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PREFERENCES, INEQUITY AND ENTITLEMENTS: SOME ISSUES FROM A CVM STUDY OF WATER SUPPLY IN MADRAS, INDIA

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Abstract: Improving the urban environment in developing countries is now an emerging priority. In that context, valuation is an important source of information to the policy-makers. This paper discusses the application of a multiple choice contingent valuation method to improvements in water supply in Madras, based on a 1996 survey of households in Madras. It is proposed that property rights regimes for the environmental goods concerned can be incorporated into the valuation framework using Sen's entitlements approach. As a step in that direction, a water endowment function has been defined for households in Madras. Issues for policy and research are raised.

1 INTRODUCTION

In this paper we discuss some issues in valuing the improvement to urban environment in the developing world with a case of water supply in Madras (Chennai), India.

Development research has included environmental issues during the last three decades, discussing mostly at the macroeconomic level. 'Micro' level discussions have focused predominantly on rural communities (Dasgupta and Maler, 1990, 1995). However, demographic projections indicate that urban areas in the developing countries in Asia and Africa will be absorbing a significant share of their population growth in the next two decades (UNCHS,1996) and play a larger role in economic growth (The World Bank, 1991; Peterson *et al.*, 1991). Therefore, improving the urban environment is an emerging priority (Bartone *et al.*, 1994; WRI, 1996).

There have been concerns about the validity of applying neoclassical economics approaches to the developing world (an issue well-discussed in Sen, 1983; Stiglitz,

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1988; Binswanger *et al.*, 1995; Amin, 1992). We will limit ourselves to the concerns relating to valuation. Approaches to valuation are often considered to be demand-based approaches, being based on Hicksian demands and estimation of compensating or equivalent variation (or surplus). Since many of the services received from the environment are not traded in markets, valuation is done either by examining the implicit demand for these services or by obtaining values directly from the consumers. One popular version of the latter approach is the Contingent Valuation Method (or CVM).

In Section 2, issues in valuing water are briefly discussed. Section 3 discusses the research design of the Madras study. Section 4 summarizes some empirical findings and raises policy issues. Section 5 summarizes the discussion.

2 VALUING WATER AND THE INCLUSION OF ENTITLEMENTS ISSUES

Valuing Water

Water and sanitation has been an important sector of development aid. In 1994, of DAC aid, about 5 per cent went to water and sanitation projects. As of early 1997, out of the World Bank's total project portfolio of US$ 118 billion in loans/credit, water sector projects accounted for about US$ 8 billion (or approximately 6.6 per cent). For a number of nations, per capita availability of renewable fresh water resources is less than 2,500 cubic metres per annum (WRI,1996). Less than 1000 cubic metres per capita is considered to be a situation of water stress and on this basis, '20 countries already suffer from water scarcity' (WRI, 1996, p. 302). In several regions, all available potential is fully allocated. With population increase, the per capita levels will fall. Reallocation of water from one use to another is a contentious issue resulting in tensions between different interest groups and in many cases the situation is one of deadlock (with little scope for negotiation). Economic valuation can contribute to clarifying the benefits of alternative water allocations and their distribution.

Can we apply valuation approaches to urban water supply? Adam Smith discusses in the 'paradox of value' that water has scarce any value in exchange compared to diamonds though water is essential for life sustenance. A 'willingness to pay' approach to valuing water attracts criticism on moral, ethical and cultural grounds. There are two underlying issues here. First, it is sometimes argued that willingness to pay is an ethically unsound basis for attributing values to goods and services. Whatever the force of this argument might be, we argue that it is not germane to the present discussion, as our goal is to identify how individuals value water relative to other goods, on the basis of the criterion of willingness to pay.

The second issue concerns the view that water, at least in part, is a public good. For example, an adequate supply of clean water may contribute to good public health and prevent the spread of infectious diseases. Water, or more accurately the services provided by water, have, in this case, public goods properties. For public goods, an individual's willingness to pay may not be an appropriate vehicle for identifying aggregate social preferences. Many goods are 'public' due to their consumption being non-rivalrous and non-excludable. However, Randall (1993, pp. 147) points out the expression 'public goods' creates much confusion and that 'nonexclusiveness and nonrivalry may occur together or separately, and the economic analyses of the

phenomena are different'. According to Randall's classification, water supply falls in a category of exclusive but 'congestible' i.e., 'a good which is nonrival for some number of users, while rivalry sets in as that number is increased and becomes intense as the number of users approaches the capacity constraint'. In many cities in the developing world, urban water authorities are operating at or pretty close to the capacity constraint (which can be overcome with investments, but these take time and by or soon after completion, excess capacity if any will be eroded by population growth or expansion of urban areas or both).

Elements of a CVM

The contingent valuation method implies that valuation is 'contingent on the constructed or simulated market' (Portney, 1994). CVM has attracted a debate between those who believe that the method can be designed to provide the targeted information (Portney, 1994; Hanemann, 1994; Carson *et al.*,1995) and those who believe that the method is fundamentally flawed (Hausman, 1992; Diamond and Hausman, 1994). We take the position that a well designed CVM can provide useful information.

