economies of scope). Similarly, there has been a sign change in case of CMTRATIO as well.

Issues for consideration :

As already mentioned, given the smallness of sample, these results must be seen as preliminary indications and there is need for further exploration. Further, there are two issues : the percentage of households complying with rules may not be a very precise measure of degree of co-operation; also there can be a distinction between reported rule conformance and actual rule conformance (specially if Civic Exnora leaders feel that reporting a lower percentage of households to be rule-conforming may in turn encourage more households to violate the rules). However, some preliminary indications are listed below :

a. There could be a significant relationship between the management style of the committee and the degree of co-operation from households. Both from the pair-wise likelihood maximisation results and the multi-variate case discussed above, it appears that where committee members work collectively, co-operation from households will be high.

b. As the number of members of the committee increases, the scope for maintaining better contact with members seems to increase. Related to this is the committee ratio. The pair-wise maximum likelihood estimation indicated a positive relationship between number of members on the committee and co-operation (and a negative relationship between CMTRATIO and co-operation). However, the multi-variate results gave an opposite result. This needs to be explored further.

c. Relationship between co-operation and fee levels was difficult to explore, given that the range of fees observed in the sample Exnoras was quite small.

d. Co-operation seems to be unrelated to the age of the collective action institution. Getting the co-operation of as many people from day one as possible (i.e., relying on demonstration effect to win over indifferent members may not be effective) seems to be the message.

e. Evidence on economies of scope is mixed. In pair-wise MLE estimation, co-operation was seen to be positively associated with the number of services. However, in the multi-variate equation above, we found the opposite to be the case.

7.7 Conclusions :

The effectiveness of a collective action arrangement may depend on many factors, only some of them being internal to the organisation and its functioning. While some of the earlier findings from co-operation literature are confirmed in Madras, there was some evidence of co-operation being negatively affected by group size. Co-operation was also found to be positively associated with the effectiveness and management style of the committee (in particular, having a more participatory management structure and one which encourages the committee to work as a team).

The Exnora type collective action arrangements, though apparently apolitical in stance, are inherently political institutions emerging as organised negotiation instruments to create political space for a particular interest group in the domain of the functioning of the local state machinery. In eulogising such institutions one has to be cautious that at the extreme, there is the danger that such arrangements can legitimise (and institutionalise) the rent-seeking behaviour of the state apparatus while simultaneously discharging the contributors from any moral or conscience burden by highlighting only the positive consequences ('cleanliness') of their co-operation. For instance, it can be argued that, though novel, such arrangements are not aimed at fundamentally altering the nature of the state but merely at adjusting its actions at the margin to accommodate the needs of those with a 'voice'.

Different layers of the state apparatus receive different types of benefits from such accommodation - for the upper echelons, it provides opportunities for highlighting their progressive nature (as providers of a developmental state that recognises the non-state 'civil society' institutions) and enable the flow of international aid; for the lower echelons, it may create a more efficient rent seeking formula (as some one else takes the burden of door-to-door collections). On the other hand, if the local state sees such collective action as potential threat (in terms imposing accountability), the local state may try to weaken such institutions.

It appears that collective action arrangements of the Exnora type may emerge only under certain conditions, when these are mutually beneficial to the accommodating state apparatus and the citizens. Such collective action approach may not work if citizens have access to the (local) state to negotiate their needs through other means such as caste or other social networks. More specifically, in relation to waste management, it appears that collective action for primary collection is more likely to work only if the main weakness in existing municipal waste infrastructure is primary collection. In small towns and in peripheral areas of the metropolitan area, where there is hardly any capacity for secondary collection, it is unlikely that co-operative solutions for primary collection (based on monthly contribution) can be effective. Thus, such institutions may be mainly vibrant in some cities and bigger towns and also, in some parts of such cities while there may be few such institutions elsewhere in the same city.

Further research is needed in refining the way co-operation has been defined and measured here. Some of the relationships discussed here need to be examined with the help of a panel data or in fact using alternative research methods in the phenomenological tradition (focus groups, participant observation and case studies). Other issues to be explored are : whether the composition of committee members has an impact on co-operation; whether co-operation depends not so much on the number of services provided but how effectively each of these services is provided; whether flexible sanctions interfere with the need for maintaining equality of treatment.

Chapter Eight
Some Aspects of Consumer Preferences for Waste Management in Madras

8.1 Introduction :

In this chapter, I would like to discuss some issues concerning waste management from the point of view of households in Madras. Discussion in the previous chapter has focused on co-operation based institutions in Madras, namely, Civic Exnoras where households contribute monthly a fee in return for which they receive a house-to-house collection service. Against that light, an exploration was undertaken to understand whether households would co-operate to keep their streets free from garbage (at some cost). The questions that I wanted to examine are the following, namely:

a) if Civic Exnora is formed in every street, would the households join ?

b) which aspects of waste management do households attach importance to, i.e., would they support programmes for primary collection (in the form of Civic Exnora) or would they also support secondary collection and disposal of garbage ?

c) what are household preferences in relation to the so-called 'zero waste' strategy that requires households to minimise waste generation and engage in home-based vermi-composting[1] of all the organic wastes ?

In section 8.2, I will present some cross-tabulation results about waste disposal habits of respondents. In section 8.3, information on civic awareness of respondents and in particular their awareness about Civic Exnora is provided. Section 8.4 presents a discussion on choice sets used in Madras survey, various specifications (mainly, the multi-nomial logit models) and issues related thereto. Based on this, welfare estimates are also discussed in that section. The chapter concludes with section 8.5, where some issues are identified.

8.2 Waste Disposal Habits of Households in MMA :

Waste disposal habits or behaviour are determined by climate, cultural factors, housing conditions, expectations about the role of (local) government and other factors. Also, some characteristics of waste (for example, odour and impact of flies and rodents) exhibit a distance-decay function. When primary waste collection service is not reliable, people explore other options. When regulation is either absent or is followed in its breach rather than compliance by a majority, there are incentives to dump the wastes in open access spaces such as streets and public spaces. In hot and humid climates, there are disincentives for accumulation or storing of wastes and positive incentives for disposing of wastes as and when they arise. Waste management in any city in the developing world requires understanding and re-aligning these incentives in institutional arrangements.

In Exnora type arrangement, the households are required to keep the wastes in their own premises and hand it over to the street beautifier once a day. The master plan proposals and also the newly introduced CES-ONYX collection system are designed to collect wastes once a day. In Madras Metropolitan Area, the 1996 survey indicates that 55% of households disposed of wastes only once daily. About 23% of households disposed of wastes as soon as they arise. In the lowest income group, nearly 62% households said that they disposed of wastes as soon as they arise.

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[1] Composting with the aid of earth-worms - This has been experimented by some Civic Exnoras in Madras. The technical details of the type of earth worms and the number of days required for composting etc., were worked out for Exnora by Sultan Ismail.

Table 8.1 How frequently households in MMA dispose of wastes.

How frequently wastes are Disposed	(Mean) Monthly Income of Income Class 2,000	3,000	4,500	8,000	20,000	Entire Sample
As soon as wastes arise	61.5%	28.2%	14.3%	12.0%	6.7%	23.0%
Once daily	23.1%	48.7%	61.9%	60.0%	86.7%	55.8%
Once in 2 or 3 days		10.2%		12.0%		6.2%
We burn/compost	15.4%	12.8%	23.8%	16.0%	6.7%	15.0%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
Sample N	20 (11.5%)	44 (34.5%)	32 (18.6%)	33 (22.1%)	19 (13.3%)	148 (100.0%)

When we view the patterns spatially, a different picture emerges. In suburbs and urban agglomeration areas, (where primary collection services are very weak or absent), burning of the wastes is the predominant mode of disposal : 46% of households in the 9 adjoining towns and 57% in the rural areas of MMA resort to this method (Table 8.2).

Table 8.2 : Spatial variations in Waste disposal frequency

How frequently wastes are Disposed	Spatial Unit Madras City	9 towns	Rural	Entire Sample
As soon as wastes arise	23.2%	20.8%	28.6%	23.0%
Once daily	68.3%	25.0%	14.3%	55.8%
Once in 2 or 3 days	6.1%	8.4%		6.2%
We burn/compost	2.4%	45.8%	57.1%	15.0%
Total	100.0%	100.0%	100.0%	100.0%
Sample N	109 72.6%	32 21.2%	7 6.2%	148 100.0%

A related question is : who handles the wastes in the household? While this question is relevant from several dimensions (gender and role of girl child in household work, for example), it is difficult to capture all the dimensions from an interview. In the Madras survey, a much narrower question of who disposes of the waste from the household was used. Such information could be of use in awareness programmes concerning waste disposal (for instance, in containers as proposed in the Master Plan). In the entire MMA, in one out of every four households, it is the servant maid who disposes of the wastes in the bin. Some people in Madras indicated in the interviews that maid-servants do not have any incentives to make sure wastes are thrown only in the bins and are not strewn all over.

Table 8.3 : Who handles the wastes at home (figures in percentage)

Who handles/ disposes the Waste	(Mean) Monthly Income of Income Class					For all households in MMA
	2,000	3,000	4,500	8,000	20,000	
A member of the family	100.0%	91.7%	50.0%	35.7%		56.1%
Servant/ maid		4.2%	25.0%	21.4%	83.3%	25.8%
Street beautifier		4.2%	25.0%	42.9%	16.7%	18.2%

The above table also indicates that 18.2 per cent of households in the sample are covered by Civic Exnora (and, hence, wastes are collected by the street beautifier). However, the above information was available only from 66 households of the 148 households in the sample, and hence, needs to be treated with caution. A more robust indicator is whether the households are already members of a Civic Exnora. This information was available from all the 148 households. From this, it was seen that 15 of the 148 households or about 10.1% of households are already members of Civic

Exnoras[2]. As table 8.4 indicates, at present, Civic Exnora system seems to be predominantly catering to the middle and high income groups.

Table 8.4 : Sample respondents as per Civic Exnora membership

	Number of respondents already served by a Civic Exnora		Percentage of those already served by a Civic Exnora
	No	Yes	
	(a)	(b)	(c)
2,000	100.0%	0.0%	0.0%
3,000	97.7%	2.3%	6.7%
4,500	90.6%	9.4%	20.0%
8,000	75.8%	24.2%	53.3%
20,000	89.9%	10.1%	20.0%
Sample N	133	15	15

Note : Columns a and b are row percentages; c is of column percentages.

The Extent of Recycling and Recovering Resources from Wastes

The questions on recycling and recovery of materials at household level were posed to a sub-sample 51 households within the sample of 148 households[3]. Hence, the figures may not be very representative, but only give a general idea. Households in the sub-sample were asked about three major items: paper, glass and cloth. According to the responses, 90% of these sub-sample households recover paper in

[2] On this basis, and taking average number of households per Civic Exnora as 189, the total number of Civic Exnoras in Madras Metropolitan Area is estimated as 610 as opposed to the 1,500 figure from Ramkumar (1996).

[3] This decision was mainly taken to decrease the average time taken in the interviews. However, independent samples t-test indicates that these 51 households and the remaining 77 households (who were not posed these questions on recycling) are not systematically different. The t-test results are: income -1.818; years of schooling -1.762; number of rooms in the house -0.214; household size-1.514. The null hypotheses of equal means cannot be rejected at 95% level for all four variables.

their household waste and sell it to waste paper merchants; 86% sell any glass items to waste/scrap buyer rather than dispose of it in garbage. Nearly 61% of households mentioned that they sell any waste clothes to vendors who exchange such clothes for utensils. These figures are supported by the composition of waste in Madras. In the preparation of master plan, the terms of reference did not include a comprehensive analysis of waste composition. Yet samples of wastes were collected at the landfill site and the analyses indicated the presence of less than 5% of paper, less than 5% of rags and less than 1% of glass (ERM,1996a).

8.3 Awareness about Civic Exnoras And Civic Awareness :

While Exnora has won international acclaim, interestingly, my survey indicates that more than 53% of all households in MMA were unaware of Exnora. Within Madras City, where most of the Civic Exnoras are functioning, 44% of all households were not aware of it. In the outskirts of MMA, 77% of households in the 9 towns and 87% of households in the rest of MMA were unaware of Exnora concept. If we disaggregate those in Madras City by house type[4], it was seen that 95% of households living in hutments/slums, 100% of those living in detached houses were not aware of Exnora concept. In all other types of houses, more than 67% households were aware of Exnora.

In addition to awareness about Exnora, I have obtained answers concerning three other variables, to understand civic awareness:

- *the zone/ward number* (this information is displayed on all street-name placards in Madras City Corporation area) - 65% of households did not know this;

[4] In chapter 4, a discussion on 7 house-types was presented. See tables 4.10 and 4.11.

- *the organisation responsible for solid waste management* - only 14% of the households did not know this (or 86% of households gave the expected answer);

- *where and how the waste is ultimately disposed* - 84% of the households were unaware of what happens to the garbage that is collected.

The last one seems to reflect an 'out of sight is out of mind' attitude. Also, perhaps, not much discussion (in local newspapers etc.) had taken place on how the waste collected daily are disposed of. Table 8.5 below indicates that awareness about Civic Exnoras is positively associated with income (last column). There is no clear relationship between income and awareness about other four indicators.

Table 8.5 : Household income and civic awareness

Mean Monthly Income Rs.	Zone/ward number	SWM responsibility	Where the city's garbage is disposed of	Awareness about Civic Exnoras
	(a)	(b)	(c)	(d)
2000	35.0%	80.0%	20.0%	25.0%
3000	29.5%	86.4%	18.2%	27.3%
4500	43.8%	84.4%	12.5%	53.1%
8000	39.4%	97.0%	12.1%	63.6%
20000	26.3%	78.9%	21.1%	73.7%
Entire sample	35.1%	86.5%	16.2%	46.6%

An analysis with respect to education levels also showed a similar picture: awareness about Civic Exnoras was associated with educational level of respondent but in relation to awareness about the other four items mentioned in the table above, no appreciable relationship with education was noticed. Awareness can also be related to the media coverage. Print and television media have been the most influential media in promoting environmental issues. Table 8.6 presents some information on awareness of respondents about Civic Exnora and their access to media.

