

Anand, P. B.

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Water scarcity in Chennai, India: Institutions, entitlements and aspects of inequality in access

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Discussion Paper No. 2001/140

Water ‘Scarcity’ in Chennai, India

Institutions, Entitlements and Aspects of
Inequality in Access

P. B. Anand*

November 2001

Abstract

The main contributions of the paper can be divided into five areas. (a) It tries to explain conceptually, the institutional arrangements for water supply in Chennai and whether the state government’s decision about improving the performance of the water utility depends on particular political circumstances. A plausible explanation is also given of the impact of ground water regulation on the supply decision of private sector (tanker truck operators), using a crowding out framework. (b) It discusses how Amartya Sen’s entitlements approach could be used to understand water scarcity as a problem of some people not having enough water rather than a problem of there being not enough water, and in that light, to examine inequality in access to water supply. (c) The paper presents a water balance sheet for Chennai. While I do not use a computable general equilibrium (CGE) model, I suggest a possible framework to use such models for water supply policy issues at city level. (d) Aspects of water quality are discussed by focusing on the steps taken by households to improve water quality at home, and whether access to energy also contributes to entitlement deprivation of the poor. (e) Monthly household expenditure on water supply is briefly examined. These expenditures comprise direct costs, the cost of time spent in collecting water, and expenditure incurred in improving the quality. Expenditure on water is found to be positively associated with years of education of the respondent, water endowment, home ownership and location within Chennai City (as compared to residing in the peri-urban areas). The low income households do spend a slightly larger proportion of their monthly income on water supply as compared to others, mainly in the form of the cost of time spent in collecting water. Due to energy prices and lack of access to certain sources of energy, they may also be suffering from entitlement deprivation in having to settle for using water of low quality and increased health risk.

Keywords: utilities, water supply, entitlements, regulation, Asia

JEL classification: D63, H42, H7, L51, L95, Q25

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* Centre for International Development, University of Bradford, Bradford BD7 1DP, UK. E-mail: p.b.anand@bradford.ac.uk

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1 Introduction

Water scarcity can be defined in a number of ways and how one defines it has implications for policy. In one approach, water scarcity has been interpreted as a problem of there being not enough water in aggregate terms (as in the case of arid regions, such as the Middle East) or in per capita terms (as in the case of countries with annual renewable fresh water sources, measured in cubic metres per capita, CMPC, below a certain level)¹. Water scarcity in this approach is a result of providence (in terms of water as a natural resource) and population. A national metric tells us little about distribution within a nation.² More importantly, describing water scarcity as a problem imposed by environmental constraints or population can lead to an alarmist or doomsday rhetoric.³ An extension of this view-point is the hypothesis that water scarcity is a potential source of violent conflict between nations.⁴ While they may be well-intentioned, they may be criticised for making a patronizing assumption (that some nations and societies are morally so backward as to be prepared to wage a war to acquire a commodity). The main problem in such arguments is that a conflict over rights (to resources) is incorrectly interpreted as a conflict over resources themselves.⁵ On the whole, while the intention of the providence approach may be to highlight the urgency to act, it may have quite the opposite effect. It may turn policy makers into *fatalists*, as it presents water scarcity as a problem of nature and population, both beyond the control of policy, specially in the short run.

Another approach to water scarcity sees it as a symptom of poverty. Not having adequate water or sanitation is thus, seen as a characteristic of less developed countries.⁶ Thus, the policy conclusion seems to be that economic development will (in due course) lead to improvements in water supply and hence, there is no need to worry about specific symptoms of poverty. Thus, this approach may turn policy makers into *patient optimists*.

¹ For example, areas where water availability is less than 1,700 cubic metres per capita (CMPC), are defined as experiencing 'water stress'. See WRI (2000: 107).

² As of 1991, India's total potential of renewable freshwater is estimated to be 2,200 CMPC. However, per capita availability varies considerably from 16,000 CMPC in Brahmaputra basin to as low as 360 CMPC in Sabarmati basin (Ministry of Water Resources, Government of India at URL: <<http://www.wrmin.nic.in>>). Also see Nussbaum and Sen (1993), for various criticisms on national or per capita measures.

³ As examples of doomsday view, I would include Postel (1995) and Falkenmark (1997) and some arguments in Gleick (2000). Others such as Shiklomanov (1997), and Kuylenstierna et al. (1997), acknowledge the limitations of such assessments based on national or regional indicators. Rock (1998) and Anand (1999a), explore whether there is any Kuznets-type relationship between GNP per capita and the amount of fresh water available per capita.

⁴ See for example, Homer-Dixon (1998), and Swain (2000).

⁵ This is more than a subtle difference. What are referred to as wars over resources (whether water or oil or diamonds or territory) are often wars over contested rights or contested claims seeking to modify the existing distribution of rights or conflicts triggered by usurpation of one party's rights by another.

⁶ 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.

A third approach to water scarcity also sees it as a problem of poverty, but as something that needs to be addressed quickly and not something that can be left to the trickle down effect of economic development. Thus, scarcity is interpreted as a problem of there being enough water but not enough money or technology or human resources to bring that water to the people. Much international financing of water resources and water supply projects during the period 1950 to 1990, reflects this thinking. This approach may turn policy makers into *enthusiastic engineers*.

A fourth approach is to consider access to water supply as an important ingredient of quality of life and water scarcity as a capability deprivation. Attention to poverty is shifting from income based measures of poverty to inequality and capability deprivation (Sen 1999). That by itself does not mean one has to study each ingredient of quality of life. However, there is scope to examine whether water scarcity can be redefined as a problem of some people not having enough water and what societies can do about this. This requires the examination of whether some people suffer from systematic and appalling deprivation and what needs to be done. For example, an argument is that some people (the poor) may be more vulnerable to health impacts of water supply problems. Hence, improving access to water and sanitation has been considered to be an important target by itself 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. While the capability approach is recognized by international donors⁷ and research community,⁸ as of now, there is little evidence of its use by water supply policy makers (and hence, no short name).

Against this background, this paper focuses on understanding water ‘scarcity’ at the level of an individual city and it tries to examine the institutional and individual responses to water supply shortages and scarcity in Chennai (Madras), India. The plan of the paper is as follows. Section 2 briefly considers some strands of the relevant literature on understanding water supply issues. Section 3 discusses water supply provision in Chennai. Included in this section are an explanation of how ground water regulation affects market response and a discussion on a water balance sheet for Chennai. Section 4 focuses on issues of inequality in access to water supply using entitlements approach. Section 5 focuses on the various steps that households in Chennai take to improve water quality. Section 6 examines monthly expenditures incurred by households in relation to direct costs, costs of time in collecting water and costs related to improving water quality. Some issues for policy and further research are summarized in section 7.

⁷ See for example, the World Bank (2000), though Skirbekk and St. Clair (2000) feel that ‘... it is highly questionable that the WDR could be consistent with Sen’s approach’ because of WDR’s emphasis on measurement.

⁸ See various papers presented at the conference ‘Justice and Poverty: Examining Sen’s Capability Approach’, University of Cambridge, St. Edmund’s College, Cambridge, June 2001. See URL at <<http://www.st-edmunds.cam.ac.uk/~vhi/sen/index.shtml>>

2 Institutions and entitlements in relation to water supply?

If scarcity of water in Chennai is considered as a problem of there being not enough water, responses could be to look for distant sources or ingenious schemes (including desalination and cloud seeding). If on the other hand, scarcity of water is considered to be a problem of some people not having enough water, the kind of questions that need to be asked will be different. In this regard, I will consider three strands of literature (while acknowledging there may well be other strands, equally important): institutional arrangement for water supply, the second one using cost benefit analysis, and the third one relating to entitlements issues.