At the centre of CVM is a question designed to elicit willingness to pay for a given level of change in environmental quality. Before posing this *valuation question*, the respondent is apprised of the conditions governing the market: who will regulate the environmental good, who are required to pay, and how much of the good is to be supplied, whether non-payers will be excluded and if so how, etc. The description of these details is built into a *scenario*. The respondents also need to know the *payment vehicle*, i.e., how they will actually pay the stated amount; whether it will be paid once for all or periodically, if so how frequently etc.

The valuation question can be posed in several ways. An open-ended question in the form of 'how much are you willing to pay ...' may be used, but responses to such a question have been found to be affected by trivial factors. There is no incentive for the participant to reveal the truth and hence such questions encourage strategic behaviour. Also this form of question may induce the participants to look for behavioural cues from the interview context. A bidding game approach was suggested by Randall *et al.* (1974) where the respondent is given a starting value and depending on the response (will pay/ will not pay) the amount is either increased or decreased until the person's final bid amount is registered. In such procedures, responses have been found to suffer from a starting point bias (Boyle *et al.*, 1985). To avoid this, the participant may be confronted with a single dichotomous choice or referendum question: under the given conditions, would the participant purchase the good. A referendum format question is incentive compatible and hence is often preferred. The NOAA Panel (Arrow *et al.*, 1993) recommended the use of the referendum format. There have been a few attempts to use a multiple choice or polychotomous choice (PC) question form (Morrison *et al.*, 1996; Ready *et al.*, 1995). In the case of goods where exclusion is feasible (in Randall's classification), there is scope for private and public sector provision of the good. In such cases, PC may be well suited to elicit values.

A credible CVM study should satisfy several conditions requiring a very careful design and testing of the survey instrument, the use of probability based sampling design and survey, and the choice of an appropriate model for specification of welfare changes.

Incorporating Sen's Entitlements Approach

In addition to good instrument design and survey implementation, it is also essential to choose appropriate parametric modelling to reflect developing country situation. In many developing countries, there are complex institutions for allocation of property rights among individuals. An individual's valuation can be significantly influenced by the property rights regime if the environmental good and benefits from it accrue predominantly on the basis of property rights.

We feel that Sen's entitlements approach (Sen, 1981; Sen, 1990) developed in the context of the analysis of famines provides direction in this regard. The emphasis on increasing the total quantity of water or per capita availability of water is the environmental equivalent of Malthusian fixation with (per capita) food availability decline.

According to the entitlements approach, the amount of water that a person actually consumes depends on the entitlement set E_i of person i which 'can be characterized as depending on two parameters viz., the endowment of the person and the exchange entitlement mapping'. (Sen, 1981, pp. 45). Given that markets for water are not fully established, the endowment portion rather than the exchange entitlements (as in the case of food), determines the amount of water that a person gets in a system.[1]

In this light, a parametric equation for willingness to pay for water should include besides income (y), a vector of prices (**p**) and socio-economic characteristics/taste variables (**s**) like education, social status, number of women in the household etc., an entitlement component:

$$WTP_i = f(z(Ei), y, \mathbf{p}, \mathbf{s}) \quad (1)$$

where function z depends on the endowment a person already has. Where the good in question is a pure public good (i.e., equal entitlement to everyone) the entitlement term is likely to be unimportant. Defining entitlements and measuring them on a metric and estimating the parameters for them is a difficult but important task in this direction. There is a tendency to focus attention entirely on increasing the quantum of water supplied without touching the existing distribution of entitlements. The presumption that the project will necessarily benefit everyone is difficult to sustain when seen from entitlements approach. In reality, the high and middle income consumers may have incentives to push for increased provision (Baumol and Oates, 1988, pp. 243).

3 MADRAS—RESEARCH DESIGN

The need for qualitative research in the design of CVM instruments is well-recognized (Bishop *et al.*, 1995, pp. 634; Arrow *et al.*, 1993). The research design for Madras CVM study included both intensive and extensive approaches. Qualitative research focused on understanding the water markets in Madras, the various options available

[1] For instance, hoarding of water in a metropolitan city (even elsewhere) may be extremely costly. Endowment is determined by property rights regime. From a legal point of view, while riparian rights dominate surface sources, the ground water rights are inalienably attached to land ownership. Some of these may be captured by land values and in turn by house rents. However, citizens may collectively try to protect or increase their entitlements, for instance by protesting against certain land use plans or densification.

to users and some indications of the prices. In some cases, participant observation methods were used to understand the transactions in water vending.

Two focus group discussions were held early on in the research to view critically issues of clarity of the questionnaire, framing of the valuation question, scenario plausibility, question ordering effects, timing and scheduling of interviews etc. Use of double-bounded dichotomous choice questions proved difficult. Participants take CVM surveys very seriously and respond to the question after careful thinking and, in some cases, discussion among themselves. When they are confronted with a repetition of the question with a higher or lower price, it was felt to be akin to a game and the seriousness of the researcher was questioned. Also, respondents felt that a single dichotomous choice question was too rigid forcing them to make assumptions about what would happen to other options available to them. It was found that a multiple choice approach was preferable to a dichotomous choice model.