Table 8.6 : Awareness about Civic Exnoras and the media usage by households in MMA

Medium		Awareness of Civic Exnora		
		Unaware (a)	Aware (b)	Of Total (c)
Do you read a Newspaper?	No	84.6	15.4	26.5
	Yes	41.7	58.3	73.5
Do you have a TV?	No	90.0	10.0	6.8
	Black & white	66.7	33.3	44.6
	Colour TV	36.1	63.9	48.6
Do you have cable TV?	No	67.5	32.5	55.2
	Yes	35.4	64.6	44.8

Notes : For each row, column (a) and column (b) add up to 100; for each medium, the figures in column (c) add up to 100.

From the above table, it is evident that : 90% of those not having a TV or nearly 85% of those not reading a newspaper are not aware of Civic Exnora. Television seems to have a greater penetration in MMA : nearly 94% of all households have a TV whereas one among every four people (or 25% of all) does not read a newspaper.

8.4 Modelling Household Preferences for Waste Management Services :

In this section, an analysis of the various options for waste management offered in the survey is presented. The arrangement of this section is somewhat similar to the discussion on multi-nomial logit models of water supply in chapter 6. First, the details of the attributes and choice set are discussed. Then, results from MNL models are reported. An exploration is made of a nested MNL model. Relevance of socio-economic variables are considered. Welfare estimates are obtained and their implications are discussed.

8.4.1 Options for Waste Management :

The discussion in previous chapter indicates that Civic Exnora provides primary collection. A point was also mentioned that Civic Exnoras may be unable to function effectively if a secondary collection system does not exist. Hence, the attributes that were of interest to me were: (a) primary collection, i.e., whether an option would provide for waste collection from door-step (COLLECT); (b) whether it also provides for secondary collection and transport of wastes to disposal site (TRANS); (c) whether an option provides for disposal of wastes (DISP); (d) in the light of discussions on environmental impacts and sustainability, whether an option requires a commitment on the part of household for waste minimising, recycling (RECYCL). On the basis of preliminary discussions in the field and focus groups, I decided to use five options in the household survey: the following four alternatives and a fifth one of choosing 'None':

a. Option X : The proposal that a new Civic *Exnora* in their neighbourhood will be started and it would cost Rs. W1 per month. (This option is not explicitly offered if the respondent is in a street already covered by a Civic Exnora. However, if they say that they prefer the status quo, the response is noted.)

b. Option XT : The proposed / existing Civic *Exnora* plus, a scheme to improve *transport* of wastes from transfer stations to the disposal sites to be implemented by the Municipal Corporation/ local body and it would cost Rs. W2 per month.

c. Option XTD : The proposed/ existing Civic *Exnora* plus the *transport* scheme plus a membership of a scheme towards improving the *disposal* of wastes and it would cost Rs. W3 per month.

d. Option Zero : Zero waste management strategy - where the respondent would be given technical assistance to create and maintain vermi-composting pits (or card board boxes) in one's own premises and the amortised capital costs and cost of time was given as Rs. W4 per month.

The values of attributes of the four options are summarised in table 8.7.

Table 8.7 : Attributes of the various alternatives

Attribute	Option X	Option XT	Option XTD	Option Zero
COLLECT Whether the option provides for wastes to be collected No = 0; Yes =1	1	1	1	0
TRANS Whether the option includes secondary collection and transport : No = 0; Yes =1	0	1	1	0
DISP Whether the option includes disposal component : No = 0; Yes = 1	0	0	1	0
RECYCL Whether the option promotes recycling : No = 0; Yes =1	0	0	0	1

The prices (namely, figures W1, W2, W3 and W4) were randomly assigned to each questionnaire. The price ranges used are shown in table 8. 8. The prices were ordered such that in a given questionnaire, W1< W2 <W3. In general, W4 was such that W1<W4.

Table 8.8 : Price ranges used for waste management options

	Frequency			
Class interval of price Rs.	Option X	Option XT	Option XTD	Option Zero
Upto 20	59	10	0	0
21 – 40	78	65	10	1
41 – 60	10	53	25	5
61 – 80	1	16	33	15
81 – 100		2	18	19
101 – 120			10	13
121 – 140			1	5
141 – 160			1	8
161 – 180			1	0
181 – 200				2
Total	148	146	99	70
Mean	27.07	43.89	73.31	102.93
Standard deviation	12.71	17.25	27.27	33.38

After the options were explained and any questions were discussed, the respondent was requested to indicate which of these options was most preferred and why. Describing all four options would take about 16 to 20 minutes. To balance between giving adequate number of options and to avoid monotony and boredom for respondents, I found that giving 3 options was a reasonable solution. In some cases, I was able to give all 4 options (about 34% of the sample) and in some cases I was able to give only 2 options (20.9%). These details are shown in table 8.9 below.

Table 8.9 : Respondents as per choice sets : Madras City and Rest of MMA

Number of options	City		Rest of MMA		Total
2	X and XT	21	X and XT	10	31 *(20.9%)*
3	X, XT, XTD	33	X, XT, XTD	14	47
	X, XT and ZERO	14	X, XT and ZERO	4	18
	X, XTD and ZERO	2			2
	Sub total	49	Sub total	18	67 *(45.3%)*
4	All four options	39	All four options	11	50 *(33.8%)*
		109		39	148

8.4.2 Details of Non-response

About a fifth of the sample households (31 out of 148 households) did not choose any of the options (hereafter referred to as non-respondents). Of these non-respondents, nearly 61% were in Madras City. During the survey, the reasons for not choosing any option were noted and *post-facto* these are placed in one of the 8 groups as shown in table 8.10.

Table 8.10 : Reasons for not choosing any of the options for solid waste management

Reason given	Percent of all non-respondents	Rating for solid waste management
Others will not co-operate	25.8	2.67
It is government's responsibility	16.1	2.20
Present system is OK	12.9	3.00
Cannot afford (beyond Rs. 10 per month)	12.9	2.00
Already paying taxes	9.7	1.67
Not interested	9.7	2.67
No leadership for such schemes	3.2	3.00
Other reasons	9.7	1.67
	100.0	

Doubts about co-operation of others and a feeling that waste management is government's responsibility were the two foremost reasons for not joining an improvement scheme. It is interesting to see that those who said the present system is OK, indeed had given a high rating for existing solid waste management system. Those who had doubts about others' co-operation or saying they were not interested are perhaps actually *status-quo*ists as they consider existing waste management services to be satisfactory (rating of 2.67).

Nearly 65% of the non-respondents were men. Doubts about co-operation by others were stronger among the women non-respondents than among men. 36% of women non-respondents thought that others will not co-operate, whereas, 20% of men thought so. Doubt about others' co-operation was the predominant reason among non-respondents from the 9 suburban towns; another 30% of the non-respondents from those towns thought that it was government's responsibility to provide waste management services.

8.4.3 MNL models :

As discussed in chapter 6, in the multi-nomial logit (MNL) models, households choose that option which maximises their utility. The observable part of utility is a function of attributes of the option. As in equation 6.7, the odds of choosing a waste management option can be expressed as :

$$\log (P_{ij} / (1 - P_{ij})) = \beta 1{*}PRICE + \beta 2{*}COLECT + \beta 3{*}TRANS$$
$$\beta 4{*}DISP + \beta 5{*}RECYCL \qquad 8.1$$

Table 8.11 below presents a set of estimation results for the model specified in equation 8.1 above and two special cases thereof. The following details are reported in the table :

a. parameters of attributes;
b. the value of log-likelihood function when it is maximised, namely, $L(\beta^*)$;
c. the value of log likelihood function when all parameters are assumed to be zero, namely, $L(0)$;
d. a goodness of fit measure, rho squared bar (as discussed in chapter 6).

Table 8.11 : Results from MNL models

Variables	Model S-5	Model S-4A	Model S-4B
PRICE	-0.00404 (-0.424)	-0.0120 (-1.585)	-0.0327 (-3.737)
COLLECT	-14.4314 (-0.082)	-14.3804 (0.081)	
TRANS	-0.3858 (-1.373)		-0.1473 (-0.538)
DISP	0.3900 (1.051)	0.4544 (1.261)	1.1263 (3.284)
RECYCLE	-15.796 (-0.090)	-15.1399 (-0.085)	0.0927 (0.140)
$L(\beta^*)$	-124.5885	-125.5323	-150.2962
L(0)	-238.1968	-238.1968	-238.1968
Rho squared bar	0.4560	0.4562	0.3522
LR test statistic		1.8876	51.4154
Chi square		2.71 at 90%	6.63 at 99%
Degrees of freedom		1	1

Note: Figures in parentheses are t-ratios.

Model S-5 is specified with all 5 attributes; the other two models are specified with 4 attributes each. The following points can be noted:

a. In terms of goodness of fit, models S-5 and S-4A are pretty close to each other. If we consider S-4A to be a restricted specification (with only 4 attributes) and model S-5 to be the unrestricted case, a likelihood ratio test (as discussed in chapter 6) cannot reject the null hypothesis that model 4-A is the correct specification.

b. Model S4-B has some attributes that are highly significant. However, it has a lower value of goodness of fit measure. Also, a LR test between model 4-B (as the specification in null hypothesis) and model S-5 rejects model 4-B.

c. In all three models, the attribute PRICE has expected sign. The expected sign for COLLECT was positive; but here it was seen to have negative sign.

To test the relevance of including respondent characteristics, model S-5 has been respecified with alternative specific constants for the following variables: location (city = 0; MMA = 1); gender (female = 0 or 1); income; ownership of house; whether respondent lives in a hutment. Though the t-ratios of parameters have not improved with the inclusion of ASCs, the value of log likelihood function when it is maximised prima facie shows some improvement. However, a goodness of fit measure such rho squared bar will not improve much because the difference in L(β*) between S-5 and S-5C is about 14; but the number of parameters (K) in a model such as S-5C would be 25 (5 for five attributes plus 4 ASCs for each of the 5 respondent characteristics). The expected probabilities of selecting the various options, however, have not changed at all.

Table 8.12 : Model specification with ASCs

	S-5	S-5A	S-5B	S-5C
Model includes ASCs for	--	MMA	MMA, Female, Income, Owner	MMA, Female, Income, Owner, Hutment
L(β*)	-124.5885	-121.2475	-113.5337	-110.5036
L(0)	-238.1968	-238.1968	-238.1968	-238.1968
Expected Probabilities:				
X	0.3514	0.3514	0.3514	0.3514
XT	0.2162	0.2162	0.2162	0.2162
XTD	0.1892	0.1892	0.1892	0.1892
Zero	0.0338	0.0338	0.0338	0.0338
None	0.2095	0.2095	0.2095	0.2095

From the above table, it appears that the socio-economic characteristics included here do not seem to contribute substantially to improve the specification.

8.4.4 Model Specification : IIA and Nesting issues

I have attempted to test for the IIA property using model S-5. The unrestricted model was specified with all the options; a restricted model was specified with one of the options omitted. However, omitting one of the options resulted in the Hessian becoming singular. Greene (1995 : 501) notes this possibility :

> "There is a possibility that restricting the choice set can lead to a singularity. It is possible that when you drop one or more alternatives, some attribute will be constant among the remaining choices. Thus, you might induce the case in which there is a 'regressor' which is constant across the choices....Hausman and McFadden suggest estimating the model with the smaller number of choice sets and a smaller number of regressors. There is no question of consistency, or omission of a relevant attribute, since if the attribute is always constant among the choices, variation in it is obviously not affecting the choice."

In another attempt, I have used model S-4A to test for the IIA property. Option XT was dropped and the model was re-estimated. A Hausman-McFadden test could not be carried out as the variance difference matrix was not positive definite. Parameter estimates from the two models (table 8.13) are fairly close to each other.

Table 8.13 : IIA property : model S-4A and impact of dropping option XT

	Model S-4A	S-4A when XT was dropped
PRICE	-0.0120 (-1.585)	-0.0123 (-1.161)
COLLECT	-14.3804 (0.081)	-13.4945 (-0.095)
DISP	0.4544 (1.261)	0.4001 (0.793)
RECYCLE	-15.1399 (-0.085)	-14.0688 (-0.099)
Valid N	148	116

Figures in parenthesis are t-ratios.

Comparison of ratios of probabilities in these two specifications is shown in table 8.14 below.

Table 8.14 : Comparison of probabilities in model S-4 and when one of the options was omitted

Probabilities of choosing	Model S-4	S-4 when XT excluded from choice set	Model S-5
X	0.3176	0.4483	0.3514
XT	0.2500	0.0000	0.2162
XTD	0.1892	0.2414	0.1892
Zero	0.0338	0.0431	0.0338
None	0.2095	0.2672	0.2095
Ratio of probabilities			
X to XTD	1.6786	1.8571	1.8571
X to Zero	9.4000	10.4000	10.4000

Though the ratio of probabilities in the case when model S-4A is estimated by dropping XT from choice set and those from model S-4A do not match, they do match with model S-5 up to fourth decimal.