2.1 Institutions for delivering water supply

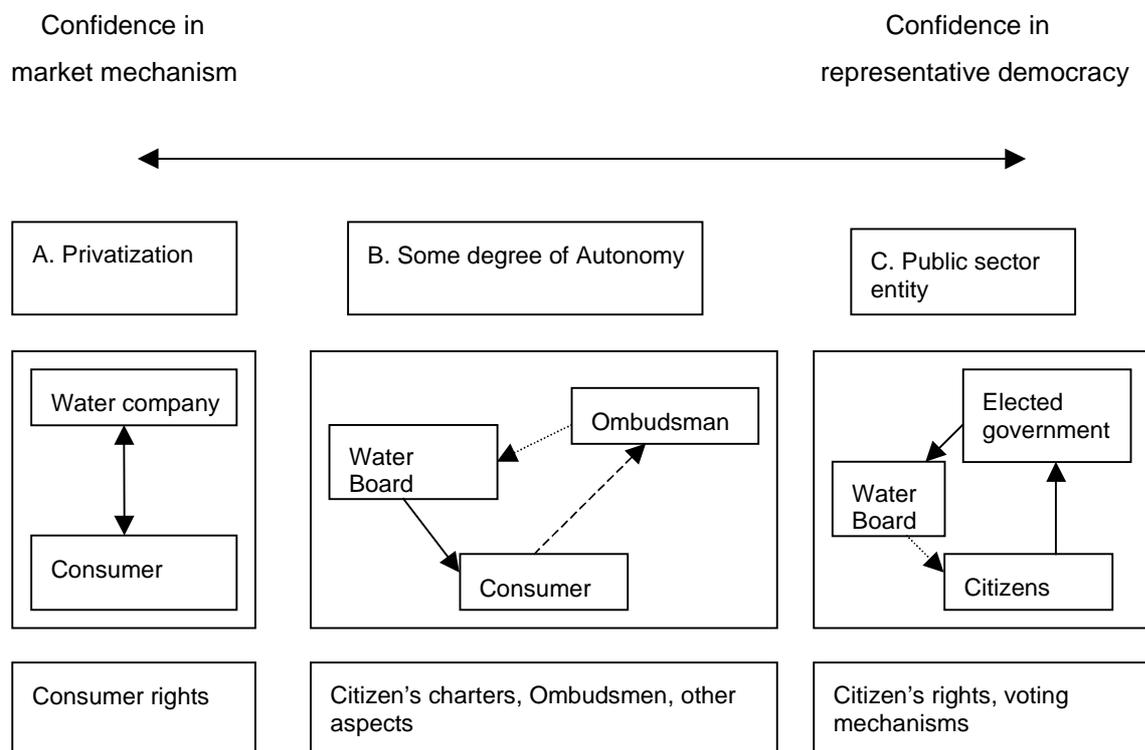
Various studies of institutions focused on the question why villagers in certain developing countries engage in collective action and develop institutions to allocate and manage irrigation waters and whether such institutions can be created and sustained elsewhere (Wade 1988; Ostrom 1990, 1993; Bardhan 1995, 2000; Uphoff 1996). Hirschman's exit and voice framework has been used to understand how citizens are likely to react in relation to the degree of market failure and a lack of accountability in the provision of various public services in cities (Paul 1992; 1994). I have argued elsewhere that urban residents are more likely to engage in collective action in case of public goods and take recourse to exit in case of goods where private property rights are recognized (Anand 2000). Since water supply is a private good, I feel that the property rights issues are more important than collective action and incentives. Another strand of studies relating to institutions focused mainly on privatization of infrastructure and whether the British, French or other models of privatized water utilities can be applied in the context of developing countries (World Bank 1994; Government of India 1996; Brockman and Williams 1996; ECLAC 1998; Hardoy and Schusterman 2000). Though water supply is a private good, in many countries it has been publicly provided, mainly because of two reasons: (i) water supply infrastructure is capital intensive with natural monopolies; and (ii) that the needs of the poor can be best protected by keeping water supply in the public sector. In recent years, both these arguments have been questioned. The need to evolve institutions to strike a balance between insulating infrastructure provision from political control and capture on the one hand and the need to maintain accountability on the other has been widely recognized. Depending on how much faith one has in state and market institutions, the various generic arrangements for water supply can be shown in Figure 1.

While it has been common in many countries to have water supply as a purely public sector provision (model C), in some Latin American countries and some South East Asian countries, there have been attempts to change it to model A through privatization. For many countries that have not yet privatized water utilities, model B is likely to be relevant.⁹

⁹ There is no 'pure vanilla' of model B and what is suggested above can lend itself to various alternative forms depending on how close to the state or market the arrangement is. For example: (a) Arrangement BA – creating contestable market rather than a privatized monopoly or by establishing property rights to water and allowing a Coasean bargain to take place (with provisions for ensuring some life-line level of supply). Instead of one company supplying water, there could be various

Figure 1

Alternative approaches to reforming water and sanitation provision



2.2 Cost benefit analysis strand

Studies in this strand, mainly focused on extending conventional project analysis to water supply projects.¹⁰ Given that many governments provided water supply at nominal charges or for free, estimating the benefits of water supply projects requires some information on consumer willingness to pay. Some studies used the contingent valuation method and argued that consumers in rural areas are willing to pay for obtaining connections (World Bank Water Demand Research Team 1993; Singh et al. 1993; Griffin et al. 1995; Altaf et al. 1993). In the process of exploring economic aspects of water supply, some of these studies also examined water vending activities in developing countries (for example, in Whittington et al. 1991; Cairncross and Kinnear 1992; Fass 1993) and whether there is considerable mark up in prices and whether this can be explained as rent-seeking behaviour by some agents have also been explored (Lovei and Whittington 1993; Crane 1994). While at a theoretical level, cost benefit analysis text-books began to include chapters on water supply issues (as for example, Whittington et al. 1994), in practice, the trend seems to have been quite the opposite. In some cases, the presence of water vending is seen as sufficient indicator of demand for

companies competing to supply water; (b) Arrangement CB – with water board remaining a state entity but some aspects of it being contracted out; (c) Arrangement BB – with water board remaining a state entity but with considerable autonomy and be subjected to scrutiny by an independent ombudsman, and so on.

¹⁰ See ADB (1999) and also Swarna and Whittington (1994). Also see WELL and DFID (1998).

water supply requiring no further economic analysis to justify increased investments (World Bank 1995: 23).

2.3 An entitlements approach to household water supply

While the above two strands covered a range of issues, property rights issues seem to have been completely ignored in urban water supply.¹¹ One way to focus on property rights and institutions concerning water supply is to use Sen's entitlements concept (Sen 1981; Sen 1990). Sen's argument concerns food grains and the 'fixation' with per capita food availability decline (or FAD). Sen argued that famine and starvation is a matter of '... some people not *having* enough food to eat, and not a matter of there *being* not enough food to eat'. Further, according to Sen (1984: 454):

“In a fully directed economy, each person i may simply get a particular commodity bundle that is assigned to him ... Typically, however, there is a menu – possibly wide – to choose from. E_i is the entitlement set of person i in a given society, in a given situation, and it consists of a set of vectors of alternative commodity bundles, any one of which the person can decide to have. In an economy with private ownership and exchange in the form of trade (exchange with others) and production (exchange with nature), E_i can be characterised as depending on two parameters: the endowment vector x and an exchange entitlement mapping $E_i(\bullet)$ which specifies the set of commodity bundles any one of which person i can choose to have through 'exchange' (trade and production).”

Sen points out that the expression entitlement here is used to connote '... the legal, political, economic and social characteristics of the society in question' and the individual's position in it. Entitlements approach helps us to see famine and starvation as an acquirement problem in relation to specific institutions and as 'economic disasters, not just as food crises'. Sen argues that a policy response such as rushing more food to famine-stricken areas may not alleviate starvation, when the main cause of famine is one of entitlement failure.

Thus, individuals have various endowments (either in the form of things they have acquired, such as land, or a capacity that enables them to acquire, such as labour or knowledge and certain rights). These endowments combined with institutional arrangements determine the individual's entitlements which in turn determine the various functionings which can be achieved. The 'totality of all the alternative functioning vectors a person can choose from ... reflects the person's capabilities' (Sen, 1985: 27). These functionings reflect well-being because '... how well a person is must be a matter of what kind of life he or she is living, and what the person is succeeding in "doing" or "being"' (Sen 1985: 28). A number of alternative explanations of entitlements and criticisms exist (see Sen 1990; Gore 1993; Gasper 2001). Gasper (1993) points out that the expression entitlements can have different meanings such as: '... present rights to resources, or rightfully held resources, or a set of possible titles arising from the use of rights and resources'. Leach et al. (1999) discuss environmental

¹¹ There has been some discussion on property rights in relation to ground water (for example, Moench 1998), but much focus in this literature seems to be on irrigation (for example, Shah 1993).

entitlements as the ‘... alternative sets of utilities derived from environmental goods and services over which social actors have legitimate effective command and which are instrumental in achieving well-being’. They, however, feel that instead of focusing on particular endowments, entitlements and capabilities which ‘... represent only a snapshot in time’, it is important to focus on the relationships among various forms of institutions operating at a range of scales (p. 234).

There are various reasons why an entitlements approach may be useful for understanding access to water supply:

- i) Water ‘scarcity’ is often perceived as a situation when per capita water availability declines below what is considered to be acceptable norm.
- ii) Similar to food, water supply is also a private good whose acquirement is subject to social and political institutions, cultural norms and property rights. In some contexts, societies may include provisions for non-entitlement transfers of water (such as through public fountains). However, this is to supplement access to water through other institutions rather than to substitute it. When non-entitlement transfer is the only form of access to water, inequality can be expected to be pervasive.
- iii) Water scarcity can have important consequences for well being. For instance, when water shortages are serious, educational institutions in cities such as Chennai have been closed down temporarily. Scarcity of water supply may in turn restrict the functionings of households in several ways. For example, though households take all due care with regard to securing and storing drinking water, acute shortage may force households to economize water by lowering standards of hygiene in flushing the toilets or in washing up which may lead to bacteriological contamination causing diarrheal or other diseases. When water supply is rationed and there is no certainty as to the hours or times when water will be supplied, a member of the household is forced to stay at or close to home, lest they miss out when water is delivered.
- iv) Some groups in the population may suffer from lack of water even when there is no decline in water availability in the region.
- v) An acute water scarcity can co-exist with a transfer of water to non-human consumption uses, such as agriculture or industry or simply for other luxury uses (see Bhatia 1992). This is equivalent to the counter-movement of food away from famine regions that Sen talks about.
- vi) Policy responses to water scarcity often focus on pumping or moving more water to a region suffering from water scarcity. These are akin to the so called ‘direct delivery’ method of supplying food in case of famine relief (Dreze and Sen 1989: 85).