Based on the outcomes of these focus group discussions, the questionnaire was finalized and pretested using initially a convenience sample and then a randomly drawn sample. Also, the questionnaire was translated to Tamil and then re-translated to English to check for consistency. The interviews were conducted by one of the authors with a sample of 200 households in Madras drawn by multi-stage cluster sampling design to represent the Madras City, the nine adjoining towns in the urban agglomeration area and the rest of the Madras Metropolitan Area (MMA). Given the resources available, that was the sample size feasible.[2]

However, enormous attention was given to the sample selection process. In the first stage clusters, nine out of ten zones were covered (instead of covering only a sample of clusters). In the second stage, wards were selected within the zones based on a number of parameters including population size, growth rate, population density, female literacy rate and household size.

A control ensured that in each zone at least 30 per cent of the sample households were drawn from low income households.[3] Each interview took about 50 minutes to one hour. The survey implementation strategy, particularly, the timing of the interviews was varied to ensure adequate representation of female respondents. Of the final sample, 43 per cent of the respondents were women.

Survey Completion Rate and Non-Response

The sample completion rate was 74 per cent as the survey had to be called off in the first week of October, 1996.[4] As shown in Table 1, the non-completion is spread over the entire sample and not just to one geographic zone or to one income group. Though the coverage of the rest of MMA (which accounts for 11 per cent of all MMA households) is less than it should ideally be, it is not a cause for strong concern as the

[2] It may not be appropriate to compare but, the 'state of the art CVM' study of Exxon Valdez Oil Spill had a sample of 1599 dwelling units for a population of 90 million English speaking households in the entire USA.

[3] As per detailed surveys in 1991, the proportion of households living in slums and low income clusters in Madras was estimated to be 30 per cent in Dattatri and Anand (1991).

[4] Three main reasons: (i) first phase of Krishna water project was inaugurated at a grand function with much media publicity — with scope for systematically affecting household perceptions after this event; (ii) local elections were to be held after a gap of 23 years and as door to door campaign was intensifying we were being mistaken to be political elements; (iii) heavy rains in the beginning of October, 1996.

Table 1. Sample allocation and completion (number of households).

Spatial unit	Sample allocated N	Sample completed			
		Low income (L)	Middle & High income (M)	Total $C = L + M$	C as % of N
Madras City	140	44	65	109	78%
9 Towns in MUA	38	16	15	31	83%
Rest of MUA and Rural	22	4	4	8	36%
Total for MMA	200	64	84	148	74%

population weight for that region is quite small. The sample completion rate compares favourably with many CVM studies.[5]

The NOAA Panel (Arrow *et al.*, 1993) recommends the documentation of item non-response i.e., those not willing to pay any amount or not responding to the willingness to pay question. In Madras, out of the 148 respondents, 18 respondents, i.e., 12.2 per cent of the sample, did not choose any option for water supply improvement (i.e., they preferred the status quo). Of these 18 respondents, only 3 had no source within their premises. The non-responders were from all income groups except the highest income class; 10 of them were men and 8 were women. Some of the female respondents said that the reason they did not respond to the valuation question was they could not decide without the consent of the head of the household (husband/father). Mitchell and Carson (1989, pp. 267) point out that in CVM surveys item non-response rates of 20 to 30 per cent are not uncommon. We find that the item non-response rate of 30 per cent in the lowest income group in Madras is a cause for concern but given the elaborate procedures we have used in sample selection, we feel that it is a random element and not due to sample selection bias.

While the wording of the valuation questions was not changed in implementing the survey, some of the other questions were improved based on experience. Additional probes were introduced where necessary, to ensure that the question is understood by the respondent as intended.

4 WATER MARKETS AND WATER ENDOWMENT: SOME RESULTS FROM MADRAS

Water Supply System in Madras

Madras has been given the dubious distinction of being the metropolitan city in India with the lowest per capita water supply of just about 72 litres per capita per day (lpcd).[6] However, like any central tendency statistic, this figure does not indicate the inequities in the system and the relative (and endemic) deprivation of some households. However, it does show that Madras is poorly endowed with water. According

[5] For instance, the well-known Alaska study (Carson *et al.*, 1992) had a response rate of 75 per cent.

[6] See for instance, MMDA's Master Plan, page 95 where a comparison is made with Bangalore (90 lpcd), Bombay (150 lpcd), Calcutta (190 lpcd), Delhi (160 lpcd) and Pune (275 lpcd). Also see Government of Tamil Nadu 91993).

to the Government of Tamil Nadu (1993) per capita water availability in the state of Tamil Nadu is 719 cubic metres per annum compared with India's 1185 cubic metres.