Do households compare these options in a hierarchical manner? Is a nested multi-nomial logit (NMNL) model a better specification than a MNL model such as model S-5? The options can be considered in the form of a tree :

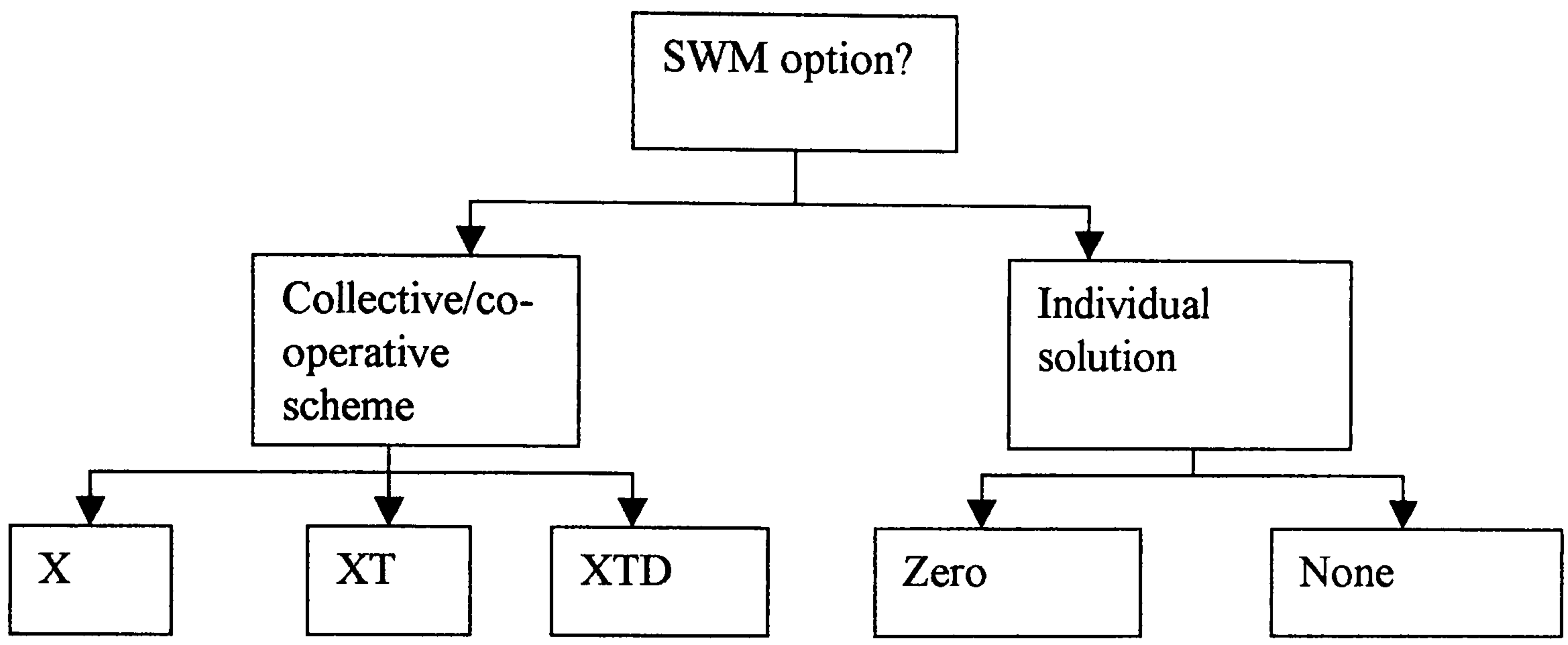

Figure 8.1 : A nested structure for waste management options.

Table 8.15 reports the parameters from the nested MNL model along with those of model S-5. (As mentioned in chapter 6, in the nested model, in addition to parameters of attributes, parameters are also estimated for the inclusive values. In the above structure, there are only two inclusive values at level 1. These are called COOP and INDIV relating to the two branches in the tree.)

Table 8.15 : Parameters from Nested model v. model S3

	Nested model	Model S-5
PRICE	-0.00317 (-0.291)	-0.00404 (-0.424)
COLLECT	-37.006 (-0.025)	-14.4314 (-0.082)
TRANS	-0.4073 (-1.357)	-0.3858 (-1.373)
DISP	0.3943 (1.060)	0.3900 (1.051)
RECYCLE	-6.733 (-0.055)	-15.796 (-0.090)
IV parameters		
COOP	0.1913 (0.029)	
INDIV	1.3250 (0.167)	
$L(\beta^*)$	-123.6782	-124.5885
L(0)	-250.5837	-238.1968
LR test statistic	1.8206	
Chi square	4.61 at 90%	
Degrees of freedom	2	

Is the nested model a better specification than MNL model? To answer this question, the following points may be considered:

a. The parameters of attributes PRICE, TRANS and DISP from the two models are fairly close to each other. However, the parameters of COLLECT and RECYCLE have the same sign in both the models but their magnitudes are different. However, none of the parameters in both the models were significant (as seen from t-ratios reported in the table).

b. The values of IV parameters are quite far from 1. Following McFadden (1984) (and as mentioned in chapter 6), the parameters k_{rh} and λ_r are 'measures of independence of alternatives within subclusters and clusters'. If $k_{rh} = \lambda_r = 1$, the model reduces to a simple MNL model. As one of the λ_r in the model lies outside the interval 0 and 1, it seems to indicate a misspecified hierarchical structure.

Further, a Wald statistic as suggested by McFadden (1984) can be computed :

$$
\begin{aligned}
W &= (1-\lambda_r) / SE_{\lambda r}{}^2 \\
&= (1 - 0.1913) / (0.029^2) + (1- 1.3250) / (0.167^2) \\
&= 949.94
\end{aligned}
$$

This is Chi square distributed with *r* degree of freedom, here *r* being 2. We can see that the critical chi square value for 99.5 per cent significance is 10.60. Hence, the null hypothesis that MNL specification is correct specification rather than the nested model can be rejected. However, a LR test as reported in table 8.15 above, cannot reject the null hypothesis. In this case, the LR and Wald tests are giving us different signals. McFadden (1984) noted this possibility that LR test can produce a different result from a Wald test.

c. To gain some insight into clustering of alternatives, elasticities from the MNL and NMNL models are compared in table 8.16. We can see that there is no significant difference between the elasticities from the two models.

Table 8. 16 Comparison of elasticities : MNL model and NMNL model

		Elasticity for choice				
	Attribute	X	XT	XTD	Zero	None
MNL model	X Price	-0.071	0.039	0.039	0.039	0.039
	XT price	0.038	-0.135	0.038	0.038	0.038
	XTD price	0.055	0.055	-0.144	0.055	0.055
	Zero Price	0.014	0.014	0.014	-0.182	0.014
NMNL model	X price	-0.046	0.040	0.040	0.006	0.006
	XT price	0.040	-0.097	0.040	0.006	0.006
	XTD price	0.054	0.054	-0.103	0.008	0.008
	Zero price	0.000	0.000	0.000	-0.169	-0.169

On the basis of the above discussions, the signals are mixed. From parameter estimates and elasticities it appears that there is no significant difference between a nested specification and a simple MNL model. On the other hand, from Wald test based on inclusive value parameters of clusters, it appears that NMNL model is a better specification, though one of these inclusive values lies outside the (0,1) interval. This suggests a possibility that there is some misspecification of hierarchical structure. These issues need further exploration, possibly with a larger sample.

8.4.5 Some Results of Probit Regression Models

The MNL models have considered choice attributes. Using ASCs, some respondent characteristics have been included. Here, an attempt is made to use binomial probit regression using a 'random effects' panel format. Some of the respondent characteristics considered are : location dummy (MMA - which is given a value of 0 if the respondent lives in Madras City and 1 otherwise); tenure of house (OWNER -

this is set to 1 if respondent lives in own house; 0 otherwise); gender of respondent (FEMALE) and mean monthly income of the income group (INCOME).

Table 8.16 : Some results from Probit regression

Parameter	Model 1	Model 2	Model 3	Model 4
SWPRICE	-0.0004	-0.0004	-0.00012	0.00002
COLLECT	-0.6523**	-0.6517**	-0.6498**	-0.6493**
TRANS	-0.122*	-0.1236*	-0.1284*	-0.131**
DISP	0.067	0.0662	0.059	0.055
RECYCLE	-0.900**	-0.902**	-0.921**	-0.93**
MMA	-0.040	-0.041	-0.0361	
OWNER	0.0367	0.0363		
FEMALE	0.0227			
INCOME	0.00002	0.000002		
$L(\beta^*)$	-248.64	-248.76	-249.67	-250.03
L(0)	-301.59	-301.59	-301.59	-301.59
Chi squared	105.90	105.66	103.85	103.12
Significance level	0.0000	0.0000	0.0000	0.0000

Note : ** p value less than 0.01 (i.e., 1 per cent)

* p value less than 0.05 (i.e., 5 per cent)

From the results above, it is seen that price (or monthly charge) is not significant. Some of the attributes are very significant. People seem to be reacting to primary collection, transport of wastes to disposal site and recycling (as in case of vermi-composting). Socio-economic characteristics such as location or income or ownership of house do not seem to make any difference at all.

8.4.6 Welfare estimates :

As discussed in chapter 6, from the parameter estimates of MNL models, point estimates of implicit prices of the different attributes can be considered to see how respondents trade-off different attributes. From model S-5, the implicit prices are estimated below in table 8. 17.

Table 8.17 : Implicit prices for attributes of waste management Rs. (1996)

	Beta from model S-5	Implicit price Rs
PRICE	-0.00404	
COLLECT	-14.4314	3,572.13
TRANS	-0.3858	95.50
DISP	0.3900	- 96.53
RECYCLE	-15.796	3,909.90

From the absolute values of the attributes, it appears that primary collection (COLLECT) and recycling of wastes in their disposal (RECYCLE) are considered to be more important. As discussed in chapter 6 earlier, if we also interpret the negative implicit prices to be willingness to pay and positive implicit prices to be compensation, we see that there is willingness to pay for disposal but for other attributes, people expect compensation. However, these are based on *ceteris paribus* assumption and hence, care should be taken in interpreting the results. An alternative approach to welfare implications is to calculate and use the compensating surplus. As mentioned in chapter 2, compensating surplus (CS) can be estimated using :

$$CS = (-1/\beta_M)(V_0 - V_1)$$

where β_M is the coefficient of the monetary attribute (PRICE). V_0 is the value of the utility function before the change (in environmental quality, in this case waste management) and V_1 is the value of the utility function after the change. As per model S-5, an indirect utility function can be specified as:

$$V = \beta 1*PRICE + \beta 2* COLLECT + \beta 3*TRANS + \beta 4*DISP + \beta 5*RECYCLE$$

For each of the options X, XT, XTD and ZERO, the value of V_1 can be calculated based on the values of the attributes of those options (shown in table 8.7) and mean value of PRICE attribute (shown in table 8.8). For example, using model S-5, for option X, we have the following values of attributes: PRICE = 27.07; COLLECT = 1; TRANS = 0; DISP = 0: RECYCLE = 0. Therefore, value of indirect utility function is:

$$V_1 = -0.00414 * 27.07 - 14.4314* 1 - 0.3858 * 0 + 0.3900 * 0 -15.796 * 0 = -14.5408$$

We can compare this with the value of utility function for current situation. For example, for those within Madras City who are not paying any money but are getting the service of collection and transport (provided by the Corporation of Madras), the values of attributes are: PRICE = 0; COLLECT = 1; TRANS = 1; DISP = 0 and RECYCLE = 0. Thus, the value of indirect utility function is:

$$V_0 = -0.00414 * 0 -14.4314 *1 - 0.3858 * 1 + 0.3900 * 0 - 15.796*0 = -14.8172$$

Based on these two values, we can now calculate compensating surplus for these households when option X is chosen:

$$CS = -1/(-0.00414) *(-14.8172 + 14.5408) = -68.425$$

As already noted in chapter 6, a negative amount of CS is interpreted as willingness to pay to achieve the improvement. Estimates of CS using this approach for households in different situations are shown in table 8.18.

Table 8.18 : Estimates of CS

		V_0	V_1	CS
1	Providing collection (X) through Exnora type arrangement where no service exists	0	-14.5408	-3599.20
2	Providing collection (X) through Exnora type arrangement in Madras City	-14.8172	-14.5408	-68.42
3	Providing collection (X) through Exnora type arrangement in MMA where households are presently recycling	-15.796	-14.5408	-310.70
4	Providing secondary collection to those who already have a Civic Exnora (i.e., change from X to XT)	-14.5408	-14.9945	112.31
5	Providing disposal (i.e., from XT to XTD)	-14.9945	-14.7234	-67.11
6	Moving toward zero waste strategy (from XTD to ZERO)	-14.7234	-16.2118	368.43
7	Providing XTD in Madras City	-14.8172	-14.7234	-23.22
8	Providing XTD in MMA	-15.796	-14.7234	-265.50

From this the following points can be observed:

a. Of all the welfare gains from waste management improvements, most gains accrue from improving primary collection (from the value of CS in row numbered 1). Improving primary collection where no such services at all exist (for example, in peripheral villages in MMA) results in significant welfare gains. Improving primary collection in MMA towns where households are presently engaging in recycling also results in welfare gains. Hence, households there will be willing to pay Rs. 310.72 per month (row numbered 3). Improving primary collection through Exnora-type systems in Madras City is also welfare improving: people there will be willing to pay Rs. 68.42 per month (row number 2).

b. It appears that households are not willing to pay for improving secondary collection: For instance, though households in Madras City are willing to pay for an overall package of primary collection, transport and disposal (XTD), their willingness to pay for this package (Rs 23.22) is less than their willingness to pay for primary collection alone (Rs. 68.42). The corresponding figures for households in MMA are Rs. 310.70 for primary collection alone and Rs. 265.50 for XTD system. While *prima facie* this appears to violate scope sensitivity and rationality, two points can be raised in interpreting this result:

  - While Exnora type arrangements for primary collection are real and existing, arrangements for improving secondary collection (i.e., transport) and disposal based on household payments are hypothetical schemes. Madras households are not aware of such schemes. Hence, they may be sceptical about such schemes.