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 endowment¹² of person i as follows:

$$E_i = \sum_j m_{ij} * Q_j \quad (1)$$

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

If we feel that some sources are of poor quality (say, unprotected) then a distinction can be made. If we assume, all sources to be substitutable to each other, then we have the additive formulation as above. Similarly, if salinity affects some of the sources, it is possible to adjust the endowment calculation accordingly. Another important element concerning water quality affects entitlements through the relationship between access to energy, energy prices and the marginal rate of substitution between energy and water.¹³ In a two-dimensional case, households have a budget constraint (consisting of income and time, which can also be converted into income) and have two goods to choose, water on one axis and a composite good (of all other commodities, including leisure) on the other axis. Due to inequality in access to energy or the differential impact of energy prices on different households (for example, some may have access to subsidy), the poor may face a rate of transformation between the two goods which is steeper than the budget line. As a result of this entitlement deprivation, the poor settle for poor quality water and thus, be more vulnerable to health impacts and so on.

In this background, I will examine water supply provision in Chennai and will attempt to use the entitlements approach to discuss inequality in access. As in any field, the price of specialization (in the form of evolution of literature into various strands) is a partial vision. What institutions can or cannot do may depend on what individuals need and what they themselves can or cannot do and this may in turn depend on the property rights and issues of access.

3 Water supply provision in Chennai

According to the WHO-UNICEF (2000) assessment, world wide, 94 per cent of urban population compared to 71 per cent of rural population is 'covered' by water supply.

¹² 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.

$$E_i = \sum_j m_{ij} * Q_j^{Pub} + \sum_k m_{ik} * Q_k^{Prv}$$

¹³ Thanks to Tony Addison for pointing out this possibility to me.

The Government of India (2000: 208) estimated that 90.2 per cent of India's urban population is covered by water supply. As per the Chennai Metropolitan Water Supply and Sewerage Board (hereafter referred to as CMWSSB, or the Metro Water Board), 92 per cent of households in Chennai are covered by water supply (CMDA 1995: 92). The above figures seem to suggest that as far as the urban areas are concerned, the global development target has already been achieved or is easily achievable. Yet, even a casual visitor to cities such as Chennai will notice quite a lot of activity going on in relation to securing water, both by firms as well as by individuals – an observation that appears to be incompatible with the statistic suggested above.¹⁴

This study uses the data-set from a primary household survey in Chennai (Anand 1996). Reference is also made to various documents and interviews with local policy makers and researchers in Chennai at different points in time during the period 1996-2000. Details of the household survey are provided in Appendix 1.

3.1 Institutional arrangements in Chennai

Depending on where one lives within Chennai metropolitan area, four distinct systems of water supply can be found in Chennai:

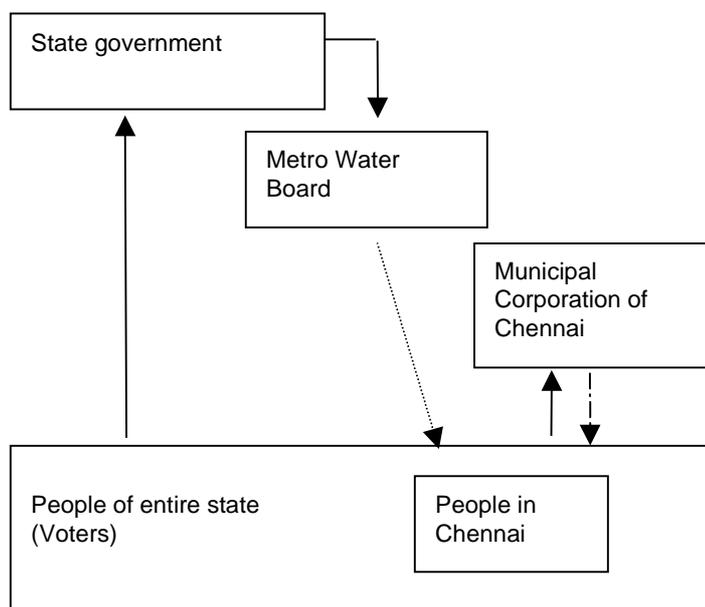
- i) Supply of water by the Metro Water Board – mainly for Chennai City;
- ii) Municipal supply – in 9 towns adjoining Chennai;
- iii) Self-provision by many households and industries – by drilling of shallow wells or deep tubewells;
- iv) Private market – (a) bulk supply by means of tanker trucks of 12, 000 litres capacity and (b) retail distribution of 'bottled water' in jerry cans of 10 or 12 litres capacity.

In relation to the generic models discussed in Figure 1 earlier, water supply in Chennai was originally of model C (when water supply was one of the services provided by Chennai Corporation). In 1978, the water supply and sanitation functions were moved from Chennai Corporation to a state government board, namely the Metro Water Board (see Figure 2). Thus, the arrangement shifted slightly towards model CB. However, this seems to have created problems of accountability.

Voters in the entire state elect 234 members to the state legislature. Of these, 14 are elected from constituencies contained within Chennai City and another 6 from constituencies contained in the rest of Chennai metropolitan area. The party having a simple majority in the state legislature forms the state government. Thus, as a creature of the state government, the Metro Water Board is accountable (through the state legislature) to the entire population of Tamil Nadu state (approximately 50 million) rather than to the people of Chennai (6 million) though it supplies water only to people of Chennai City and a few adjoining areas (and not even the whole of Chennai metropolitan area).

¹⁴ About 30 years ago, Ashokamitran's (1994) Tamil novel was centred around individuals in Madras trying to secure water. Various newspaper reports in recent times also give an indication of water scarcity and shortages. See the archives of The Hindu at the URL: <http://www.hinduonnet.com/thehindu/>

Figure 2
A conceptual view of Metro Water Board in relation to its customers



To make Metro Water Board more directly accountable to its customers, it can be moved back to model C (proponents of democratic decentralization) or towards model BB (where it is made more autonomous but also subject to independent scrutiny) or it can be privatized (model A). Each arrangement has its own pros and cons.¹⁵

During 1998, the Metro Water Board issued a citizen's charter (CMWSSB 1998) with the apparent intention of making it more responsive to its consumers (a step in the direction of model BB in relation to Figure 1). Also, during 1998-2000, a committee was set up jointly between the Metro Water Board and the Corporation of Chennai to be chaired by the Mayor (a step in the direction of model C in Figure 1). However, these remained ad hoc measures issued by executive fiat rather than formal arrangements made by amending the existing laws. If the intention is to make the Metro Water Board more responsive and accessible to its consumers, why not amend the law rather than use executive provisions?

Public policy is not made by an autonomous and altruistic agents. A plausible explanation for the short term reforms is that by keeping an important local service (water supply and sewerage) under its control, the state government can influence how

¹⁵ A reading of the Tamil Nadu State Water Policy issued in 1994 (G.O. Ms. No. 716 PW (WR) Department dt 13-07-94) indicates: (a) an excessive and exclusive focus on engineering aspects and a blue-print attitude; and (b) an emphasis on 'integrated' management of water resources which is presented as a justification for centralization of decision making to the extent to conceive of several layers of committees with a grand committee of 36 members (including several members of the rank of Secretary to the government) at the top to be chaired by the Chief Minister which is supposed to make decisions in relation to all aspects of water resources management, formulate policy and decide on projects. This large committee is supposed to meet periodically, at least once every three months. In this climate, the prospects for moving to model C appear rather limited.

citizens perceive the performance of local government and hence, the prospects of its candidates being elected. Let us imagine two political parties A and B, of which A is in power in the state government (and hence, controls the Metro Water Board). Its decision whether Metro Water Board should improve its performance or not depends on who is incumbent at the local government and what its own prospects of getting elected to the local government are. The possibilities faced by the state government are shown in Table 1 below.

If the probability of party A winning the local elections is either very high or very low, it seems that the performance of a local level service does not matter. A strategy about performance of services may be crucial only when elections are competitive and hence, the chances of winning are perceived to be low or marginal. In that case, the state government’s strategy seems to depend on which party is incumbent at the local government. If A is incumbent at the local government and it faces a stiff challenge, then the state government has incentives to use its power to improve the performance of the Metro Water Board. If the local government is presently controlled by the opponent (B), then the state government may have incentives to actually make the Metro Water Board worsen its performance. In all other cases, the state government has no incentives to improve the performance of the Metro Water Board.

The above is just one explanation of how the state government may use the performance of the Metro Water Board to influence the politics concerning the local government. In a different context, for example, when there is a liquidity problem with regard to state government finances, good performance by the Metro Water Board may be helpful to raise resources for new projects (which are then diverted to meet with the short term liquidity problem). In this climate, irrespective of which political party is in power, the state government has incentives to remain myopic and keep reforms of organizations such as the Metro Water Board in an *ad hoc* and temporary manner rather than enshrine them in the law.