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

(i) Supply of water by the Madras Metropolitan Water Supply and Sewerage Board (in short Metro Water) — for Madras City and a few adjoining urban centres;
(ii) Some extent of municipal supply — in the case of the nine adjoining urban areas within Madras Urban Agglomeration (MUA), referred to as nine Towns;
(iii) Self-provision by many households and industries — by digging of shallow wells or deep tubewells;
(iv) 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.

As Madras has been facing acute water shortage during some particularly dry years, many households use two or three sources of water. This is evident from our Survey data in Table 2. According to this sample, about 42 per cent of households in Madras City and more than 70 per cent of households in the Rest of MMA are not covered by the piped water supply system i.e., do not have yard tap connections.

Private Market Responses

According to a survey of 50 water utilities in Asia, Madras is among a group of cities where there is 'no significant water vending' (McIntosh and Yniguez, 1997, pp. 85). However, as in the case of any resource that is scarce, markets have emerged in Madras in the form of bulk supply by private tanker trucks and retail water supplies by private mineral water companies.

In 1996, there were about 150 tanker trucks operating in the private sector. 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 8 MLD. It was difficult to obtain information on the customer-base of water vendors, but at least half of the demand is from non-residential users (offices, factories, construction sites, hotels, hospitals, etc.).

Table 2. Households in Madras as per various sources of water: 1996. (*Source*: Madras household survey, 1996.)

	Madras City	9 Towns	Total for MMA
1 No source within the premises	19.3%	16.1%	17.6%
2 Shallow well	15.6%	54.8%	28.4%
3 Tubewell	6.4%	—	4.7%
4 Tap connection	12.9%	6.5%	10.8%
5 Well and connection	16.5%	16.1%	15.5%
6 Tubewell and connection	27.5%	3.2%	20.9%
7 Well, tubewell and connection	1.8%	3.2%	2.0%
8 Sub-total for households with water connection (categories 4 + 5 + 6 + 7)	58.7%	29.0%	49.2%
Total for all categories	100.0%	100.0%	100.0%

With regard to the mineral water markets, the overall size of the market is estimated to be 0.1 MLD, though it is said that Madras is one of the fastest growing markets for mineral water consumption.

A third type of response is in the form of rent-seeking behaviour for the water supplied through static tanks. These number about 3400 and each is about 3000 litres in capacity. These static tanks are filled every day by tanker trucks hired by Metro Water from private operators. This is supposedly a gratuitous supply for slum dwellers and others not having yard tap connection. However, it was observed that the tanks are regulated by local individuals who collect Rs.0.25 per kudam (container of 20 litres capacity) from the consumers. A part of this is passed on to the tanker driver as a token of gratitude for filling their tank. Though one may jump to conclusions about rent-extracting behaviour or clientelism in the Indian system, it can be seen as a decentralized system of rationing a scarce resource.

Distribution Equity

The per capita figure of 72 lpcd masks the inequities in distribution. The exact share of water available to different income groups cannot be worked out without detailed consumption surveys. From the available data, the average water consumption rates for different users are estimated. This information is presented in Table 3. 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.

As of September 1996, only 71 MLD of the 433 MLD supplied by Metro Water was metered. (Out of about 230,000 connections, only 11,000 connections were metered and all of these are for non-domestic uses.) The tariff involves two components: (i) the water tax levied under section 34 of the Metro Water Act, on the basis of annual value of premises; (ii) the water supply charges levied on and collected from all consumers under water supply regulations (except those drawing from public fountains and static tanks).

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.[7] In comparison, the tariffs charged for metered consumers and effective average cost for others are shown in Table 4.

Table 3. Per capita water supply from different sources (lpcd). (*Source*: Anand, 1997.)

Households according to source	Water available in lpcd
Households having a tap in house	152
Tubewells in the house	125
India Mark II pumps (public tubewells)	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

[7] 840 million divided by 2; divided by 365 days; and divided by 433 MLD, gives cost per MLD.

Table 4. Average cost of water faced by various users in Madras. (*Source*: Anand, 1997.)

User category	Cost in Rs	Quantity	Units	Average cost Rs per 1000 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

Some important conclusions emerge. The low income households without any entitlements to water face an average price of water that is nearly seven times that faced by an average household having a yard tap connection (or more than four times the average cost of supply by Metro Water). Unmetered industrial users paying Rs.0.10 per 1000 litres while average cost of supply for Metro Water is Rs. 2.66 per 1000 litres is a disconcerting finding.[8]

Several studies have pointed out that when public water supply systems do not respond to the requirements with sufficient flexibility, reliability and efficiency, a hidden water economy arises (See Serageldin, 1995; Fass, 1993; Lovei and Whittington, 1993; Crane, 1994). Madras is no exception.

Water Endowments of Households in Madras

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 water consumption in the Madras survey, the average figures from the metropolitan-level as estimated in Table 3 are used in conjunction with the responses that households gave to the questions on (i) the various sources from which they presently draw water, (ii) whether the ground water drawn by the household is saline/brackish. The calculation of water endowment of person i is then done as follows:

$$E_i = \sum_j m_{ij} Q_j \qquad (2)$$

[8] In late August, 1997, new tariff rates have been announced with significant increases to all consumer-categories. However, the point regarding inequity remains valid.