  - While they do not mind contributing monthly to improve primary collection whose benefits are localised, they may be reluctant to contribute to schemes (such as improving secondary collection and disposal) whose benefits are public goods in nature and not localised, though they recognise that improving waste management system as whole is valuable and important.

c. While there is willingness to participate in XTD type system, a move to zero waste strategy will lead to welfare losses (row number 6).

8.5 Conclusions :

The analysis in this chapter has examined some details of preferences of respondents for waste management services. In general, waste management capacity of Madras Corporation is better than that of many of the suburban municipal units (serving areas within MMA). Does a system of providing waste collection through Civic Exnora-type institutions improve welfare? From the results on compensating surplus, it appears that improving primary collection has significant welfare gains. Though households in Madras have willingness to pay for a scheme that provides for improvement in primary as well as secondary collection and disposal, they seem to value primary collection highly. As benefits from primary collection are localised, such behaviour seems reasonable.

A number of issues remain to be explored further:

a. While the MNL model showed IIA property, we had mixed indications whether a nested specification was better than MNL specification. Is this because the options presented did not cover the full range of attributes? Or, perhaps the attributes considered by me are not fully capturing the different dimensions of solid waste management that households may be using to make their decisions. There is need for exploring this further, possibly with focus group discussions.

b. The welfare estimates reported earlier seem to be insensitive to scope. That is, the compensating surplus for an option that provided only primary collection (X) was larger than the CS for an option that provided collection, secondary collection and transport and disposal (XTD). It can be argued that one of the attributes (primary collection) is valued far highly than other attributes because its benefits are localised. Also, expectations about the role of local government in providing secondary collection, transport and disposal (which have city-wide benefits) could be entering the picture. This is an issue for further research, possibly with a specific focus on lexicographic preferences. While I do not have clear evidence on this, perhaps, consumers in Madras may feel too strongly about primary collection being more important than secondary collection and disposal to consider them in a compensatory framework. This needs further exploration.

c. On the whole, both here and in chapter 6, it was seen that households seem to be deciding based on choice attributes rather than socio-economic characteristics. Water and sanitation are essential services and hence, one could expect that preferences do not significantly vary with socio-economic characteristics. There is scope to test for this result in further research, for example, by doing a split sample study with a marketed commodity.

d. An issue not explored here but that needs to be explored relates to institutions and privatisation. While private provision was considered among the options for water supply in chapter 6, no such option was included for waste management. However, as already mentioned, Corporation of Madras introduced a private company to provide waste management (primary collection, transport and disposal) in 3 of the 10 zones in Madras. In the absence of information on this aspect, I cannot say whether such a policy is welfare improving or results in welfare losses.

There are other issues not examined in this research but which may require further enquiry. During this research, it was noticed that awareness of Civic Exnoras is strongly associated with income (reported in table 8.5 earlier). However, from the MNL models, we saw that inclusion of socio-economic characteristics did not significantly improve the specification. If socio-economic characteristics are not important, why are civic Exnoras conspicuous by their absence from low-income areas? This issue also needs further enquiry.

Chapter Nine
Conclusions

9.1 Introduction :

Access to information is key to effective functioning of a democracy. This research was conceived at a time when the policy environment in India, specially at state and local government levels, was one where access to information was severely restricted. In my own case, I was told that "as a policy, information required by you for studies cannot be divulged"(Appendix 2). The right to information movement was just beginning. In such an environment, policy makers and planners of water and waste infrastructure providers had little information as to what the preferences of their consumers are. Also, independent researchers and local activists and media cannot verify the bases of public policy. A good deal of work had been reported on participatory and 'rapid' methods (referred to as participatory rural appraisal or PRA and rapid rural appraisal or RRA) in rural context. While such methods can be applied in urban context specifically to consult people in a given neighbourhood, there is a limitation in using such methods for city-wide policy making. As long as the researcher makes the decision as to 'who participates', results from such methods cannot be generalised. Against this background, I wanted to explore whether surveys designed with probability based sampling methods surveys can be used to understand preferences of consumers.

Following this introduction, in section 2, I will summarise the responses to the various research questions raised in chapter 1. Following this, in section 3, some issues for further research are highlighted.

9.2 Summary of findings :

Though I have acknowledged the criticisms on micro-economic models based on utility and took note of some alternative approaches, I have approached this research mainly from the random utility framework. I have attempted to modify my approach to accommodate some of the criticisms. In particular, the following points may be highlighted:

a. While understanding household preferences for the options is an important part of this study, it has also explored other relevant issues outside this framework.
b. An attempt has been made to use participatory approaches where relevant. The questionnaire for the survey itself has been designed on the basis of focus group discussions on specific aspects of provision of water and sanitation services in Madras (discussed in chapter 3).
c. To understand how respondents consider water supply and waste collection in relation to a host of other services, they were requested to indicate their rating for various services (on the lines of Paul's studies mentioned earlier).
d. To gain insight into water supply in Madras, household (consumer) survey data was collated with other sources of information such as interviews with water vendors, wholesale water traders, mineral water producers and water policy makers.
e. In analysing water supply provision, an attempt has been made to examine property right issues using Sen's entitlements approach (discussed in chapter 5).
f. In understanding waste collection services, an attempt was made to understand the Civic Exnoras, how they work and some factors determining the level of co-operation from households, drawing mainly from literature on common property institutions (discussed in chapter 7).

To use McFadden's words, the conception of consumers in this research is far from that of the K-T (wo)man. However, the above mentioned points indicate that they are not entirely in the shadow of the Chicago-(wo)man either.

I do not wish to summarise all the various issues raised in this research. In chapter 1, I have listed some research questions to be explored in this research. Here, I will attempt to summarise a few points in response to these questions.

(1) Water supply and waste management in relation to quality of life in Madras, rating of service providers and differences between the rich and the poor:

These concern the first three research questions. In Chapter 4, from a discussion on both Tendulkar and Sundaram approach and also a composite index of quality of life, it was noticed that water supply and waste management are important elements of physical quality of life in Madras. With regard to rating of these service providers (question 2), out of 14 environmental services, we saw that water supply and waste management are neither top performers nor are they the worst performers. However, (with regard to question 3), it was found that both water supply and waste management are considered by the rich to be satisfactory while the poor thought these two services are among those which are 'bad' or 'very bad'.

Questions on Water Supply

(2) How does the 'formal' view of water supply in Madras compare with the results from the survey? (question 4) and what proportion of households in Madras have access to different sources of water supply (question 5)? Discussion in chapter 5 focused on these issues. The survey indicated that about 42% of households in Madras city did not have access to piped water supply system whereas the 'formal' or 'documented' view was that 92% of population was covered. As noted in page 135, the main reason for this difference is that the 'formal' coverage figures include many households who depend on communal stand-posts, water fountains and static tanks. Some of these, (nearly 20% of households according to my survey, table 5.2), do not have any source within their premises. This explains the visual images in different parts of Madras where a number of people (specially among the poor) queue up for water or carry water as a daily routine.

(3) To what extent do households depend on water vending? What kind of payments are involved? (question 6). The water balance sheet exercise and the discussions on private water markets indicate that there is some degree of water vending in Madras. In terms of quantity, this may form only a small part of the total water flows in the Madras Metropolitan Area : at the very least, about 13.1 million litres a day out of 600.1 million litres a day (8MLD from tanker trucks; assuming vending to be to the extent of about 5 MLD from static tanks out of 10 MLD supplied to static tanks; 0.1 MLD of mineral water). However, in terms of expenditures, the share of private operators will be significant (as the unit costs estimated in table 5.6 indicate).

(4) With regard to inequality in access to water supply (questions 7,8, and 9), some limitations of the indicators presently used (water availability per capita, and percentage of people covered) were noted. Calculations in chapter 5 based on the water balance sheet and the various pieces of information from this survey indicate clearly the degree of inequality in access to water supply in Madras. I have also attempted to use Sen's entitlements concept for water and found that water endowment is a better indicator of water supply and the associated property rights. Based on this indicator, I have argued that the assumption 'everyone in the city will benefit, and in particular, the poor will benefit' is highly questionable. I have also showed with Lorenz curves that without any interventions in the form of giving water connections to the poor, increasing the total quantity of supply as with Krishna water project will actually benefit those who already have high levels of water endowments.

(5) With regard to household preferences for attributes (questions 10,11 and 12), discussion in chapter 6 indicated that YARDTAP is an important attribute. It was highly significant and had positive sign. The multi-nomial logit models did not indicate clear preferences for other attributes such as water quality or quantity. The ENVIRON attribute was very significant in some models and had a negative sign. This and also the welfare estimates indicate that a policy

of forcing households to engage in rain water harvesting and recycling may lead to substantial welfare loss.

(6) Welfare measures also indicate that there will be welfare gains from providing yard tap connection to all households in the 9 towns and rest of the MMA. It was seen that such a policy would benefit households in all categories (i.e., levels of water endowment) in those areas.

(7) From the nested multi-nomial logit models it was not evident that households in Madras eliminate options in a hierarchical manner by narrowing options based on one or two attributes such as whether it provides a yard tap connection or whether it is being provided by private sector. However, in the multi-nomial logit models, the attribute PRIVATE had a negative sign and in some of those models the parameter was significant. Welfare measures indicate that a policy to privatise water supply in terms of a private agency providing yard tap connections, will benefit those with high water endowments. There will be welfare loss from such a policy for the poorer households.

Questions on Waste Management

(8) With regard to question 13, I have explained in detail in chapter 7 as to how Civic Exnoras function. In that chapter, a discussion on estimating cost curves indicated that compared to the average group size (i.e., the number of households served by a Civic Exnoras) of 189, average cost per household will actual fall by increasing the group size up to about 240 households and they remain constant up to a group size of about 360 households where after they begin to increase. In the pair-wise and multi-variate likelihood estimation results, the group size variable was not significant but it had the expected negative sign.

(9) With regard to some of the hypotheses developed in the literature for rural commons, we found that there are mixed signals about economies of scope (examined here as a relationship between co-operation and number of services provided). An important result from this analysis appears to be that where committee members work collectively, co-operation by households is likely to be high.

(10) With regard to questions 16, and 17, the discussion in chapter 8 indicates that there are significant welfare gains from primary collection. Compared to these welfare gains, the monthly payment for an arrangement such as a Civic Exnora is very small. Hence, it is highly likely that if a Civic Exnora is formed in every neighbourhood, in most cases households would be willing to join. Awareness about Civic Exnora is positively related with income. However, the multi-nomial logit models and also the probit models indicate that socio-economic characteristics do not play a substantial role in explaining household choice for waste management options. This also relates to question 19. I have conjectured that success of a primary collection arrangement such as Civic Exnora depends crucially on there being a good secondary collection system. This may be the reason why Civic Exnoras are absent in many peripheral areas (in 9 towns and rest of MMA). Households within Madras city may need a Civic Exnora where there is a good secondary collection but primary collection is weak. If households have other routes (for example, through social networks such as caste or community groups), through which they can contact local service providers and pressurise them to provide primary collection, then Civic Exnora type collective action may not be successful. This may probably be the reason why Civic Exnoras are absent in northern parts of Madras city. These are conjectures and need to be explored further.

(11) With regard to question 18, the welfare estimates indicate that there are some welfare gains from improving secondary collection and disposal. However, it appears that households are mainly concerned about primary collection. This

is understandable since benefits from improved primary collection are localised whereas improved secondary collection and disposal will have benefits for the entire metropolitan area whose local impacts may be fairly small in most locations. This issue needs further exploration.

9.3 Some Issues for Further Research :

In the various chapters, I have identified subject-specific issues requiring further research in relation to the models discussed therein. I will briefly re-capitulate some of these here.

One of the main limitations of my study has been the small sample size. Given the resources and time available to a PhD student, this was the best one could do. Ideally, one would like to explore choice situations discussed here with a larger sample than the one used in this study. A larger sample could have enriched the capability of some of the multi-nomial logit (MNL) and nested multi-nomial logit (NMNL) models to identify relationships. In spite of the small sample size, the analytical models discussed in the various chapters have given some insight into the choice processes. Also, as a study of consumer preferences for various attributes of water supply and sanitation in an Indian city, this study is an exploratory study. Studies such as Singh et al. (1993) are relevant but there was limited information on the various attributes. Hence, I could not use choice-based sampling methods. There is scope now for further research to build on the findings here in terms of expanding the way attributes are defined, and in terms of using the parameters here to develop choice-based sampling approaches.

My exploration to construct a water balance sheet for Madras, the first of its kind for any Indian city, indicates that such an exercise may be useful to understand which uses are getting how much water. I have also briefly discussed in chapter 5 the interaction of public sector policy and supply from private sector using a reaction function and whether consumers consider water supplied by public sector to be superior to water supplied from private sector. There is scope for further exploration of these issues. Also, my explorations here on extending Sen's entitlements approach to water supply and on exploring some hypotheses developed primarily in the case of rural common property resources to institutions such as Civic Exnoras, have scope for application elsewhere.

My results in the case of Civic Exnoras indicated a very weak relationship between co-operation and group size and an ambivalent result regarding the economies of scope (i.e., the impact of the number of services provided on co-operation from households). One important result from those explorations was the finding that where committee members work collectively, a high degree of co-operation from households is likely to occur. In these explorations too, my sample size (of 16 Civic Exnoras) was limited. There is scope to explore these issues with a larger sample. There is also a need to explore the interaction of local government and Civic Exnoras. Also, I have conjectured that citizens are more likely to form organisations such as Civic Exnoras under two conditions : one, is that there is a good secondary collection of wastes but primary collection is poor; and second is that citizens do not have other forms of access to local government, such as caste or community networks. My feeling was that the former may explain why there are few Civic Exnoras in the peripheral towns and the latter may explain why there are few Civic Exnoras in the wards in North Madras. There is need to explore this conjecture.