Table 1

Should the Metro Water Board co-operate with the local government and improve its own performance (when the state government is of party A)?

Incumbent in the local government is:	The chances of A being successful at local government elections		
	Very low	Low or marginal	High
A	<i>Don't bother</i>	<i>Co-operate</i>	<i>Don't bother</i>
B	<i>Don't bother</i>	<i>Don't co-operate</i>	<i>Don't bother</i>

3.2 Households as per the main source of water supply: census 1991

While the models above concern piped water supply, it forms just one of the various sources from which Chennai households get water. As per the 1991 Census, Chennai urban area had about 1.01 million households. Distribution of these households according to the main source of water is given in Table 2 below.

From the above table, we can see that about 35 per cent of all households in Chennai depended on a well as their main source of water. Another 22 per cent of the households depended on a tubewell or a handpump, which draws water from deep ground water aquifers. Within Chennai City, only 44 per cent of all households drew water from a tap.¹⁶ The share of people drawing water from a tap in the urban agglomeration area (outside the City) is even lower. Information from Census thus, seems to suggest that the coverage figures mentioned in the official documents may be inflated or that the definition of coverage may be problematic.

Table 2
Number of households in Chennai Urban Agglomeration (CUA)
as per main source of water: 1991

	Within the premises		Outside the premises		Total		Entire CUA
	Chennai City	Rest of CUA	Chennai City	Rest of CUA	Chennai City	Rest of CUA	
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: Data from the Census of India, 1991.

3.3 A portfolio of water sources: 1996 survey

The Census figures above indicate that households in metropolitan cities such as Chennai often depend on more than one source of water. They may be doing this because of risks from various sources, the property rights and other factors governing access to such sources, the water needs of the household, opportunity cost of labour (determined by the number of members in the household and labour market participation rates), quantity and quality of water from different sources and so on. Table 3 presents information from the Chennai household survey on the distribution of households having access to various sources of water.

¹⁶ This is (335, 125/760635). More than a third of these households (i.e., 129, 360 out of 335, 125), in fact, depend on a tap which is outside the premises.

Table 3
Households in Chennai as per various sources of water: 1996

	Chennai City	9 Towns	Total for CMA
A No source within the premises	19.3%	16.1%	17.6%
B Shallow well	16.5%	54.8%	29.1%
C Tubewell	6.4%	--	4.7%
D Shared Municipal Tap Connection	8.3%	--	6.1%
E Municipal Tap Connection	4.6%	6.5%	4.7%
F Well and Connection	15.6%	16.1%	14.9%
G Tubewell and Connection	27.5%	3.2%	20.9%
H Well, Tubewell and Connection	1.8%	3.2%	2.0%
I Sub-total for households with connection categories (D+E+F+G+H)	57.8%	29.0%	48.6%
Total for all categories	100.0%	100.0%	100.0%

Source: Author's calculation from the household survey, 1996.

It can be seen that about 42 per cent of households in Chennai City and more than 70 per cent of households in the rest of CMA are not covered by the piped water supply system. These figures are in line with Census results mentioned above. About 37.8 per cent of households in the metropolitan area and 44.9 per cent of households in Chennai City depend on more than one source of water. Among the households living with Chennai City, the largest category is that of households having a tap and a tubewell (27.5 per cent).

3.4 Estimating the allocation of water to different users

A simple definition of water supply is the transfer of water from certain sources to certain end users. To make water supply effective, the water planner needs to take into account all three aspects, namely, source development, the process of transmission, the demands of different end users. Decisions concerning one can impinge on the effectiveness of interventions concerning the other aspects. In Chennai, over the last three decades, a lot of attention focused mainly on *increasing* the sources of water, the other two dimensions have concerned relatively less attention.¹⁷ A balance sheet may be a useful tool to get a glimpse of all three aspects of water supply. I have attempted to collate various sources of information including the household survey conducted by me in 1996, data from the Census of India, data from the Central Groundwater Board, the

¹⁷ Much attention focused on bringing water to Chennai from distant sources. In 1983, an agreement was signed with the neighbouring state of Andhra Pradesh to draw 12 TMCft of water from river Krishna (Government of Tamil Nadu 1983). In September 1996, the first phase of this project was inaugurated and about 3 TMCft or roughly 200 million litres per day (MLD) has been added to raw water supply for Chennai. See Ramakrishnan (1996), for some details. Also see various reports in The Hindu on efforts to bring water from Neyveli, Erode, Mettur and Tirunelveli (13 July 2001); Palar (26 July 2001); Veeranam (19 August 2001); and setting up of two desalination plants in Chennai (25 July 2001).

Institute for Water Studies, the Metro Water Board (CMWSSB 1995), and so on, the details of which are discussed elsewhere (Anand 2001). The resulting water balance sheet is shown below in Figure 3.

According to the water balance sheet, in an average year, before the Krishna water project, Chennai 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 per cent of 600.1 MLD) came from surface sources and the remainder came from ground water sources. Of this, the Metro Water Board's supply was about 380 MLD. As per the Metro Water Board, in 1996, water supply was about 290 MLD and with the water received from Krishna project, this was increased to 480 MLD (CMWSSB 2000). However, 'due to poor rainfall and lesser receipt of water from the Krishna source', the total quantum of water supplied by the Board once again declined to about 250 MLD in 1999 and 2000. Though the water balance sheet developed here relates to the position before 1996, the overall picture in terms of relative shares, specially the user side of it, is unlikely to have changed significantly.

With regard to end-uses, (a) 71 MLD of water was supplied to metered connections (to non-residential users); (b) 302 MLD of water was supplied to unmetered connections of which 101 MLD was supplied to residential use (including 4 MLD for public fountains); (c) 10 MLD of water was supplied to static tanks by tanker trucks of Metro Water Board. This is summarized in Table 4.

In Table 4, the expression private sources includes supplies from the so called water vendors and also self-provision by households (from wells and tubewells). According to the information provided by the Metro Water Board, the survey of 50 water utilities (McIntosh and Yniguez 1997) lists Chennai amongst cities with 'no significant water vending'. However, this is contestable. Water vending in Chennai can be seen in terms of three categories.¹⁸ The first category is that of wholesale operators who supply water by tanker trucks of 12, 000 litres. As shown in the balance sheet, supply from this source was about 8 MLD. The second category is that of 'bottled' water, supplied mainly in 12 litre jerry cans. A number of private firms are engaged in this activity. Supply from this route works out to about 0.1 MLD. The third category is that of retail water vendors who supply drinking water to households not having water connections. These mainly draw water from the 'static tanks'. These were about 3, 700 in 1996, scattered through out Chennai. Each tank has a capacity of about 3, 000 litres. These are filled everyday by tanker trucks of Metro Water Board. Vendors then draw water from these tanks and supply it to their customers. A majority of them have improvised a bicycle to transport water, while a small number of them have been using specially built push-carts or tricycle carts with a large drum. As seen from the water balance sheet, about 10 MLD was supplied through static tanks. About a third to one half of this is taken by water vendors while the rest is taken by households in the vicinity of the static tanks. Thus, the extent of water vending can be placed at about 11.4 to 13.1 MLD (or about 2 per cent of 600.1 MLD). In recent years, Metro Water Board has increased the number of such tanks to about 5, 500 and that these are filled every day by making 3, 800 trips by tanker trucks contracted by Metro Water Board, to distribute about 35 MLD (CMWSSB 2000). Increasing the number of static tanks appears to be a policy response to keep prices in this segment low.

¹⁸ For details on water vending in Chennai, see Anand (1999b) and Anand (2001).

Figure 3
Water balance sheet for Chennai urban agglomeration: 1996

(figures in MLD)

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

Source: Anand (2001).

Table 4
End uses of water in million litres per day (MLD)

	By public sector	Private sources	Total
Residential ¹⁹	193	131.1	324.1
Industrial	47	?	47
Commercial	9	4	13
All other uses	101	?	101
Unaccounted for water	115	?	115
Total ²⁰	465	135.1	600.1

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

3.5 Explaining the interaction between regulation of ground water and market response

From the balance sheet, we see that the Metro Water Board depends on ground water for nearly a half of all water it supplies. In 1987, the state government enacted the *Chennai Metropolitan Area Groundwater (Regulation) Act, 1987*, giving additional regulatory powers to the Metro Water Board.²¹ Under this legislation, certain areas around Chennai are listed in the schedule and in those areas, everyone who sinks a well or drills a tubewell needs to obtain a license. Similarly, anyone transporting water by tanker trucks also needs to obtain a license.

Apart from having one's own well, the two main suppliers of water to consumers are the Metro Water Board (or government) and the wholesale water vendors (or the market). Thus, for simplicity, we can analyse this as though there were just two producers whose interaction is shown by a reaction function (following Cullis and Jones 1992: 399). This is shown in Figure 4.