Table 5. Water endowment levels of households in Madras. (*Source*: Madras Household Survey, 1996.)

Water endowment in lpcd	Mean monthly income Rs					Total
	2000	3000	4500	8000	20.000	
0	65.0%	52.3%	21.9%	12.1%		31.8%
16	10.0%	13.6%	6.3%	24.2%	15.8%	14.2%
94	15.0%	22.7%	37.5%	33.3%	26.3%	27.7%
110		6.8%	6.3%	6.1%	31.6%	8.8%
125	10.0%	2.3%	6.3%	6.1%		4.7%
219		2.3%	21.9%	12.1%	26.3%	11.5%
235				6.1%		1.4%
Total	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

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.

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 as:

$$E_i = \sum_j m_{ij} Q_j (1 - Sal_j) \tag{3}$$

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 is shown in Table 5.

From the endowment details, it is possible to construct a Lorenz curve for water in Madras. This is shown in Figure 1 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 1 (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.

Design of Choices for Water Valuation Question

The choices need to be plausible, realistic and independent. There are several issues that need to be addressed:

(i) preferences between complete ownership versus collective ownership of water source;

(ii) preferences between government agency versus private sector;

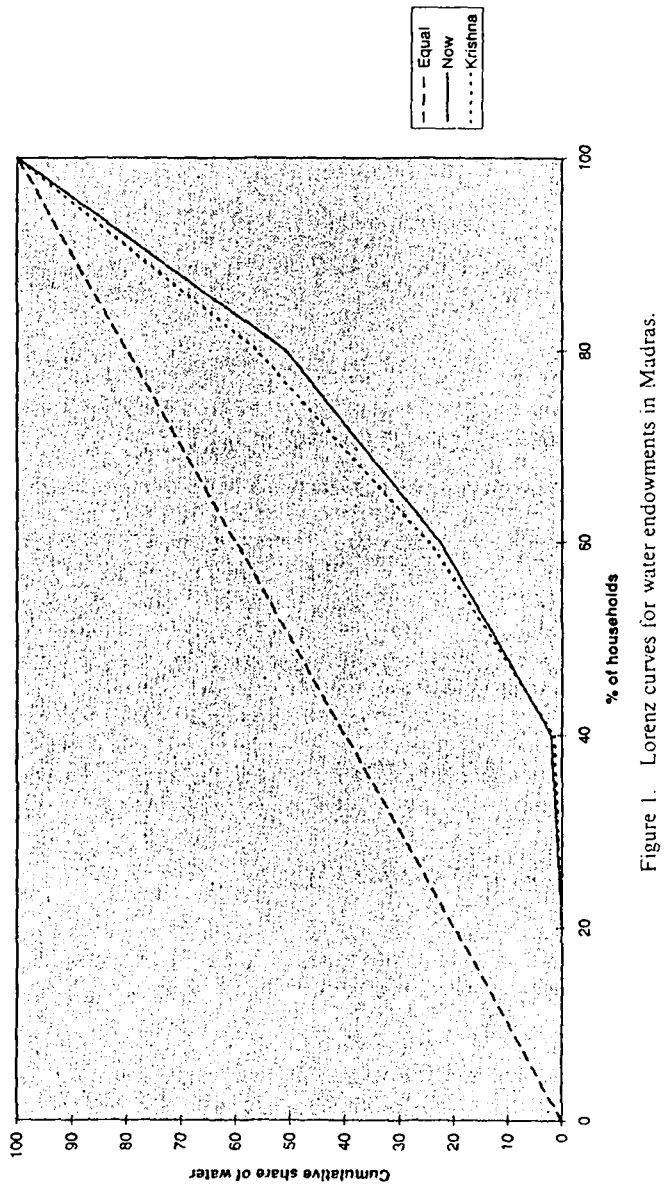

Figure 1. Lorenz curves for water endowments in Madras.

Table 6. Summary of characteristics of options used in Madras survey.

	IH-1	IH-2	OH-1	OH-2	PP	ENVS	TS
Convenience of yard tap connection	Yes	Yes	No	No	Yes	No	No
Quantity of water in lpcd	150	50	150	50	150	30% saving	as reqd by user
Treated water	Yes	Yes	Yes	Yes	Yes	No	No
Recycled water to be used	No	No	No	No	No	Yes	No
Requires plumbing work	Yes	Yes	No	No	Yes	Yes	No
Public sector/Govt.	Yes	Yes	Yes	Yes	No	No	No
Requires space/land for new tanks/storage	No	No	No	No	No	Yes	Yes
Co-operation of others required	No	No	Yes	Yes	No	No	Yes
Start-up costs	Yes	Yes	No	No	Yes	Yes	No
Risk perceived	Low	Low	Medium	Medium	High	High	High
Scope for price variations (seasonal)	No	No	No	No	No	No	Yes

(iii) preferences regarding quantity and quality of water;
(iv) preferences relating to conservation and recycling, etc.