I have briefly referred in chapter two to Paul's studies and his use of exit-voice framework. While that framework is not directly relevant to water and waste management, from my analysis of water and waste management, it appears that there is some scope for exploring how local government services are delivered. Paul used the degree of market failure as a determinant of when exit or voice will be chosen by citizens. I feel that property rights may be a better variable rather than the degree of market failure. Where the good or service in question is such that entitlements and property rights are important, my conjecture is that there will be little collective action. On the other hand, where a good or service is such that property rights are less important or they are incomplete or inadequately defined, then collective action may be an important way to secure the provision.

Now, I would like to identify some generic issues for further research. The analysis in this thesis was based on the micro-economic model of consumer behaviour and its extension in terms of the random utility maximisation. As discussed in chapter 2, this rather fragile and elaborate model is built on various assumptions about (a) who makes the decisions (the consumer); (b) the aim of the decision (increasing utility to reflect desire fulfilment or happiness); (c) the nature of preferences; and (d) how the researcher/analyst obtains information on these. In that chapter, some criticisms of this model and the suggested alternatives were also considered. In this light, issues for future research can be identified in the form of a tree as shown in figure 9.1. Items in the last row in this figure are not exhaustive but shown as examples.

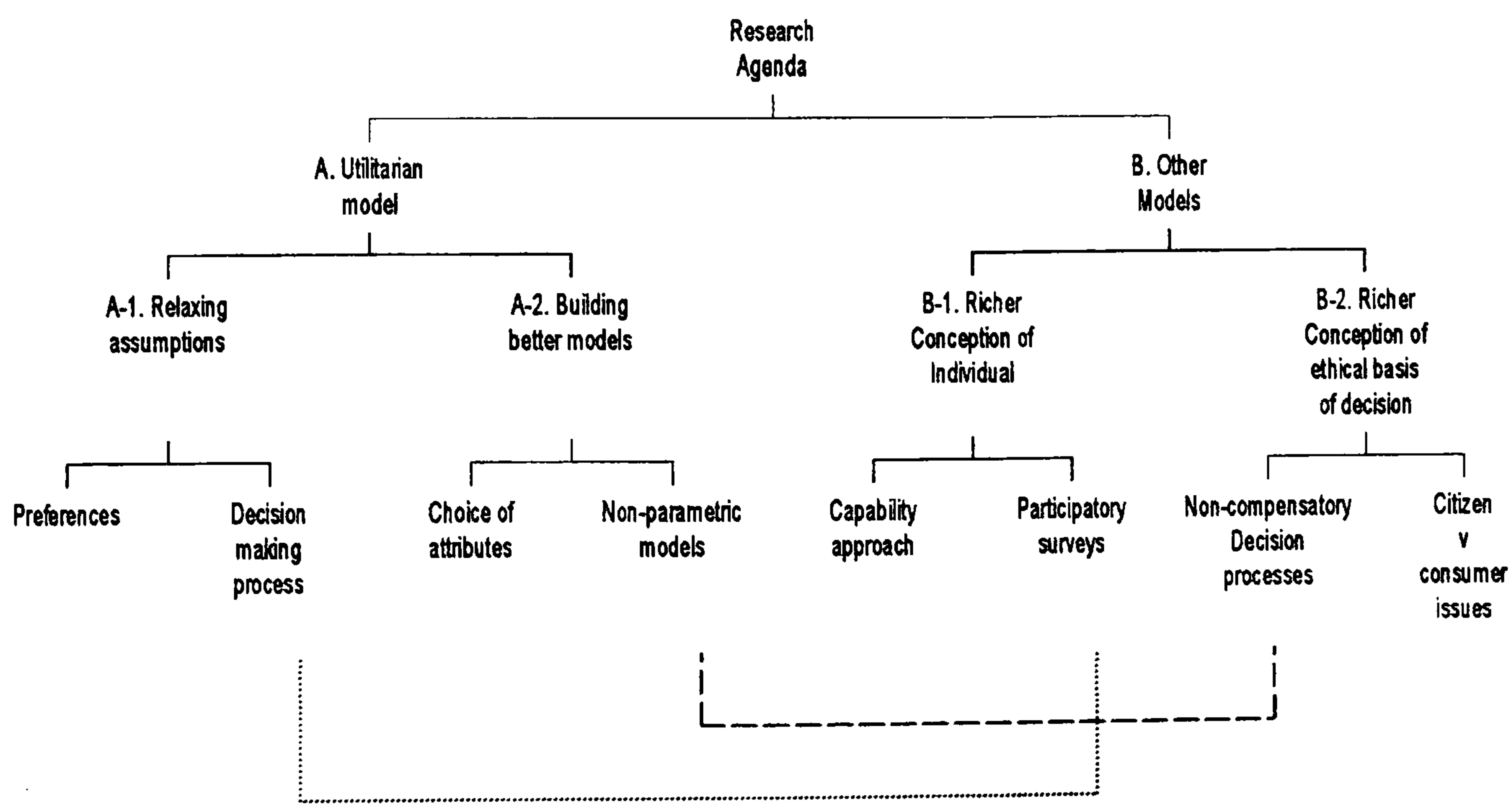

Figure 9.1: Some topics in a research agenda.

A. Research issues using the Utilitarian model

In this side of the research agenda, one continues to use the utility maximising rational agent as the centre of analysis. However, extensions may be identified in terms of relaxing specific types of assumptions such as preferences being incomplete or intransitive and checking whether one can still adequately explain consumer behaviour in spite of this violation. There is also scope for conducting split-sample experiments to compare a standard CVM with the choice models.

Similarly, assumptions regarding the decision making process can be relaxed. As already mentioned, in the field of marketing research, the conception of consumer is very similar to that of micro-economic model but the conception of decision making process is more detailed. There is some scope for further research with regard to the decision making process. For example, in the Whittington et al.,(1992) study participants were given some time to think. There is scope to explore the role of the following with regard to decision making by consumers: (a) information from local newspapers on water and waste collection services; (b) whether these affect their opinions about the service providers; (c) whether general (ideological) preferences about certain institutions affect decisions about services provided them; (d) decisions of neighbours (or other relevant households or local leaders) affect decisions by individual consumers.

With regard to improving the models, there is scope to explore the attributes and whether a richer description of attributes helps us to understand consumer preferences better. I would think that there is scope to explore a large number of related attributes and perhaps use factor analysis to see if groups of attributes are considered in bunches by respondents. As already mentioned, there is scope to explore choice-based sampling methods using information from this thesis about the parameters. In discussions on discrete choice models, there is also a suggestion to use non-parametric regression models. This is another area for exploration.

B. Research issues using other models

There is scope for exploring preferences for water and sanitation with a richer conception of the individual, as for example contained in Sen's capability approach. The issues of water and sanitation should then be seen in the larger frame of individual freedoms in cities such as Madras and the quality of life, rather than from the point of view of commodities. Operationalising capability approach for water and sanitation in particular, but for quality of living in cities in general, is a topic for further research. How can we define functionings with respect to quality of life in cities such as Madras? Are water and sanitation commodities affecting other functionings or are they part of what Sen calls 'basic capabilities'? What kind of distribution rules need to be considered (other than 'capability equality')? What are the implications for understanding urban poverty? My exploration in this thesis of using entitlements approach for water supply indicates that there is scope for further enquiry in this direction further.

Another potential topic for exploration (not shown in the figure) is on the lines suggested by McFadden (1999), to evolve the concept of person in economic models from the 'Chicago man' to a richer behavioural model, that McFadden calls as the K-T man following Kahneman and Tversky. As discussed in chapter 2, such a richer model would need to understand attitudes as well as preferences and be open to the idea that preferences can change based on the decision (and feedback).

I have included another area with some potential for exploration in this branch. I would like to call these 'participatory surveys' – to combine the two positive elements of sample surveys and participatory methods. This would involve two steps. In step 1, using the principles of sampling design, one can identify specific clusters of houses or neighbourhoods to be sampled. In step 2, all the households in the identified cluster may be consulted using participatory methods just as these were applied in villages. (This may not be novel but I have not seen any studies using this approach.). The main issue is that if the decision-making unit is a neighbourhood community and not an individual consumer (or a household), then micro-economic models cannot be applied. To overcome this, we may introduce a third step where a sample of respondents from this neighbourhood will be interviewed after participatory discussion has taken place in step 2. (Hence, the dotted line connecting decision making process under the utilitarian model and the participatory surveys).

Another line of enquiry is to explore the philosophical basis of consumer decision making. There is scope for exploring attitudes and values and how these affect decisions concerning social/public goods such as water and sanitation. Issues of non-compensatory decision process may be highly relevant here. There is also scope for exploring citizen-consumer model suggested by Sagoff. Some work has been reported on using a "citizens' jury" to determine environmental policy. There is scope to explore this in relation to 'participatory surveys' mentioned above.

Appendix 1

A Short Summary of
Micro Economic Model of Consumer Behaviour

This Appendix summarises the consumer behaviour in micro-economic theory, well discussed in the literature (Varian, 1996; Dobson et al., 1995; Braden and Kolstad, 1991; Johansson, 1987; Katz and Rosen, 1998). I will mainly follow Johansson, 1987.

a. Commodity bundles:

As mentioned earlier, at the centre of the economic model of consumer behaviour is *a consumer choosing the best things that she can afford* (Varian, 1996 : 33 : italics mine). Such a consumer would choose various goods and services within the budget constraint. A commodity bundle is a complete set of the various goods and services that the consumer can buy (acquire). Such a commodity bundle can be shown as :

$$\mathbf{x} = \{x_1, x_2, x_3 \ldots x_n\}$$

where x_1, x_2, etc., are the quantities of each of the goods and services. These are assumed to be nonnegative continuous variables.

The consumer evaluates alternative sets of commodity bundles and chooses that bundle which provides the highest level of satisfaction.

b. Preferences of the consumer:

In this process, various assumptions are made about the preferences of such a consumer[1] :

a. Preferences are complete - that any two bundles can be compared. Thus, if there are two bundles **x** containing (x_1, x_2, $x_3 \ldots x_n$) and **y** containing (y_1, y_2, $y_3 \ldots y_n$), the consumer is able to tell us whether **xRy** (i.e., **x** is preferred to **y**); or **yRx** or whether the consumer is indifferent between the two bundles.
b. Preferences are reflexive – any commodity bundle as is as good as itself.
c. Preferences are transitive – that is if a consumer thinks that **xRy** and **yRz**, then **xRz**.

Varian (1996 :35-36) points out that except in extreme situations (which lie outside the domain of economic analysis), the axiom of completeness is hardly objectionable. He adds that "..it isn't clear that transitivity of preferences is *necessarily* a property that preferences would have to have". He points out it is not compelling on grounds of pure logic alone and that it is more of a hypothesis about people's behaviour.

c. Comparing two bundles :

Given the resources available at her disposal (say, income m), the consumer has to choose between bundles **x** and **y** (which differ in the quantitites of the n commodites). If each of the n commodities have prices { p_1, p_2, $p_3 \ldots p_n$ }or **p**, the consumer considers only those commodity bundles that are attainable within her budget:

$\mathbf{x}.\mathbf{p} \leq m$

$\mathbf{y}.\mathbf{p} \leq m$

[1] These assumptions are also referred to as those of rational behaviour by consumer. See Boadway and Bruce, 1984.

Then she compares the two bundles and chooses that bundle which gives the highest level of satisfaction. In micro-economic analysis, the satisfaction derived by consumer from the consumption of commodities is referred to as utility (Dobson et al., 1995:14). Utility from consuming commodity bundle (x_1, x_2, $x_3 \ldots x_n$) can be expressed as a real-valued utility function $U(x_1, x_2, x_3 \ldots x_n)$ or $U(\mathbf{x})$.

d. Cardinal and Ordinal Utility :

Theories based on measuring the magnitude of utility i.e, cardinal utility, presume that the consumer converts the satisfaction received from each of the goods into a quantity of utility and compares two commodity bundles or 'states of being' on the basis of the total magnitude of utility in each state. In the ordinal utility approach, utility is only an index that captures the relative rankings of the commodity bundles or states of being. All one needs to know is whether one commodity bundle is considered superior to another rather than by how much. Modern micro-economic theory deals predominantly with ordinal utility functions.

e. Properties of Utility function :

A well-behaved utility function is assumed to have various properties: (a) if $\mathbf{x}R\mathbf{y}$, then $U(\mathbf{x}) > U(\mathbf{y})$; (b) utility is non-decreasing in any commodity and increasing in at least one (non-satiation assumption); (c) the marginal rate of substitution between any two goods being compared is decreasing[2] (strict quasi-concavity assumption); (d) the utility function generates at least twice differentiable demand functions (on a set of strictly positive prices and income).

[2] MRS - the slope of indifference curve – tells us about the consumer's relative preferences for the two given commodities. For strictly convex indifference curves, MRS decreases as the quantity of one good is increased exhibiting the property of diminishing marginal rate of substitution. Varian (1996: 52) summarises this : "...the more you have of one good, the more willing you are to give some of it up in exchange for the other".

f. Ordinary DemandFunctions:

In this background, the consumer's objective is to choose that bundle which is ranked superior to other bundles, given the budget constraint, (i.e., which has the maximum value of the real valued index - the utility function). The commodity bundle representing this situation, is the optimal bundle – or the bundle demanded by the consumer, given her income and prices of the various commodities. The planner or researcher cannot observe the utility functions. However, by observing the choice made by the consumer, the planner or researcher deduces information about (revealed) preferences[3]. By observing these, the researcher can construct a demand function – "..the function that relates the optimal choice – quantitites demanded to the different values of prices and incomes" (Varian, 1996 : 78).