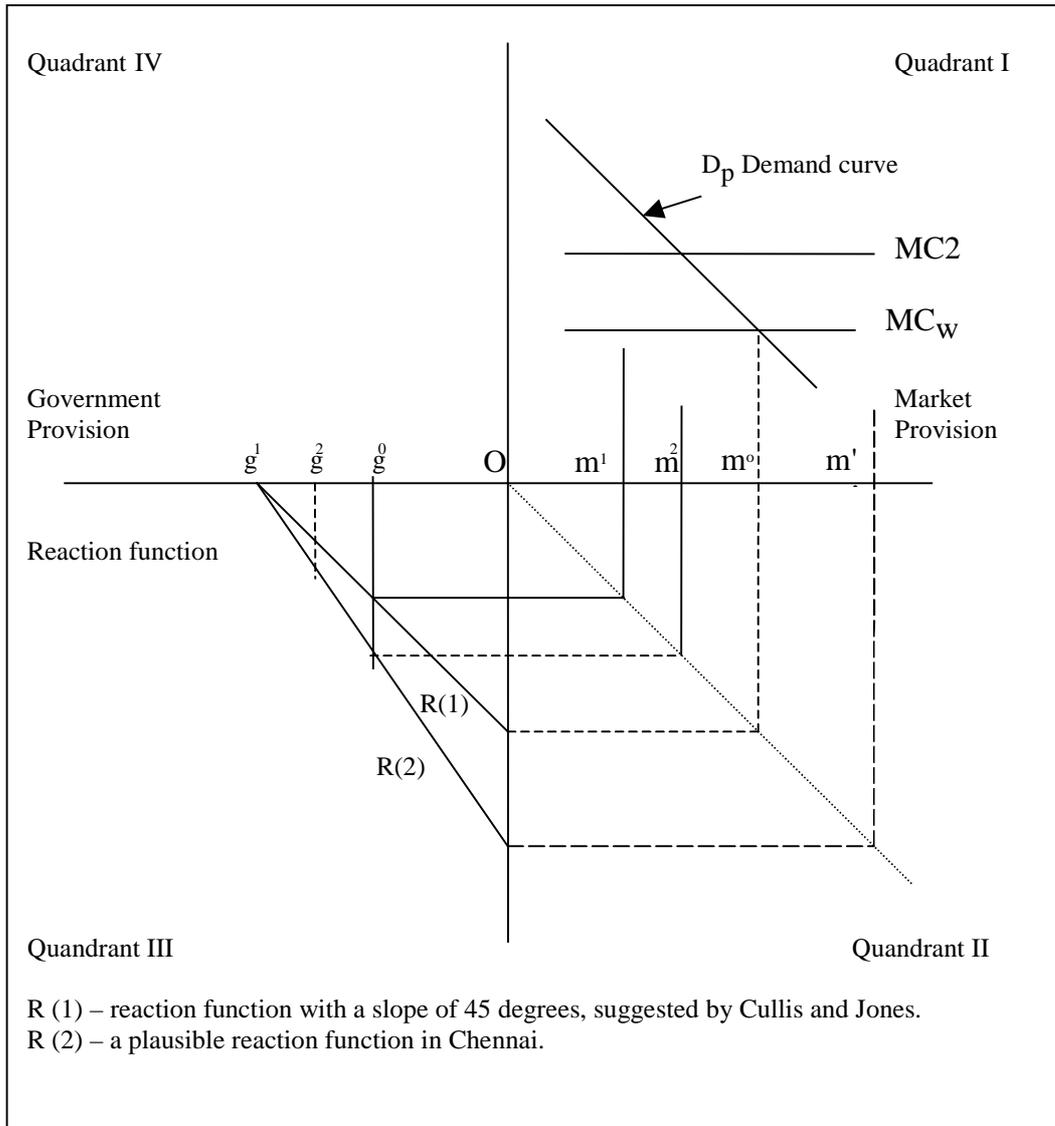
Quadrant I relates to market provision of water. Quadrant IV indicates the government provision. The assumptions here are: good G (water per capita per day) is a rival good and both public and private sectors can produce this at a constant marginal cost of MC_w . If there were no public provision, the 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,

¹⁹ 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 (bottled water).

²⁰ This is given by 433 (from Metro Water) + 32 (from municipal sources in CUA).

²¹ Apart from Gujarat, Tamil Nadu is the only state in India to have a ground water regulation law that gives licensing powers to the water utility. Supporters of this regulation argue that because of it, the fall in water table in some coastal villages in the outskirts of Chennai has been arrested (Ramakrishnan, n.d.). However, as I argue below, this regulation may also have favoured bigger firms among water tanker operators and thus, make the market structure oligopolistic.

Figure 4
Ground water regulation and private sector response in Chennai



let us assume²² that 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

²² There are four reasons why the government does not produce the entire quantity. (a) Given that individual households have inalienable right to ground water through their property right to land, the government feels that it cannot realistically claim the entire quantity. (b) Property rights, in terms of government owned well-fields, limit public water supplies at Og^0 . (c) The government does want to produce the entire quantity but by the time the projects are implemented, population growth takes place, effectively creating a shortfall. (d) Government's limited resources are needed for supplying pure public goods which will not be supplied by the private sector. As water supply is not a public good, there is scope for market provision. The government takes this into account and hence, decides to produce Og^0 which is $< Og^1$. Another possible reason which can only be hypothesised is that the government is interested in keeping the problem alive to use it as a tool periodically at the time of elections. This may also be linked to the argument that the system has created a *transitional gains trap*: 'once a rent has been successfully sought out through government lobbying, it is very difficult to

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 the 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):

$$G_t = G_g + P_m$$

$$P_m = Om^0 - a G_g + b (G_g - T_g) \quad (2)$$

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:

$$\frac{d P_m}{d G_g} = -a + b \quad (3)$$

The reaction function R(1) is one where $a=1$ and $b=0$. For a case like water supply, 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 the Metro Water Board, people of Chennai may have $a>1$. Therefore, it is conceivable that the reaction function in Chennai for water has a slope of more than -1 (i.e., a steeper R(2)). The implication of steeper R(2) can be explained as follows:

- i) If the government does not provide this service, the 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.
- ii) 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 the 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 .

remove even after it has ceased to produce positive profits for its rent seeking beneficiaries’ (Tullock 1993: 68).

- iii) However, in consumers' view, water supplied by public sector and private sector are not perfectly substitutable. They use a steeper $R(2)$. Given Og^0 , they require Om^2 from the market.
- iv) As the regulation limits the market to supply Om^1 a water shortage occurs.
- v) 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 .
- vi) Grey market activities may result in over-extraction of water in nearby sources pushing the marginal cost of extraction to $MC2$.
- i) 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 thereby further increasing grey market activity and political pressure to increase government supply.

This seems to be a plausible summary of what has been happening in Chennai with regard to ground water regulation. It is a rather simple model based on assumptions about rational behaviour by both planners and by private agents/water traders.²³ Notwithstanding the limitations of these assumptions, there are some issues concerning regulation. The stringent licensing requirements to transport water (through tanker trucks) or to sell water have the effect of restricting market response to Om^1 assuming the reaction function to be Og^0 . The above discussion suggests that the regulation should not be limited to controlling the number of tanker trucks but should be made more flexible to facilitate markets to function and at the same time have provisions stringent enough to ensure that aquifers are not irreversibly damaged (through over extraction) or that water trade endangers water supply provision in the metropolis. For simplicity, one may refer to such regulation as *framework regulation*.