In the Madras survey, some of these were included in designing the various options. In all seven options have been designed. Two of these were in-house (IH), i.e., yard tap connections by public water distribution network (one for residents in Madras City and the other for those in peripheral areas). The two out-side connection (OH) options correspond to the IH options except that the ownership was to be shared among five designated households (and not with the general public as in the case of a stand post). One option relates to a piped network by the private sector (PP), one to supply by private tankers (TS) and one named 'environmental option', requires the participant to indulge in rain water harvesting and recycling of sullage for flushing purpose. The various features of the options are shown in Table 6. Each option was associated with a price (randomly varied across the range). Participants were randomly assigned to various combinations each containing two or three or four options.

In addition to eliciting willingness to pay, the valuation exercise was designed to throw some light on preferences of households with respect to various possible institutional arrangements for water supply. From the analysis of the survey data, we find that:

(i) When an in-house connection option was offered along with other options, about 70 per cent of respondents chose this.
(ii) The price for an in-house option varied from Rs 25 per month to Rs 300 per month. But, for each income group, as the price increased, the probability of a 'yes' response does not systematically decline. The price range may be considered narrow but the highest price used was already ten times the current average monthly water charges.
(iii) So long as it is a yard tap connection, respondents seemed to be indifferent to whether it was public sector or private sector which is supplying it. However, when both public and private sector yard tap connection options were available, the public sector was preferred.

Table 7. Water option chosen versus present water endowment level. (*Source*: Madras household survey.)

Water endowment (lpcd)	Water option chosen in the survey								
	IH1	IH2	PP	OH1	OH2	TS	ENV	None	Total
0	42.6%	25.5%	12.8%	2.1%				17.0%	100%
16	14.3%	33.3%	4.8%		9.5%	9.5%	4.8%	23.8%	100%
94	56.1%	4.9%	19.5%	4.9%	2.4%		4.9%	7.3%	100%
110	69.2%	7.7%					15.4%	7.7%	100%
125	71.4%			14.3%			14.3%		100%
219	58.8%		29.4%				5.9%	5.9%	100%
235	50.0%	50.0%							100%
Entire sample	48.0%	15.5%	13.5%	2.7%	2.0%	1.4%	4.7%	12.2%	100%

Table 7 presents the summary of the option chosen from a given set, along with the water endowment of the respondent. The seven options are arranged in the table to reflect an ordering based on: the mode of supply (yard tap connection to non-yard tap option as one moves from left to right); the reliability of water supply (from high to low as one moves from left to right). Intuitively, one would expect the outcomes to lie around the diagonal, i.e., as the level of endowment increases, the probability of considering less reliable but innovative option increases.

Results of binomial logit models

The multiple choice results may be estimated using multi-nomial logit/probit models (see Maddala, 1983, pp. 34). If we presume that choice characteristics (as well as socio-economic characteristics of respondents) affect the choice made, McFadden's conditional logit model can be used. However, as 61.5 per cent of households across all income groups and water endowment levels chose in-house connection option, it seemed that households had a strong preference for one option irrespective of the characteristics of other options. In that sense, some of the choices may not be substitutes for each other but form completely different packages. To examine these issues, we undertook binomial logit models to examine the probability of a respondent i choosing option j given the characteristics of the individual i. The results are shown in Table 8.

As mentioned above, a binary logit model is an approximation (to a complete model using both choice characteristics and individual's characteristics) and hence the results should be seen only as indicative. However, from the table, the following inferences can be made.

Price/tariff. In general, one would expect the sign of parameter for this variable to be negative (see Griffin *et al.*, 1995, for instance). However, in all the cases in Madras, the sign was positive. Furthermore, it is significant at the 5 per cent level for the first two models. This needs further examination. The price range used could be one of the reasons, but this then highlights the conflict one may face in applying CVM in the developing world between the need to use a much wider price range for estimation and the ethical issues involved in posing such high prices. The other reason could be that the respondents may be comparing the options not only in price terms but in

Table 8. *Logit estimates of parameters of likelihood function for willingness to pay for water.*

	Model 1: Madras City In-house (yard tap) connection IH1	Model 2: Madras City IH1 expanded model	Model 3: Periphery (excl. Madras City) IH2	Model 4: Private piped network PP1 (entire MMA)
Price/monthly charge	0.0097**	0.0101**	0.0148	0.0213
Income	−0.00007	−0.00009	−0.00007	−0.0003
Education level		0.2266	0.9653*	−3.5454**
Water endowment	0.0049	0.0055	−0.0012	−0.0257**
Water quality choice	−0.0202	−0.0853	−0.4752	1.7806**
Female	0.1010	−0.1249	−1.5063	−2.0305
Owner		1.1844**	1.8055	−1.8492
House-type		−0.0799	0.2536	−1.4164*
Having toilet		0.1149	−2.2141	11.5129***
N	94	93	37	38
Log likelihood	97.926	91.326	38.942	16.823
Log likelihood (constant only model)	104.606	101.7571	49.082	52.574
Pseudo-R squared	0.06	0.10	0.21	0.70

***Significant at 1%; **Significant at 5%; *Significant at 10%.

terms of 'perceived risk'. This issue of price-risk categorization also needs further exploration.