This can be expressed as :

$$\left.\begin{array}{l} \max U(\mathbf{x}) \\ \text{such that } m - \mathbf{px} = 0 \\ \text{where } \mathbf{x} = \{ x_1, x_2, x_3 \ldots x_n \};\ \mathbf{p} = \{ p_1, p_2, p_3 \ldots p_n \} \text{ and } \mathbf{p}>0;\ m>0. \end{array}\right\} \qquad \text{A1.1}$$

Following Johansson (1987), the first order conditions are :

$$\frac{\partial U(\mathbf{x})}{\partial \mathbf{x}} - \lambda\, \mathbf{p} = 0 \qquad \text{A1.2}$$

$$m - \mathbf{px} = 0 \qquad \text{A1.3}$$

[3] The axioms of revealed preference relate revealed preferences to the underlying preferences. The weak axiom states that if commodity bundle (x) is directly revealed preferred to bundle (y), then it cannot happen that (y) is directly revealed preferred to x. The strong axiom covers both direct and indirect revealed preference. The direct revealed preference is when the consumer compares two bundles, say x and y. Suppose, we observe that x is revealed preferred to y; we also observe that y is revealed preferred to z. Then, from transitivity, we can deduce that x must be revealed preferred to z. This is the indirect revealed preference. See Varian: 1996 : 124-128.

where λ is the Lagrange multiplier of the budget constraint. These can be solved for the n unknown variables ($x_1, x_2, x_3 \ldots x_n$) and λ in terms of prices and income :

$$\mathbf{x}^* = \mathbf{x}(\mathbf{p},m) = [x_1(\mathbf{p},m), x_2(\mathbf{p},m), x_3(\mathbf{p},m) \ldots x_n(\mathbf{p},m)] \qquad \text{A1.4}$$

The above equation gives us the quantities of various goods, given the prices and income (also known as ordinary or Marshallian or uncompensated demand function).

Johansson (p.13) notes some of the properties of these demand functions : (a) demand for any commodity is a single valued function of prices and income; (b) demand functions are homogenoeous of degree zero in prices and income : this implies that if all prices and income change in the same proportion, there is no change in the quantities demanded.

Here demand is uncompensated because, "...as prices change, income is not adjusted to compensate for the resulting change in utility" (Kolstad and Braden, 1991 : 19). Substituting the demand functions into the (direct) utility function, gives us the indirect utility function that gives us the highest level of utility obtainable by the consumer given prices **p** and income m :

$$U(\mathbf{x}(\mathbf{p},m)) = V(\mathbf{p},m) \qquad \text{A1.5}$$

Johansson (p.14) points out that because of the assumptions made about the properties of the direct utility function and demand functions, the indirect utility function will have the following properties : (a) it is continuous; (b) strictly quasi-convex; (c) homogeneous of degree zero in prices and income; (d) decreasing in prices; (e) increasing in income; and (f) thrice continuously differentiable. Differentiating the indirect utility function V with respect to price of commodity i, Johansson (p.14-15) derives the following result :

$$\frac{\partial V}{\partial p_i} = - \lambda x_i(\mathbf{p}, m) < 0 \text{ for all } i \qquad \text{A1.6}$$

indicating that "...the partial derivatives of indirect utility function with respect to prices are the demand functions" (multiplied by $-\lambda$). Further, the derivative of the indirect utility function with respect to income is nothing but the Lagrange multiplier of the budget constraint :

$$\frac{\partial V}{\partial m} = \lambda(\mathbf{p}, m) \qquad \text{A1.7}$$

Johansson points out that because of this result, λ is also referred to as the marginal utility of income[4].

g. Compensated demand functions:

An alternative way to summarise the consumer's decision making problem is to approach it from expenditure functions. Following Johansson, given a utility level $\bar{U}$ that can be attained by our consumer, the decision is to choose such commodity bundle as to minimise the expenditure :

$$e(\mathbf{p}, \bar{U}) \quad = \min \ \{(\mathbf{p}.\mathbf{x}) \text{ such that } U(\mathbf{x}) \geq \bar{U}\} \qquad \text{A1.8}$$

Because of the assumptions made about the utility function, Johansson summarises the properties of the expenditure function : (a) jointly continuous in U and **p**; (b) concave in prices; (c) positively homogeneous in prices and linear; (d) increasing in prices and U; and (e) thrice continuously differentiable. The partial derivatives of the expenditure function with respect to prices are known as compensated or Hicksian demand functions as "...they tell us how demand is affected by prices

[4] Johansson discusses some important properties of λ: using the assumption that demand functions for commodities must be homogeneous of degree zero in prices and income, he derives the result that λ is homogeneous of degree minus one in prices and income: that is if income and prices increase π times, then λ must decrease π times.

when income is adjusted in such a way as to leave utility unchanged". Kolstad and Braden (1991 : 20) point out : "ordinary demand functions have the disadvantage that price and income effects are bundled together; therefore, the effect of a price change as reflected by an ordinary demand function will involve price and income effects. Compensated demand functions do not have this problem because they focus on price effects alone."

Given prices and income, both utility maximisation[5] and expenditure minimisation should result in the same optimum commodity bundle $\mathbf{x}^{\sim}$.

$$m = \mathbf{px}(\mathbf{p},m) = \mathbf{px}^{\sim}(\mathbf{p}, \bar{U}) = e\,(\mathbf{p}, \bar{U}) \qquad \text{A1.9}$$

We can use the above to substitute $e\,(\mathbf{p}, \bar{U})$ for m in the ordinary demand function for a commodity i :

$$x_i^{\sim} = x_i(\mathbf{p}, m) = x_i(\mathbf{p}, e\,(\mathbf{p}, \bar{U})) \qquad \text{A1.10}$$

Differentiating this with respect to price of commodity j gives us the Slutsky condition[6] :

$$\frac{\partial x_i^{\sim}}{\partial p_j} = \frac{\partial x_i}{\partial p_j} + \frac{\partial x_i(p^*, m^*)}{\partial m} * \frac{\partial e\,(p^*, \bar{U})}{\partial p_j}$$

$$= \frac{\partial x_i}{\partial p_j} + \frac{\partial x_i(p^*, m^*)}{\partial m} * x_j^{\sim} \qquad \text{A1.11}$$

[5] An assumption made in these approaches is that all income is used for acquiring the commodity bundle.

[6] Kolstad and Braden, 1991: 22 discuss Hausman's approach to compute a compensated demand function directly from the ordinary demand function – which, they note, requires solving partial differential equations but also that demand must satisfy Slutsky conditions.

The first term (in the second line) is the change in ordinary demand for commodity i due to change in price of commodity j (substitution effect); the second term is the income effect.

Johansson (1987:23) suggests that to evaluate the impact of a small change in prices and/or income on utility, equations 2.5 and 2.6 can be used. He shows that totally differentiating an indirect utility function gives us the following result :

$$dV = \sum_{i=1}^{n} \frac{\partial V}{\partial p_i} dp_i + \frac{\partial V}{\partial y} dy$$

$$= -\lambda \sum x_i \, dp_i + \lambda \, dy$$

$$= -\lambda \, [\, \mathbf{x} d\mathbf{p} - dy] \qquad \text{A1.12}$$

Johansson points out that this result is a type of a marginal cost-benefit rule, where the changes are assumed to be so small that the marginal utility of income remains constant. He extends the above to the case of a discrete change in prices from $\mathbf{p}^0$ to $\mathbf{p}^1$ and of income from m^0 to m^1 as a line integral :

$$\Delta U = V(\mathbf{p}^1, m^1) - V(\mathbf{p}^0, m^0)$$

$$= \int_c \left(\sum_{i=1}^{n} V_i dp_i + V_m \, dm \right)$$

$$= -\int_c \lambda(\mathbf{p},m) \, [\, \mathbf{x}(\mathbf{p},m) d\mathbf{p} - dm] \qquad \text{A1.13}$$

Johansson points out that :(a) the first term within brackets in the last line corresponds to areas under uncompensated demand curves for a change in prices from $\mathbf{p}^0$ to $\mathbf{p}^1$ and that the second term in the brackets represents a change in income; (b) the marginal utility of income is there to convert these monetary changes into changes in utility; (c) evaluation of the above integral depends on path c; (d) since marginal utility of income information is unavailable to economists, welfare change is evaluated in monetary terms (S), eliminating λ from the expression;

$$S \quad = - \int_c [\, \mathbf{x}(\mathbf{p},m)d\mathbf{p} - dm] = m^1 - m^0 - \int_c [\, \mathbf{x}(\mathbf{p},m)d\mathbf{p}] \qquad \text{A1.14}$$

(e) this money measure is path independent if and only if :

$$\frac{\partial x_i}{\partial p_j} = \frac{\partial x_j}{\partial p_i} \qquad \text{for all i, j (i.e., cross-price effects are symmetric)}$$

$$\frac{\partial x_i}{\partial m} = \frac{\partial (1)}{\partial p_i} = 0 \qquad \text{for all i, j (zero income effects for all goods)}$$

After considering various issues relating to the above conditions, he points out that the above path independence conditions cannot hold simultaneously. At best, one can assume zero income effects for n-1 goods, implying a vertical income-consumption path (and hence a quasi-linear utility function). He points out "if only a subset of prices and /or income is changed, the constancy condition can be weakened. Hence, the only condition is that λ is independent of the prices (income) which are changed.".

He notes that if path independence conditions hold, a unique measure of consumer surplus (S) exists; however, if those conditions do not hold, a path may exist such that surplus measure is negative even when there is positive change in utility level. Because of these deficiencies, compensating and equivalent variation are preferred to money measures based on ordinary demand functions.

h. Compensated variation and Equivalent variation measures:

Compensating variation (CV) in income with a change in prices from $\mathbf{p}^0$ to $\mathbf{p}^1$ and of income from m^0 to m^1 is defined as :

$$CV = m^1 - m^0 + e(\mathbf{p}^0, U^0) - e(\mathbf{p}^1, U^0)$$

$$= \Delta m - \int_c [\, \mathbf{x}^{\sim}(\mathbf{p}, U^0) d\mathbf{p}] \qquad \text{A1.15}$$

where c is a path between the initial and final price-income vectors. Johansson approaches this in two steps: first income is assumed to change from m^0 to m^1 while prices remain fixed at $\mathbf{p}^0$. The part of CV to keep the consumer at the initial utility level equals the actual change in income Δm (since e $(\mathbf{p}^0, U^0)$ and e $(\mathbf{p}^1, U^0)$ are the same because prices have not changed; they cancel out). The next step is to consider the effect of prices changing from $\mathbf{p}^0$ to $\mathbf{p}^1$ with income fixed at m^0:

$$CV = e(\mathbf{p}^0, U^0) - e(\mathbf{p}^1, U^0) = - \int_c [\, \mathbf{x}^{\sim}(\mathbf{p}, U^0) d\mathbf{p}] \qquad \text{A1.16}$$

which indicates the difference between two expenditures: the minimal expenditure necessary to reach the utility level U^0 when prices are $\mathbf{p}^0$ and that required to reach the same utility level when prices have changed to $\mathbf{p}^1$. Johansson notes that this equation "...gives the sum of areas to the left of the compensated demand curves between $\mathbf{p}^0$ and $\mathbf{p}^1$".

Similarly, EV measure can be evaluated at utility level U^1 but at initial prices $\mathbf{p}^1$.

The advantage of these measures is that the path independence conditions hold for these unlike in case of surplus measures from ordinary demand curves.

i. Comparing S, CV and EV:

Johansson (1987: 41-46) considers the question whether any of the three measures (consumer surplus measure S from ordinary demand curves; measures CV and EV from compensated demand curves) rank commodity bundles correctly. He points out that if the utility function is quasi-linear (and hence, demand for n-1 goods is not affected by income; all the additional income is spent on the n-th good), then the three surplus measures coincide. He adds, if only a restricted number of prices are changed, the three measures coincide, provided, the demand for the goods whose prices change is independent of income. However, if the goods are such that income elasticities are not zero, for a given utility change, the three measures will be different. He points out that : (a) if income is fixed and utility function is homothetic, then ordinary surplus measure S ranks any number of commodity bundles correctly; (b) CV and EV measures rank bundles correctly, only when two bundles (relating to the initial and final price-income vectors) are considered; (c) in case of more than two bundles (i.e., relating to $\mathbf{p}^0$, $\mathbf{p}^1$ and now a $\mathbf{p}^2$), he points out that EV still ranks them correctly as EV measure uses initial prices ($\mathbf{p}^0$) as reference; CV measure evaluates changes at final prices and in case of three commodity bundles, there is scope that CV measure "may wrongly tell us that one change is preferred to the other". However, Johansson points out that neither measure can be considered to be strictly superior to the other and that as long as one final bundle is to be evaluated in relation to two or more initial bundles, both measures rank the bundles similarly.

Appendix 2

V. RAJAGOPAL, B.E., MIE, DIP in M.M.
SENIOR MANAGER (MATERIALS)

Phone : Off. : 8524388
Extn. : 2 2 5
Res. : 4936429

Madras Metropolitan Water Suppl
and Sewerage Board
No. 1, PUMPING STATION ROAD,
MADRAS-600 002.

Chennai-28
21.4.97

P.B.ANAND
DEPARTMENT OF ECONOMICS,UNIVERSITY OF STRATHCLYDE
ØØCATHEDRAL STREET
GLASGOW G4 OLN UK

Sir,

Sub: Metrowater - Information to be given - Reg.

Ref: Your fax dated 26th March 1997

****

Further to your fax under reference cited, it is to be informed as a policy Metrowater is not in a position to divulge any information required by you for studies.

O.S.D.