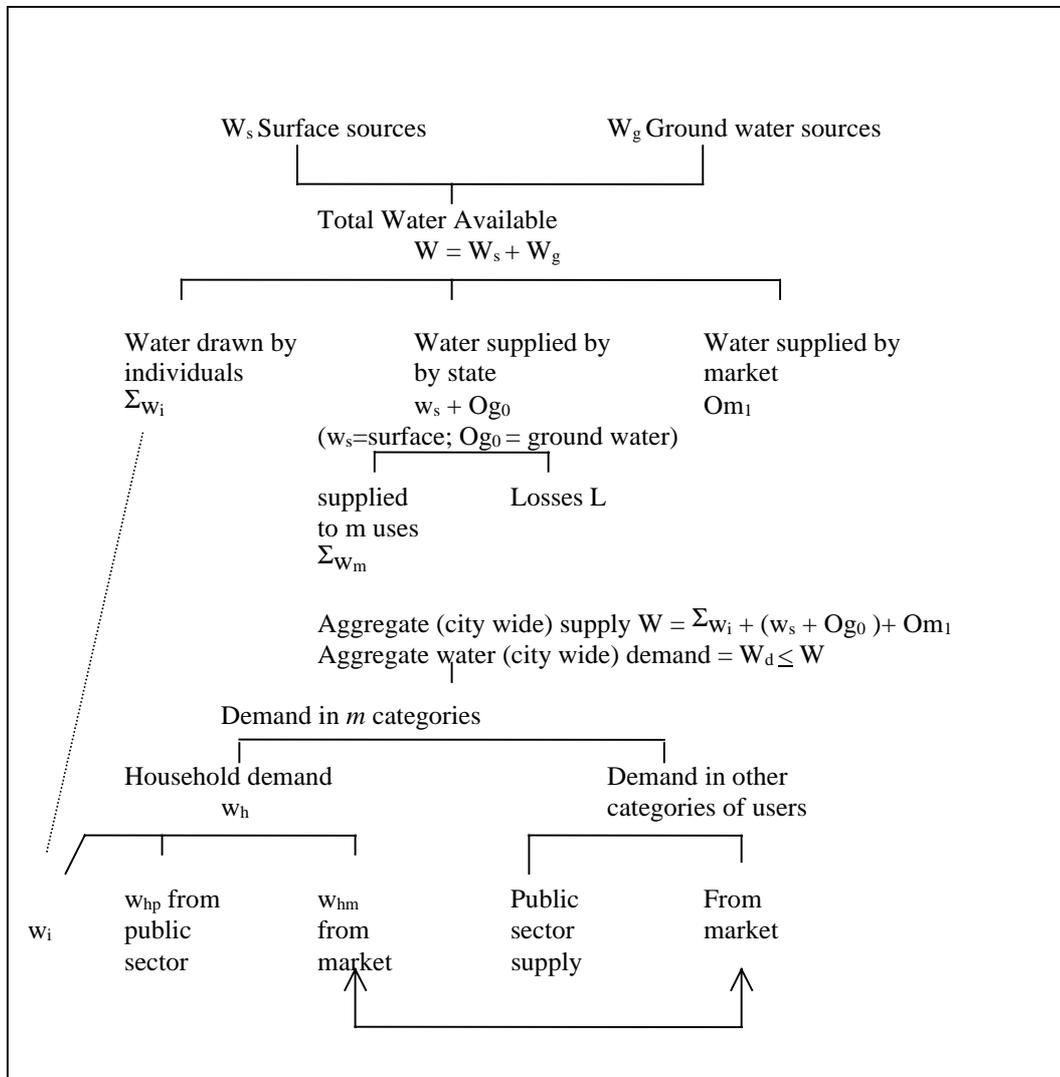
As mentioned earlier, there is also scope for introducing some kind of 'tradeable water rights' (equivalent to result in a supply of Om^1). These aquifer rights can be valid for a specified period of time and these can be auctioned to reflect the market price. A provision could be created such that some of the rents accrue (or are earmarked) to the local communities where the aquifers are located. At present, any such rent is appropriated by those who own the tubewells and by the water tanker operators. Covenants can be written into the agreements such that limitations can be placed on these rights (with due process and transparency, to avoid arbitrariness).

²³ In the case of water supply planner, the assumptions are that such a planner (a) behaves rationally and (b) makes decisions in public interest. Either of these assumptions may not work: the planner may be making incorrect (or uninformed) decisions or s/he may not be making decisions purely in public interest. Besides standard textbook arguments such as empire-building (by expanding the bureaucracy), rent-seeking etc., the planner may also be partisan and colludes with political party in power. In the case of water traders, violation of rational behaviour assumptions can take place in several ways: (a) having an *inertia* to react to market demand (which may not be entirely irrational, if it is due to high fixed costs and seasonal variability in demand); (b) not having full information about the sources; (c) not recognizing various risks and taking adequate cover and so on.

3.6 A suggested framework to develop the water balance sheet into a computable general equilibrium model

I recognize that the discussion so far has been a static analysis. An alternative approach is to use a partial or general equilibrium framework (Devarajan, 1997; Gunning and Keyzer, 1995; Goldin and Roland-Holst, 1995; Ringler 2001). This lies beyond the scope of this work but the water balance sheet developed in this paper can contribute to the development of a general equilibrium model for water markets in a metropolitan city with multiple sources and uses of water. In Figure 5, I have shown one possible way to approach water balance for a city using CGE.

Figure 5
A possible way to approach water balance for a city using CGE



The above framework indicates the need for concentrating both on supply and demand sides of water supply management in a city such as Chennai. It indicates of the potential link between the water supplied by Metro Water Board, and the other sources that households already have (w_i) and what they will buy from the market. Household decisions can have an impact on water prices for other submarkets (such as hotels, business, construction and so on). These demand factors together with regulation determine how much water will be supplied by private sector (Om_1). Of course, we need to be careful not to fall into the trap of an overly deterministic or mechanical emphasis on equilibrium. The aggregate supply and demand sides may not match because of natural constraints (such as monsoon failure), imperfect information, interaction between the different sub-markets, the role of a rent-seeking state in projecting itself as the monopoly supplier of some aspects of water supply and also using its regulatory powers to affect the roles of other agents and so on. Secondly, even if the aggregate supply and demand do match, a city-wide analysis may not sufficiently reflect the inequality in access discussed earlier.

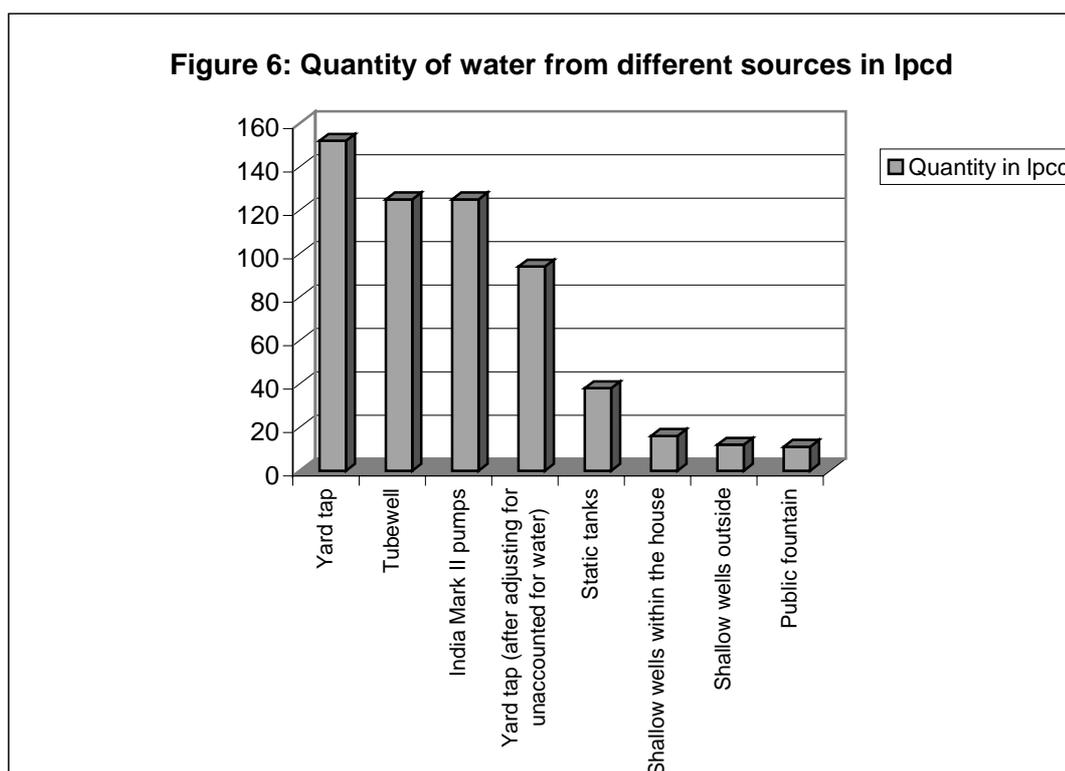
4 Exploring inequality in access to water

4.1 Distribution equity

As discussed earlier, a national, regional or city-wide statistic will not reveal inequality in distribution. 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 quantities of water delivered by different sources (Figure 6).

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 the total number of connections including public fountains), that works out to 11 lpcd.

As shown in Table 3 earlier, we know from the 1996 survey the various sources of water supply used by each household. That information can now be combined with the above estimate of quantity of water per capita from each source. For example, a household in row 1 in Table 3 (no source within the premises) has no command over water supply at all. On the other hand, a household having a well and a connection (row 6 in Table 3), can on average get about 94 lpcd from the connection and another 16 lpcd from the well: a total of 110 lpcd. A household having a well, a tubewell and a connection, thus, commands: $125 + 94 + 16 = 235$ lpcd.