Water endowment. The expected sign of this variable is negative, i.e., the higher the water endowment of a household, the lower the willingness to pay for an improvement. Model 3 (i.e for households in outskirts IH2), and model 4 (those opting for private piped network) conform to this. However, the sign in case of those opting for a yard tap connection within Madras City indicates that even though some households in Madras are relatively better off in terms of water endowment, most people do not have the water endowment of the desired level. (For instance, due to falling ground water levels and increasing salinity within the City area, the households may feel that yard tap connection is the only reliable option.)

Ownership (of house). This variable is highly significant in case of Model 2 indicating that the benefits from improved water supply seem to be captured by the house values. Its sign is positive in model 2 and model 3 indicating that owners prefer a yard tap connection (and model 4 indicates that owners do not prefer private sector to do this, though in model 4 this variable is not significant).

Having a toilet. This variable is highly significant for model 4 supporting the view that it is better endowed households who would be willing to opt for a 'new' private piped network (though relatively expensive).

For regressions with qualitative explanatory and dependent variables, pseudo R-squared values of 0.2 or above are considered to indicate a reasonably good fit. From the above results, it appears that households choose water provision in a hierarchical process: in the first stage, all options that do not have certain preferred characteristics are eliminated; from the narrowed set, the options are once again compared and the socio-economic variables (specially water endowment levels and quality of living, for example, having a toilet) seem to be influential at this stage.

Mode of supply seems to be the dominant issue (for instance, nearly 77 per cent of respondents choosing a yard tap option). Price by itself seems to be a very poor predictor of household water choice.

5 CONCLUSIONS

Urban environmental management in developing countries is a complex issue. A valuation exercise cannot by itself identify solutions nor is its only use 'getting the prices right'. It can help the policy-maker to understand the preferences of urban residents (in fact, different groups of them) between different alternative institutional arrangements and pricing regimes and the welfare effects of these alternative policies.

Our extension of Sen's entitlement approach to water supply presents an attempt to bring the property rights issue into the willingness to pay analyses. In this approach, willingness to pay should be seen as a household's expression of preference for the entitlements a household presently has and desires to have, given the socio-economic characteristics of the household and the characteristics of the choices available. A water endowment function has been proposed to reflect the 'water security' of households. However, like any property rights institution, how well entitlements for water (or any other environmental resource) function 'may depend heavily on the existence and comparative efficiency of other auxiliary institutions such as law, ideology and morality' (Lin and Nugent, 1995, pp. 2310).

It is possible to estimate the mean willingness to pay or the aggregate value of improvement for all households in Madras. These results are being discussed elsewhere. However, more important concerns are to understand the preferences of those who are already connected (captive consumers) and those who are not connected. The policy-makers would like to know (i) what benefits the improvements in the system will bring to those already connected (present clients) as compared to the tariffs they are charged; (ii) among those now not connected to the system, how many would like to connect at different costs; (iii) which section of the population will not be able to connect and will need to be catered to by creating entitlements in other forms. Upto 80 per cent of those not having any source of water now, would like to have an in-house/yard tap connection. The willingness to pay figures span a wide range from Rs. 30 to 300 per month compared with the average monthly water charge of Rs. 30 per month for domestic connections.[9] All the prices used in CVM relate to monthly charges. However, the responses are indicative of the flexibility needed in providing various payment options. For instance, if household A has a WTP of Rs X, the amount over and above the minimum monthly charge (i.e., X-30) can be capitalized at appropriate interest rate to determine the number of years required for full re-payment of the capital cost of the connection. This conclusion is in line with the argument in Singh *et al.* (1993), for a monthly tariff policy rather than capital cost policy for water connections.

Though the discussion is dominated by water issues, the approaches are relevant for many other local environmental goods such as sanitation or solid waste management. Another interesting result from this study is that citizens' preferences toward the

[9] Recently, this has been increased to Rs. 40 per month. However, we use the Rs. 30 figure because at the time of the survey, that was the relevant figure.

private sector's role are more easy to predict and explain. In the current trend toward privatization of the urban infrastructure in India, citizens in Madras seem to indicate that they are not averse to private sector water supply, but they would opt for it only when the public sector option is not available or if it is inaccessible to them.

Also, this research highlights that citizens in cities in the developing world can significantly contribute to the design of valuation questions. To that extent the design process of CVM needs to be turned upside down to make it a field-based process, rather than one where the respondents come in only at the 'pretest' stage after the questionnaire has been finalized more or less.

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APPENDIX

Valuation Question

Please note, each respondent was assigned to one of the various combinations of options depending on (a) whether the respondent is within Madras City or in the urban agglomeration area (since the Krishna Water Project and the Water Master Plan make this distinction and allocate water based on different per capita norms); (b) whether certain options are (technically) feasible given the house type; and (c) whether the respondent is already having a yard tap connection or not. Also, to avoid sequence bias, the sequence in which the options were presented was randomly varied.