Appendix 3

Questionnaire Used in
Household survey in Madras
June-September 1996

1.1 Introduction , purpose of the survey, how long it may take, what kind of information needed.

1.2 Start details :

Date : Original/Substitute

Interviewed whom : Head of Household / Home maker / Other — Male / Female

Time at start : Time at completion :

(These following details asked at the end of the interview)
Name of respondent :
Name of head of household :
House number :
Street :
Area :
Post code :
What is the ward number in which this house is located? ________________
What is the zone number? ________________

2. Rating of various local services in Madras :

2.1 Rating of various civic amenities and services : Considering the quality of life in Madras as whole (and not just your own neighbourhood), please rate the following services on a scale of 1 to 5 :

1 Very bad
2 Bad
3 Moderate
4 Good
5 Very good

		1	2	3	4	5	DK
1	Road traffic and roads						
2	Suburban train services						
3	Passenger bus transport						
4	River Cooum, River Adyar and waterways						
5	Storm drainage						
6	Sewerage						
7	Water supply						
8	Waste collection service						
9	Madras beach						
10	Fire service						
11	Electricity supply						
12	Mosquito control						
13	Tree plantation						
14	Telephones						

3. Water supply :

3.1 If you were asked to represent all people in Madras, what will you say about your satisfaction about water supply in Madras?

5/4/3/2/1

3.2 How satisfied are you with water supply situation for you ?

5/4/3/2/1

3.3 During the past twenty years Madras city has been facing water shortages in some years. What according to you is the main reason for this ?

a. Lack of adequate rains
b. Wastage and leakage in distribution system
c. Population increase
d. Illegal construction activity
e. Sinking of tubewells by everyone.
f. Lack of proper planning
g. Other : ______________________________

(Note : This was asked as an open ended question. However, from pretests, the following responses were identified as most likely responses. These were not read out to the respondent but if respondent's description matched any of these, it was circled.)

3.4 Tell me about the sources of water for the following purposes:

	Drinking	Bathing	Washing clothes	Washing utensils	All other uses
Metro Water					
Well					
Tubewell					
Tank					
Buying from a vendor					
Other					

Metro Water : Within the premises ? Yes /No
If yes, is it : tap or handpump ?

If outside the house : is it from :
A tap / handpump / Steel tank

Well/Tubewell :
1 Within the premises
2 Outside - but private
3 Outside - Public

Depth of water table from ground level :

____

3.5 How satisfied are you with the quantity of water available to you now?
5/4/3/2/1

3.6 How do you describe the taste of the water you drink ?
5/4/3/2/1

3.7 How do you rate the quality of the water you use for purposes other than drinking?
5/4/3/2/1

3.8 Presenting options :

Options are described as per attributes.

	IH1	IH2	PP	OH1	OH2	TS	ENV
Option 1							
Option 2							
Option 3							
Option 4							

For the options that the respondent was given, the corresponding prices (monthly charges) are read out. For example, if a respondent was given IH1, TS and ENV options, the table would be like this :

	IH1	IH2	PP	OH1	OH2	TS	ENV
Option 1	110						
Option 2							180
Option 3						210	
Option 4							

Option chosen : ____________________

Note : The option to choose 'None of the above' was not specifically given. However, if a respondent said that they cannot choose any of the options, then it is noted as 'None'.

Reason/s for not choosing any option?

____
____
____
___

3.9 Do you use a water filter? Yes /No

If yes :
a. What type ? 1 cloth 2 candle 3 UV ray 4 Zero B system 5 other ______
b. Year purchased ? ____________________
c. How much did it cost you ? Rs ____________

3.10 Do you use any other means to improve the quality of water? Yes/No
If yes, please describe :

3.11 Do you boil water for any purpose? Yes/ No
If yes, purpose : ______________________________

What fuel is used when you boil water?
Gas/ Kerosene/Electricity/Fuel wood/ Any other __________

Time taken for boiling : ________minutes

3.12 Are you presently buying water ? Yes / No

If yes :

How frequently do you buy from vendors?
Cost Rs. ____________ How much quantity : ____________
How do you rate the quality of that water? 5/4/3/2/1

4. Solid Waste Management

4.1 On a scale of 1 to 5 signifying very bad, bad, moderate, good and very good, please tell me how you feel about the following :

a. Solid waste collection from your street	:	5/4/3/2/1
b. Solid waste collection in this neighbourhood	:	5/4/3/2/1
c. Solid waste collection in and around High Court area	:	5/4/3/2/1
d. Solid waste collection, on the whole in Madras	:	5/4/3/2/1

4.2 Do you know who is responsible for collecting wastes from streets?

____

4.3 Do you know what happens to these wastes that are collected?

a. they burn it
b. they throw it into the sea
c. they sell it to other industries
d. they dump it in low lying areas
e. Other ______________________________

4.4 Have you heard of EXNORA ? Yea/No
4.5 Can you describe what it is ?
Reasonably correct description ? Y /N
4.6 Are you a member of a Civic Exnora in this neighbourhood? Yes/No
4.7 If answered yes to question 4.6:

a. Name of Civic Exnora: ___________________________
b. Since when you have been a member : year ________ month ______
c. How much are you paying monthly ? Rs.____________
d. How satisfied are you with the Civic Exnora's waste collection? 5/4/3/2/1

4.8 If answered no to question 4.6 :
a. Are you, in general, interested in joining such a scheme? Yes/No
b. Do you feel there is any particular difficulty in forming such a scheme?

____

4.9 Presenting Waste management options :

Option descriptions are read out.

	Exnora only X	Exnora + Transport XT	Exnora + Transport + Disposal XTD	Zero Waste management ZERO
Option 1				
Option 2				
Option 3				
Option 4				

Option chosen : __________________
If none : reason/s for not choosing any option :

____
____
____
___

4.10 How frequently do you dispose of wastes from your house?
a. Once in two or three days
b. Once daily
c. As soon as there is some waste
d. When we see the waste collection cart

4.11 Do you sell:
a. Newspapers :
b. Bottles
c. Old /used/ unwanted clothes
d. Unwanted metal items

4.12 Who disposes of wastes from you household? ____________

4.13 Where do you usually dispose of ? ________________

Where is the bin located? __________

How often do you think the municipal waste collection vehicles clear the wastes? : Everyday / Alternate day / Twice a week / Once a week / DK

5. Housing and environmental services :

5.1 House tenure: Owner / renter / other ______________

5.2 If renting : monthly rent Rs.__________

5.3 If owner : Value when purchased : Rs__________ Year ___________

Current value? ________________

5.4 House type :

House type		Number of storeys	
01	Hutment	01	Ground
02	Improved hutment	02	G+1
03	Old type Madras terrace house	03	G+2
04	Apartment	04	G+3
05	Flat	05	G+4
06	Semi detached	06	G+5
07	Independent bungalow	07	G+6 to G+10
09	Any other :	09	Above10

5.5 Details of construction :

Wall material		Roof material		Floor material	
01	Mud	01	Thatch	01	Mud
02	Bamboo/reed	02	Bamboo/reed	02	Black tiles
03	Cloth	03	Cloth/Jute	03	Cement
04	AC/GC sheet	04	AC/GC sheet	04	Coloured cement
05	Brick	05	Tiles	05	Mosaic
06	Brick with cement	06	RCC	06	Spartek tiles
07	Stone	07	Madras terrace	07	Marble
08	RCC	08	Stone	08	Granite
09	Other	09	Other	09	Other

5.6 Is the house used for any economic activity? Yes/ No

If yes: details :______________________________

5.7 Number of rooms, kitchens. Bathrooms and toilets in the house:

	Rooms other than kitchens, bathrooms, toilets	Kitchens	Bathrooms	Bath cum WC	Toilets

5.8 Do you have a connection for electricity? Yes/No

5.9 Do you have the following:

a. Water plumbing Y/N
b. Overhead tank Y/N
c. A ground level sump/cistern Y/N

5.10 If toilet is present details :

Connected to sewerage / septic tank

Household Characteristics :

5.11 Total number of members in the household :

5.12 Adults _________ Children _______

5.13 Head of the household details

Age:________ M/F Mother tongue : _____________

5.14 Economically active? Yes/ No

5.15 If yes : details of occupation :

5.16 Are any other members of the household economically active?

If yes: details

5.17 Monthly income group

Monthly income in the range	Mean income for the class	Tick if appropriate
Up to 2,500	2,000	
2,501 to 3,500	3,000	
3,501 to 5,500	4,500	
5,501 to 10,500	8,000	
Above 10,500	20,000	

5.18 Do you read a news paper ? Yes/ No

Which one: ___________________ English/Tamil/ other

5.19 Do you have any of the following ?

	Y/ N
TV Black and White	
TV Colour	
Cable TV connection	
VCR	
Fridge	
Vacuum cleaner	
Fans	
Air conditioner	
Scooter/ Motor bike	
Car	

5.20. What do you do to control or minimise nuisance from mosquitoes in your house?

a. Nothing
b. Ceiling fan /Table fan
c. Mosquito nets
d. Chemical (insecticide) sprays
e. Mosquito repellent vapours : Banish/ Goodnight/ Jet

6. Feedback :

6.1 On the whole, do you have any comments about this interview?

____

____

____

6.2 Are there any issues you wanted to raise during the interview but postponed them as you were answering questions?

____

____

____

6.3 Did you feel that this interview ought to have covered any other issues relating to water supply and solid waste management? If so describe:

____

____

6.4 What next ? I will be analysing this information. I plan to present the summary of the information to the Metro Water Board, Corporation of Chennai, Exnora International etc. Of course, all the information given by each respondent will remain confidential. Only the summary details and statistical analysis will be given to such organisations. Do you have any other suggestions or comments for me ?

Appendix 4

Details of estimation of Water Balance Sheet for Madras

This is based on the information on households as per Census 1991, the water supply details from Chapter 5 of MMDA's Master Plan, Srinivasan's (1991) paper for the Madras 2011 Research Programme, my household survey, Asian Development Bank's survey of 50 water utilities in Asia (McIntosh and Yniguez,1997), and Madras Metropolitan Water Supply and Sewerage Board's annual report for 1994-95 and other data made available by Metro Water.

The estimation is for 1995-96 while the Census data is for 1991. During this time, the number of households should have increased (population growth rate in Madras City during 1981-91 has been about 12.81% for the decade or nearly 1.2 per cent per annum). However, in order to avoid complex calculations, the 1991 figures have been used without adjustment. The metered consumers' data relates to financial year 1994-95. The assumption is that the consumption pattern of non-residential users has not changed during 1991 and 1996.

In spite of these shortcomings, it is felt that the calculation is worth-while because (a) there is no better alternative, so far; and (b) while the number of households would have increased, the sources of supply have not significantly changed till September 29, 1996, when the first phase of Krishna Water Project was inaugurated providing an additional 200 MLD of water. However, the newspaper announcements at that time said that the total supply including Krishna water would be 440 MLD and after two years it will be increased by another 200 MLD.

The calculations are presented first for Madras city and then for the rest of MMA.

(a) Water consumption in Madras City

Source 1: Tap :

According to Metro Water data, 177,301 unmetered residential customers are connected to and are being provided water from the Metro Water's distribution system. The total water produced by Metro Water (as per Asian Development Bank, 1993), is 330,000 cum per day (i.e., 330 MLD). According to the MMDA's Master Plan, the figure is 383 MLD (excluding another 50 MLD produced by hand pumps and tubewells). But this includes industrial, commercial and other consumers as well. We can work backwards from water tariffs and the financial statement, how much water was consumed by industries, and other metered consumers. This is done in the table A4.1..

Table A4.1: Estimation of water supplied by Metro Water to non-residential metered customers in Madras : 1994-95

Metered Consumers	Income FY 1994-95 Rs. '000 s	Tariff Rs. per litre	Quantity consumed in the year in million litres (Income/Tariff)	Quantity per day in mld	Quantity per connec-tion/day (litres)
Industrial	336,814	0.025	13472.6	37.0	64,870
Public authorities	58,628	0.01	5862.8	16.1	22,094
Bulk consumers	72,445	0.02	3622.2	9.9	38,170
Commercial	15,965	0.01	1586.6	4.3	581
Non-residential	12,537	0.01	1253.7	3.4	1,470
Total (metered)	496,389			70.7	

Source : Annual report of Metro Water : 1994-95 and Water Supply charges

These figures are from Schedule H to the Income and Expenditure Statement. The figures of quantity per connection are estimated by dividing the quantity per day in column 5 of the table with the number of consumers in each category.

According to this table, total quantum of supply to metered consumers is 70.7 MLD. This is rounded off to 71 MLD.

Therefore, the unmetered portion of Metro Water's supply is about 312 MLD (i.e., 383 minus 70.7). Of this 383 MLD, about 10 MLD are supplied to static tanks.

Unaccounted for water: We have no details on the losses and leakages. According to a survey of 38 water utilities in the Asia Pacific Region, unaccounted for water averaged at around 36 per cent, while in case of Bombay and Delhi, the figure was close to 30 per cent. Using this figure, for a total production of 383 MLD in Madras, unaccounted for water could be about 115 MLD. (This works out to 37% of 312 MLD).

According to the Metro Water, among the unmetered connections, there were 25,253 commercial connections; 1,162 industrial connections, 5,751 domestic non-residential connections and 1,811 connections falling under 'public authorities'. If we assume that the consumption pattern among various categories of users is same across metered and unmetered segments, then we can use the mean quantity per connection per day arrived at in the last column of table A4.1 above to work out the water consumed by these unmetered consumers. This works out to : 139 MLD. (Of this, the unaccounted portion would be 37% i.e., 53 MLD. Net consumption is 86 MLD.)

Table A4.2: Unmetered, non-residential sector consumption.