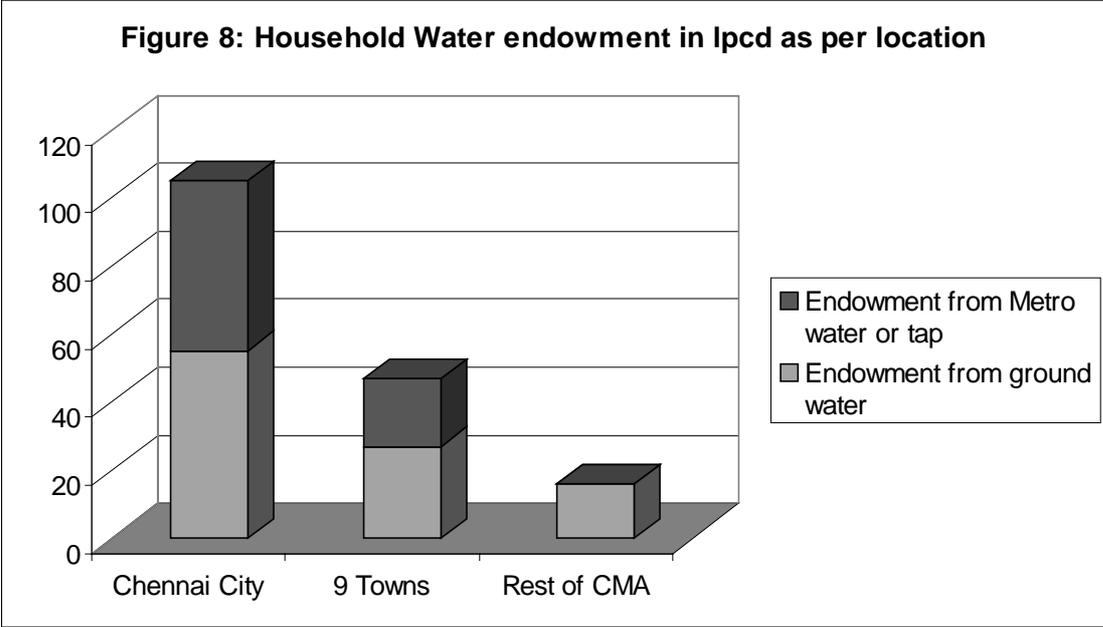
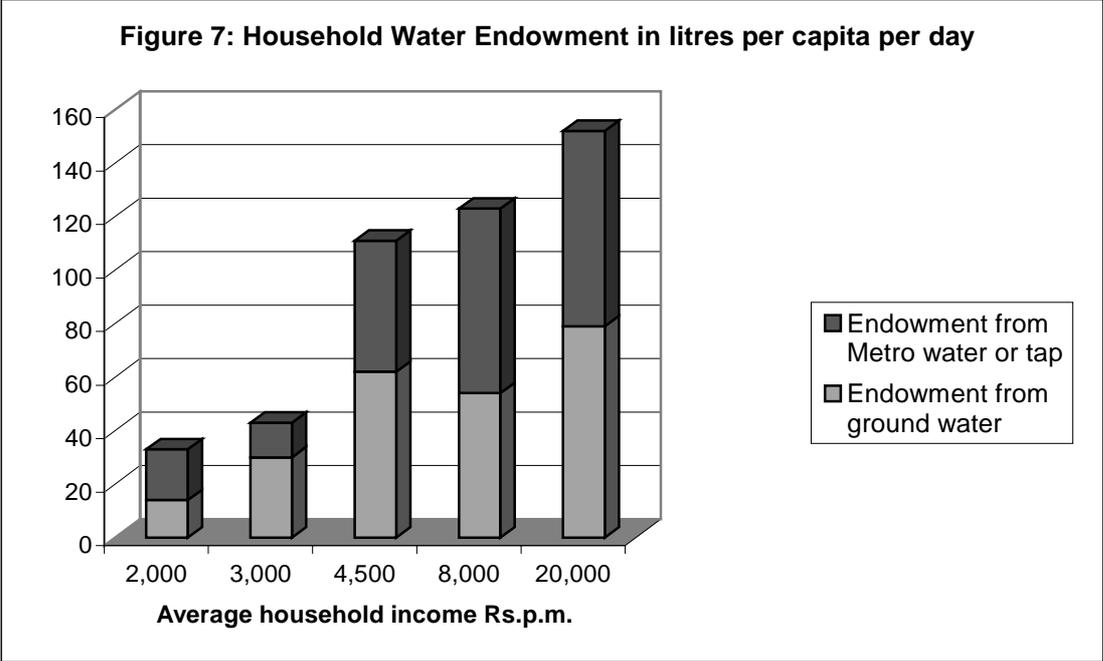
4.2 Estimating water endowment

As discussed in section 2, I have attempted to use entitlements approach to calculate the water endowment of a household based on their access to various sources. Table 5 below summarizes the endowments for households in different income groups.

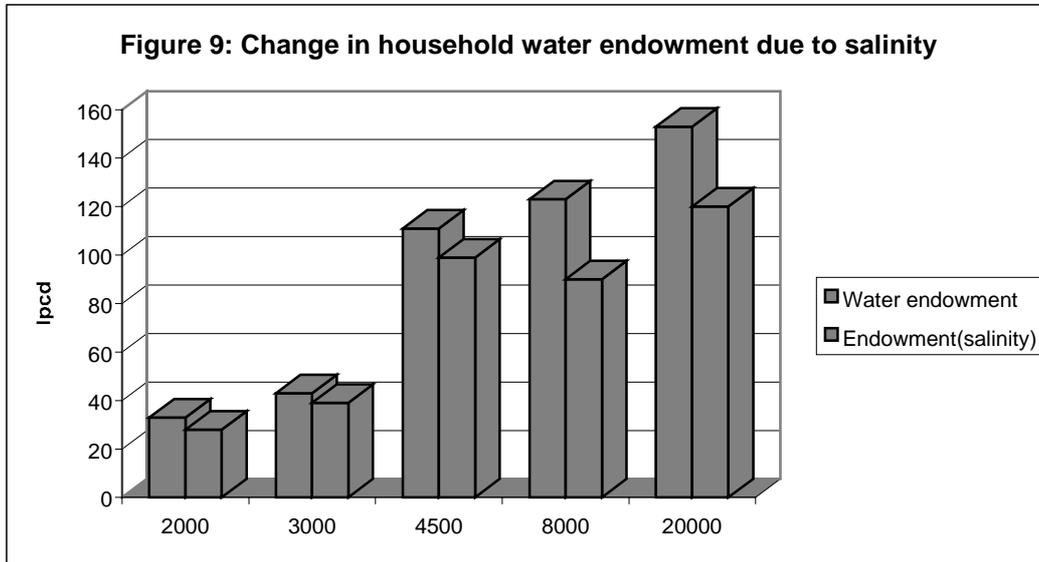
Table 5
Households in Chennai as per income and water endowment

Water endowment in lpcd	Households as per monthly income group with mean income Rs.					All income Groups
	2,000	3,000	4,500	8,000	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%
All (N)	100.0% (20)	100.0% (44)	100.0% (32)	100.0% (33)	100.0% (19)	100.0% (148)

The figures in table 5 indicate that in general, the poor have less endowment of water (also see Appendix 2 for water endowment ladders for households in different income groups). For example, 65 per cent of the lowest income group do not have any source of water in their premises. Another 10 per cent depend of shallow wells that provide only 16 lpcd of water and so on. The arithmetic mean figures for each income group are reported below in Figure 7. There is an indication of a positive association between income and water endowment. In terms of location, we can see that households in Chennai City have nearly twice as much water endowment as those living beyond the City limits in the 9 towns and in the metropolitan area (Figure 8).



Further, from Figure 9 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.



Using the water endowment, it is possible to see the distribution implications which the coverage figures do not show at all.²⁴ We see the appalling inequality in access to water which is completely ignored by the coverage figures and per capita water supply figures. The water endowment ladders (in Appendix 2) show that the poorest households in Chennai have to manage with about 30 lpcd of water as compared with about 150 lpcd that the richest households in Chennai could get. Inequality in access to water reflects the embedded inequality in opportunity in the urban economy. However, covering up this inequality with the use of distribution-neutral language of ‘coverage’ figures is at best a scandal.

4.3 Implications of an entitlements approach

An entitlements approach emphasizes the need to see the problem as one of ‘some people not having enough water’ rather than one of ‘there being not enough water’ (following Sen 1981). The above discussion indicates that an entitlements approach clarifies inequality in access to water supply and why some interventions (such as bringing more water to Chennai) may not have significant impact on the poor. While water balance sheet helps us to understand the allocation of water to different end-users, entitlements approach helps in understanding one specific group of such end-uses, namely supply to households. Entitlements approach helps in understanding why within

²⁴ It is possible to construct Lorenz curves to examine the distribution issues. This has been shown in Anand and Perman (1999: 37). It was seen that the bottom 40 per cent (i.e., poorest) households get less than 5 per cent of water supplied in Chennai whereas the top 20 per cent (richest) households get about 55 per cent of water.

a single city, lush green lawns and long queues and verbal and physical conflicts for water can co-exist.

The discussion above has clearly shown that water endowment is a much better indicator for policy purposes rather than per capita water availability or percentage of population covered. The Metro Water Board has already recognized the need to distinguish between those who have access to piped water supply and those who do not have this access (CMWSSB 2000). Unlike the earlier figure of 92 per cent (mentioned at the beginning of the paper), the above report uses a figure of 70 per cent of population having access to piped water supply, much closer to my 1996 figure of 58 per cent (Table 3). From the figures in Table 3, we also know that of those who have access to water, some of them share a connection. Thus, in theory, they have access to piped water, the water that they do get may depend on micro-level issues of ownership and control. Another study (Bajpai and Bhandari 2001) based on National Sample Survey data from 31, 323 urban households also finds that about 70 per cent of all urban households depend on tap water (as opposed to the figure of 90.2 per cent given by Government of India). They also find that of those who have access to tap, some 54 per cent require sharing with other households.

I have already mentioned various reasons why an entitlements approach is relevant to water. Other researchers (Webb and Iskandarani 1998) have used the expression 'water insecurity' to focus on similar issues. However, I feel that entitlements approach has advantages in terms of explaining acquirement problem and legal, political and social institutions governing access. Further, it enables us to understand water scarcity from a completely different perspective of individual capabilities rather than a problem of commodity. Inadequate or improperly defined entitlements limit the functionings of the households and hence their capabilities, and thus, diminish their well-being.