'Now I want you to kindly consider a few options for water supply improvement. While considering these options please note that a. water problem is just one among various environmental problems in a city like Madras; b. your household income is limited and you may have various priorities; and c. answer the question considering only the effects on your household alone.

Option 1: IH 1

As you know, Metro Water Board is in charge of water supply in Madras Metropolitan Area. To augment the quantity of water available, a project is being executed to provide 15 TMC ft of water from river Krishna in Andhra Pradesh. When the works for the project are completed, on average, every household having a connection is expected to get water at the rate of 150 litres per capita per day. That is roughly 7 kudams of water per person per day. An average family may have 5 members. Such family is expected to get 35 kudams of water per day. Remember, we will not have 24 hour water supply. To implement this project, the Metro Water Board may have to raise resources from Government undertaking such as Hudco or from the World Bank. In order to repay the loans, it will be necessary to charge every user for the service. Suppose, you are offered to join this scheme having the option to obtain a connection. There will be a monthly user charge of Rs ... (randomly inserted price). (Do you have any questions regarding the information given so far?)

Option 2: PP1

Now another option is: There is a proposition that private sector can be allowed to play some role in infrastructure sectors. On this basis, suppose there is a system where the Metro Water Board identifies certain area and designates one or more distributors. These distributors will be selected by Metro Water. They can charge only according to the maximum rates fixed by the Metro Water. They will be bulk supplied by Metro Water Board with treated water. Now, such distributors can come and lay pipelines within the given area. They can also meter the water supply if necessary. The private sector price could be higher than a purely government supply. However, such system may be able to provide connections quicker than it may take in the other system. So there are some advantages and there are some disadvantages, specially costs. Are you aware of any such private sector system in areas other than

water? (Expected responses: Gas supply; cable TV). Suppose such scheme is started in your area. The monthly charge in this scheme will be Rs ...
(Do you have any questions regarding the information given so far?)

Option 3:

There is another option. This may be called environmental option. If you choose this option, you will be required to invest some money in rain-water harvesting and also in recycling. When it rains, only a small percentage of that water is absorbed in the ground, the rest flows away. Rain water harvesting involves collecting all the water falling on your roof through separate pipelines and feeding this water through a filter into your well. Also, some plumbing work needs to be done to segregate bathing water (called sullage). This water can be recycled and there are simple treatment plants which work on gravity. When the water comes out of this plant, it cannot be used for drinking. It can be used for flushing purposes only. So you will need two sets of pipelines and tanks etc, to be built—one for rain water harvesting and the other for recycling the sullage. Also please remember that by your rain water harvesting, your neighbour may also benefit without paying any costs. Please remember, this scheme does not give you any extra water, but only leads to a saving of up to 30 per cent of water that you are now using. That is as good as increasing your water supply by that extent. If you join this scheme, there will be provision to give you a loan to cover 90 per cent of the cost of the pipelines etc., subject to a maximum. You will be required to repay this loan as a monthly charge. Suppose, it works out to Rs ...
(Do you have any questions regarding the information given so far?)
Now consider all the options available to you. Option 1 provides (this ...) ... and costs you Rs ... per month; Option 2 provides (this ...) ... and costs you Rs ... per month; and option 3 provides (this ...) ... and costs you Rs ... per month. Also remember your budget constraints. Do you have any questions regarding the information given so far?
Now, please tell me which of the options you would prefer: ...
(A follow up question on why that option is preferred is asked).
In case of non-response, the reason is enquired using appropriate probes.

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REGIONAL DIFFERENCES IN INDIA'S FOOD EXPENDITURE PATTERN: A COMPLETE DEMAND SYSTEMS APPROACH

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Abstract: This paper analyses India's food expenditure recognizing regional differences in preferences and prices. The results reveal large regional differences in expenditure pattern implying that nutrient enhancing programmes must recognize this diversity. Household composition is an important determinant of consumption, though the nature of demographic impact varies across regions. The popular AIDS yields biased elasticity estimates, especially for cereals, making its use inappropriate in developing countries. In policy applications, choice of a general demand system is important in evaluating the impact of price and income changes on basic consumption, and in designing optimal tax systems, but not necessarily in evaluating tax reforms.

1 INTRODUCTION

Econometric studies of household expenditure are of considerable importance because of the usefulness of the estimated demand parameters in several key issues. These range from the purely behavioural aspects of demand forecasting, to welfare issues of poverty and inequality measurement which depend crucially on the estimated equivalence scales and on demographic demand parameter estimates. Tax design and tax reform also require reliable estimates of price elasticities.

Traditionally, preference consistent 'complete demand systems' have been estimated on time series of national accounts data of developed countries. In contrast, the analysis of household budget data, which was pioneered by Engel's study on Belgian data, has traditionally ignored price variation and concentrated, instead, on the

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