		Quantity litres/connection/day	Quantity MLD	Adjusted quantity MLD
Commercial	25,253	581	15	9
Industrial	1,162	64,870	76	47
Public authorities	1,811	22,094	40	25
Domestic Non-residential	5,751	1,470	8	5
TOTAL			**139**	**86**

The total quantum of water supplied for non-residential uses is (70.7 + 139) i.e. 210 MLD. Another 10 MLD of this is used for supplying to static tanks (see the section on 'other sources' below). That leaves about 163 MLD for both public fountains and unmetered domestic residential customers. Of this, unaccounted portion would be 62 MLD, i.e., gross supply to residential use will be 101 MLD. Of this, 4 MLD is supplied to public fountains; residential use is 97 MLD.

There were 7,879 public fountains and 177,301 residential connections. This works out approximately about 880 litres per connection (without taking into account the unaccounted for water).

According to the Census table, the number of households using in-house connection is 205,765 or approximately 1.16 households per connection. If we use the average household size of 5 persons, this is 5.80 persons per connection and average water consumption of 152 litres per capita per day. After adjusting for losses, this works out to 94 lpcd. According to the Census again, there were 129,360 households getting water from a tap outside their house. If we presume that they were collecting water from the 7,879 public fountains, that works out to approximately 16 households per fountain or nearly 80 persons per fountain. If we use the 880 litres per connection, that works out to just 11 litres per person. This is the figure reported in the last row of table 5.5 in chapter 5.

Source 2 : Shallow wells.

125,775 households reported that they have a well within their premises. But according to a recent report on malaria, by the Corporation of Madras, submitted to The World Bank, the number of wells within the City is placed at 95,023, or 1.3 households per well. It is not uncommon for many houses to have more than one household (i.e. subdivision of the house). According to the MMDA Master Plan, the yield from this source is 10 MLD (used in water balance sheet). That gives a consumption of approximately 16 litres per capita per day. I am sceptical of this figure and feel that it is a low estimate but in the absence of any other source, this has to be used.

It needs to be mentioned here that according to the Census table, 40,760 households reported to be drawing water from a well outside their premises. Since, there are no wells provided by the public system, they must be drawing water from neighbour's wells. Therefore, the ratio of number of families per well worked out above should be adjusted as : (125,775 + 40 760 households) using 95,023 wells or, 1.75 households per well and about 12 lpcd from this source (reported in table 5.5).

Source 3 : Tubewells :

The Metro Water have installed 1,884 tubewell pumps and 7,141 India Mark II Pumps. The number of households reporting tubewell or handpump as their source (but not having the source within their premises) is 79,925. That works out approximately 8 families per one tubewell or pump. According to the MMDA Master Plan, the yield of this source is about 50 MLD. That works out to approximately 5,500 litres per hand pump or tube well per day or 125 litres per capita per day (the figure reported in table 5.5).

With regard to the 126,040 households reporting a hand pump within their premises, the estimation is slightly difficult. However, an attempt can be made using two alternatives. If we use the same 125 lpcd figure for these households as well, then the quantum of water used is 79 MLD (125 * 126,040 households* 5 members per household). This is the figure used in the water balance sheet.

According to a UNICEF study (Thomas et al., 1996), in entire Madras Basin (which is about 4,000 square kilometres in area), there were 36,706 tubewells working on electricity. If their density of distribution were to be uniform, that works out to about 9 tubewells per square km or nearly 1,550 tubewells for the 172 square kilometres of Madras City. That gives a figure of nearly 82 households per tubewell. If each such tubewell yields the same amount as a Metro Water's tubewells i.e. 5,500 litres per day, the consumption works out to 9 MLD or about 16 litres per capita per day. This may be treated as a very low estimate for two reasons : (a) the density of tubewells distribution per square km (sqkm) is fraught with danger as the number of tubewells in city centre areas (where shallow wells are often dry) is likely to be much higher per sqkm; (b) the ratio of 82 households per tubewell is fairly high. Many flat complexes have about 40 households and have a tubewell; (c) once a tubewell is installed, the marginal cost of pumping is more or less constant (in proportion to electricity tariffs) and hence unlike in case of handpumps, there is no incentive to stop at 16 litres per capita per day. Because of these reasons, the former estimate of 79 MLD may be favoured.

Source 4 : Others

According to Census 1991, the source of water for the fourth largest group is 'other' than tap or well or tubewell. Of these, 44,390 households were drawing from a source outside their premises. These can be assumed to be the households drawing water from the static water tanks provided by the Metro Water. These tanks filled once or twice a day by mobile tanker trucks operated by Metro Water. According to Metro Water, there are 3,396 such static tanks, i.e., approximately one for 13 households. Again, using the 5 persons per household assumption, and assuming that each tank is filled to its capacity which is about 3,000 litres, the consumption of this group works out to about 46 litres per capita per day. These static tanks are filled by 160 water tankers each of capacity 10,000 litres. Each tanker makes at least 5 to 6 trips a day. That makes about 8 to 10 MLD by this source. But, if we assume that the 8,195 households who reported 'other' as source of water within their premises in 1991 Census are actually households who are supplied by vendors bringing water to their house from these static tanks, then the per capita figure falls to about 38 litres per capita per day (the figure reported in table 5.5).

Source 5 : Private Tankers :

During the Madras survey I interviewed some of the private water tanker operators. On the basis of these interviews, the total number of tanker trucks operating in MMA is estimated to be about 150. Also, from various discussions, it was noted that to break even the costs, they have to operate at least five trips per day, though many of them admitted to have been making even 8 to 10 trips per day. A majority of the private tankers are of 12,000 litres capacity. If each one is making 5 trips per day, that works out to a total of (5*12,000litres*150 trucks) about 9 MLD. After taking into account losses, I have used a figure of 8 MLD in the water balance sheet. Many of them are drawing from Southern Coastal Aquifer but also from the eastern fringes of the metropolitan area such as Ayyapakam, Poonamallee, etc. The tanker operators mention that a majority of their clients were industries, hotels, hospitals. The price per tanker varies but in August 1996 it was about Rs 350 per tanker.

Source 6 : Mineral water :

There are numerous mineral water producers in Madras and this is considered as one of the sectors attracting private investment. There are at least 19 different brands though two of them are market leaders. I had interviewed the second largest mineral water producer in Madras. According to them, the total sales of mineral water (or treated water) distributed in 10 or 12 litre jerry cans is estimated to be about 3.5 million litres per month or 0.11 MLD.

(b) Estimation of Water Consumption in Rest of MUA

Source 1: Tap

Of the 247or so human settlements falling within the Madras Metropolitan Area, only 9 urban settlements have some form of water supply by piped network. According to Srinivasan,1991, the total quantum of supply through this system is about 32 MLD (about 26 MLD from Palar river and 6 MLD from local borewells elsewhere). These are the figures used in water balance sheet.

As per the Census Table, 26,925 households in Rest of MUA reported having tap as a source within their premises; another 44,525 households depended on a tap outside their premises, a total of 71,450 households. Using the average household size of 5 members, the 32 MLD of water results in about 90 lpcd.

Other sources : Wells, tubewells, others

This is a conservative estimate, basically applying the per capita figures worked out in Madras City to the Rest of MUA. In general, Rest of MUA is less built up than Madras City. Hence, water table is fairly high. Hence, water consumption is likely to be more than in case of Madras City. However, this estimate gives a conservative estimate and actual consumption will be higher than the amount estimated here.

Table A-4.3: Estimation of water consumption in MUA (outside Madras City)

	No. of households	Per capita use lpcd	Quantity in MLD	
Well (within the premises)	153005	16	12	15
Well (outside)	55650	12	3	
Tubewell (within the premises)	19300	125	12	22
Tubewell (outside)	15480	125	10	
Others (within the premises)	465	38	0	1
Others (outside)	4765	38	1	
Total			38	38

Thus, according to this estimate, the total consumption of water from non-municipal sources is 38 MLD. The expression 'other' may require some explanation. During our field survey, it was observed that some households living in urban areas not served by municipal water systems were purchasing water from vendors who transport water from a neighbouring municipality's taps.

A revised water balance sheet taking into account an additional supply of 200 MLD from Krishna water for the period after September 1996 is shown in the following page.

Water Balance Sheet for Madras including 200 MLD of Krishna water *(figures in MLD)*

	Source	*Surface*	*Ground Water*			Use	
Madras City	Poondi, Red hills	400		Metro Water 583	Metered 109	Industry	57
						Commercial	6
	Well fields		148			Public authorities	25
	South Coastal Aquifer		10			Bulk consumer	15
						Non residential	6
	Porur, Thiruvanmiyur wells		20		Unmetered 464	Industry	72
						Commercial	14
	Mun. wells		5			Public Authorities	37
						Dom. non-residential	9
						Residential	149
						Public fountains	6
						Unaccounted for Water	177
					Static tanks (filled by tankers) 10	Residential	10
	India Mark II &Hand pumps		50	....	Provided by Metro Water	Residential	50
	Priavte Wells		10			Residential	10
	Private Tubewells		79			Residential	79
Rest of MUA	Palar Sub-surface	26		Total Municipal Supply 32		Residential	32
	Local bore wells		6				
	Private wells		15			Residential	15
	Private Tubewells		22			Residential	22
	Others		1			Residential	1
Entire MUA	Borewells		8	....	Used by Private tankers	Residential	4
						Commercial	4
	Mineral water		0.1			Residential	0.1
	Total	**426**	**374.1**				**800.1**

Appendix 5

Estimation of household expenditure on water

This Appendix summarises how the various figures in table 5.14 in chapter 5 were arrived at.

A-5.1 Direct Costs :

Direct costs or payments are estimated in the following manner :

a) In case of all households living in Madras City, and not having any source in the premises, the direct cost is estimated as that of collecting 2 kudams (about 40 litres) from static tanks per day at a cost of Rs. 0.50 per day or Rs. 15 per month (estimated earlier in section 5.8; see table 5.6).
b) In case of all households living in the MUA Towns and Rural areas (outside Madras City), such provision with static tanks does not exist. Therefore, for households not having any source within the premises (and collecting water from elsewhere) the direct cost is assumed to be zero.
c) In case of all households having a well within the premises but not having an overhead tank, water is drawn manually. Therefore, the direct cost is zero.
d) In case of all households having a well and having an overhead tank, the cost of pumping water from well to the tank in terms of monthly electricity charges and maintenance costs etc., was estimated at Rs. 30 per month.
e) In case of households having tubewells, the monthly cost is estimated in terms of Rs. 40 towards electricity charges and maintenance. (Whether there is an overhead tank or not does not affect the cost).
f) In case of households having a connection (to the Metro Water or municipal network), the monthly charge of Rs. 30 was used. In case of households sharing a connection, a charge of Rs. 15 per month was used.

g) In case of households having a combination of sources mentioned so far, the direct cost is calculated as the sum of direct costs of each source (as identified in a to f above).

h) There were two cases where the source of water is tap connection, but this water is pumped to an overhead tank. In such cases the direct cost is taken as Rs. 15 for shared connection plus Rs. 30 per month per household for electricity charges for pumping water to overhead tank.

A-5.2 Cost of Time :

Estimating this involves two steps : estimating the time actually taken on average; converting this time into value. The figures about average amount of time is mainly based on information collected during participant observation methods. It was observed that it takes about 15 minutes to collect two kudams of water from static tanks. On this basis the calculation is done as below:

a) For all households within Madras City not having any source within the premise, the time taken for transporting the two kudams of drinking water from static tank to the house is estimated at 15 minutes per day or roughly 8 hours per month.

b) For all households outside the Madras City (MUA Towns and Rural areas), and not having any source within the premise, also it was assumed to be 15 minutes per day approximated to 8 hours per month.

c) For all households drawing water manually from wells, based on observation, a figure of 15 minutes per day or 8 hours per month was used.

d) The cost of time was not included in cost calculations for all other categories, namely those having wells with pumping facility, tubewells, connection or any combination of these.

The time so estimated was converted into value based on hourly wage rate taking the corresponding household's monthly income, dividing it between the number of adults in the household and assuming 25 days in a month and 8 working hours per day (i.e., 200 hours per month). For example, if household A had a monthly income of Rs. 2,000; there were 2 adults; if they were drawing water from static tank; the time cost is calculated as: 8 hours * [(2,000/2)/200] = Rs. 40 per month. (The term is square brackets is the imputed wage rate for 1 hour of an adult's time.)

A-5.3 Cost of quality improvements :

Information was presented in table 5.11 on steps taken by households to improve water quality. Based on the following assumptions, we can calculate what people are spending on water quality improvement per month :

a) Candle filter costs Rs. 500; has a life of 2 years. Therefore, cost per annum is Rs. 250 or about Rs. 20 per month.
b) For households without a gas connection: Boiling sufficient amount of drinking water (about 10 litres per household of 5 members per day) on kerosene stove takes about 25 minutes. 1 litre of kerosene fuels a stove for about 2 hours and cost of kerosene in market is around Rs. 7. Therefore cost per month is : about 6 litres per month or Rs 42 per month (25 minutes * 30 days / 60 /2).
c) For households having a gas connection: Boiling on gas takes about 25 minutes. An average household of 5 members uses gas for 2 hours a day and a cylinder of 15 litres lasts about 1 month and costs Rs. 115. Therefore cost per month for a household using gas to boil water is Rs. 23 per month.
d) Mineral water is purchased at Rs. 15 per a can of 12 litres and it lasts about one week. Therefore, the monthly cost is Rs. 60.
e) The cost of UV filter is Rs. 6,500. It has a life of 3 years and runs on electricity and costs about Rs. 8 per month; the maintenance (candle replacement) cost is Rs. 250 in second and third years. Therefore, cost per month works out to Rs. 208. (If we exclude the capital component, maintenance and electricity costs are Rs. 28 per month).

From these calculations, it is also clear that boiling water on gas is cheaper than boiling it on any other fuel (hence the association between having a gas connection and boiling of water as a household response, noted in table 5.13).

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