5 Household responses to water quality

In the previous sections, the focus has been mainly on the quantity aspects of water. As mentioned in section 2 earlier, in interpreting entitlements issues in case of water, quality has relevance specially in relation to access issues. In many cities in the developing world, some water borne diseases are endemic.²⁵ Depending on income and perceived health risks, households often take steps to deal with water quality, specially, with regard to water for human consumption (drinking and cooking). Table 6 provides information on steps taken by households in Chennai to improve water quality. About 37.2 per cent of all households drink water without substantially improving its quality.²⁶

²⁵ As per the World Bank (1993), in the case of India, communicable diseases constitute 57 per cent of all disease burden for women, and 54 per cent for men. For both women and men, nearly a fifth of disease burden due to communicable diseases is due to diarrheal diseases where water supply could play a role.

²⁶ Total of first three rows in Table 5. 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 6
Water quality and household responses in Chennai

Water quality response	Mean Monthly Income Rs.					Entire Sample
	2,000	3,000	4,500	8,000	20,000	
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 and candle filter			28.1%	30.3%	15.8%	16.2%
Ultra-violet filter			3.1%	18.2%	36.8%	9.5%
Bottled water				3.0%	10.5%	2.1%
UV filter and bottled water					10.5%	2.0%
Entire sample	13.5%	29.7%	21.6%	22.3%	12.8%	100.0%

Improving the quality of water involves some allocation of resources by the household (capital costs, fuel, time). Hence, as can be expected, response to water quality indicates a strong association with income: the higher the income, the 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 per cent 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 in Table 7.

Table 7
Water quality versus education and crowding

Household response to water quality	Years of schooling	Persons per room in the household
Drink as it is	7.0	2.99
Boil some times	8.0	2.51
Use candle filter	10.2	1.06
Boil always	13.0	2.17
Boil and use candle filter	13.2	1.65
Use ultra-violet filter	14.0	0.93
Use bottled water	17.0	1.33
Use UV filter and bottled water	15.7	0.79

It is interesting to see from the survey data that domestic fuel source (in terms of access to cooking gas or LPG) has an impact on the boiling of water as a household response to water quality. This is seen in Table 8.

Table 8
Water quality versus availability of gas connection

Water quality	Households as per gas connection available		Entire sample
	A	B	
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 and candle filter	4.2%	95.8%	16.2%
Ultra-violet filter		100.0%	9.5%
Bottled water		100.0%	2.1%
UV filter and bottled water		100.0%	2.0%
Of all households	37.2%	62.8%	100.0%

Note: For each row, figures in columns A and B add to 100. Figures in C are column-percentages.

Having a cooking or LPG gas connection seems to be the most significant parameter for people to boil water (to reduce the risk of water borne diseases). It is very interesting to notice that in terms of the five income groups, in the lowest income group (mean income Rs. 2000) not a single household had access to gas (0 per cent). In the highest income group, every one had access to gas (100 per cent). The percentage of people in the income group not having gas connection falls dramatically as one moves up the income ladder. Thus, the poor households who do not have access to gas, are more likely to drink water as it is and not boil it or improve its quality in any manner and hence, are likely to be more vulnerable to health impacts. This highlights the point about entitlement deprivation due to lack of access to energy.

6 Household expenditure on water

In this section, I want to explore briefly, household expenditure²⁷ on water. Such expenditure comprises three elements: direct payment (such as water charges, payments made to vendors or water sellers); expenditure in terms of time spent collecting water

²⁷ These are actual expenditures. In a forthcoming paper, I discuss details of survey based estimates of willingness to pay and the implications.

(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 expenditures²⁸ are shown in Table 9. These figures are averages for households in each income group.

Table 9
Household expenditures on water

Mean monthly income Rs. Per month	Average Costs Rs. per month per household in the income group				Share of expenditure on water supply in monthly income
	Direct costs (quantity)	Cost of time	Expenditure on quality improvement	Total expenditure on water per month	
2,000	11.50	24.47	6.30	42.27	2.1%
3,000	16.14	27.19	18.20	61.53	2.0%
4,500	40.94	16.97	27.56	85.47	1.9%
8,000	50.30	5.77	69.03	125.11	1.5%
20,000	60.53	0.00	123.11	183.63	0.9%
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	

Though there is some variation in expenditures towards water quality, highest variation (as seen from μ/σ) is in terms of direct costs (or costs towards quantity). It is also 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. From the last column in the table, we can see that the poor do spend a higher proportion of their income on water as compared to the rich.

6.1 The relationship between expenditure on water and income

In the household survey in Chennai, data on income was not collected. However, based on a number of parameters, each respondent was placed in one of five income groups. Based on focus group discussions and discussions with researchers in Chennai, the corresponding class interval of income for each of these 5 income groups has been and hence, the mean monthly incomes have been. During the pre-tests, respondents approved of these mean monthly income figures. Hence, exploration of relationship between expenditure on water and income (shown in the Curves and Table 10 below) has some limitations.

²⁸ Details of the estimation are in Anand (2001).

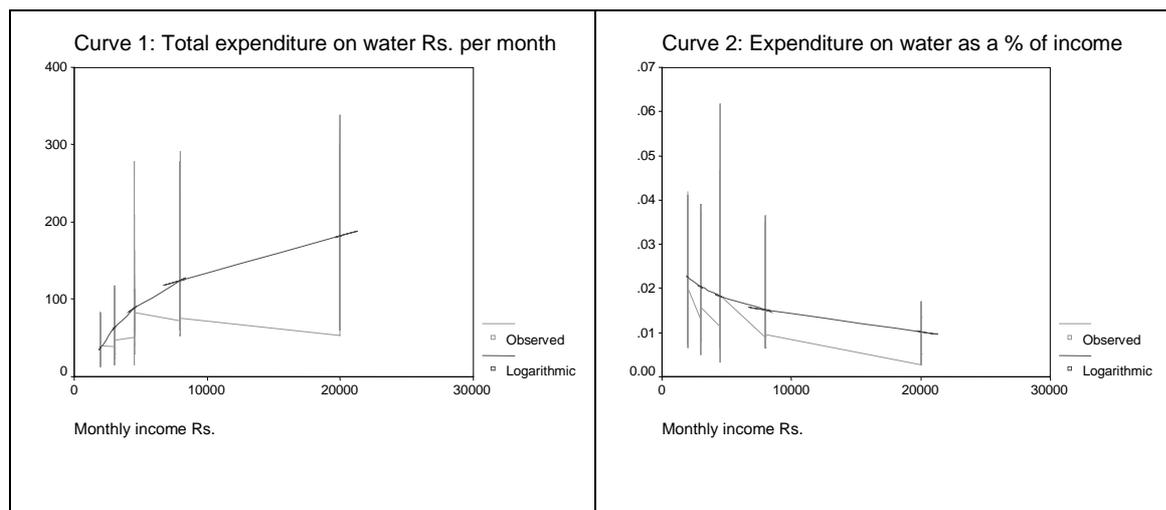


Table 10
Expenditure on water and income relationship

Dependent variable	Constant	Log (Income)	R square	Number of observations
Total expenditure on water Rs. per month	-440.325 (-7.44)	62.845 (9.058)	0.359	145
Total expenditure on water as a percentage of income	0.06314 (6.242)	-0.00534 (-4.505)	0.122	145

Note: t-statistics are given in parenthesis.

It is interesting to see that the above curves are fairly similar to the curves obtained in a study of Jamalpur, Bangladesh, between willingness to pay for water and income, (reported in ADB 1999: 46). The signs of the constant and the co-efficients in the above equations are also similar to the figures reported in that study.

6.2 Water endowment and expenditure on water

Another dimension to explore is whether there is a positive association between water endowment and total monthly expenditure on water. This can be seen from the data presented in Table 11 according to households in various water endowment levels.

A regression analysis using a quadratic form gives the following result:

$$\text{Total expenditure} = 61.784 + 0.561 * \text{WATENDOW} - 0.0007 * \text{WATENDOW}^2$$

(7.04) (2.57) (-0.77)

t-statistics are given in parentheses. R square: 0.164

Table 11
Expenditures on water by households as per water endowment

Water endowment lpcd	Average monthly household expenditures on various aspects of water supply Rs.			
	Quantity	Time	Quality	Total
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

From the equation, it was seen that the elasticity of expenditure to quantity is 0.54 for first 50 litres; 0.44 for the next 50 litres; 0.35 for the next 100 litres and 0.21 for the next 100 litres.

Some multi-variate regression²⁹ results are reported in Table 12. As mentioned earlier, the information on income is limited. Hence, here we use proxies for income, namely, years of education and water endowment (which are positively associated with income), and household size (which is negatively associated with income).

The results conform to general expectations. If what people are spending is an indication of demand, in case of a normal good, we will expect it to be positively associated with income (or its surrogate here, i.e., years of education). Similarly, we will expect the poor, (namely those who have less education and less water endowment) to spend more time collecting water. Thus, expenditure in terms of time spent collecting water should be negatively associated with income. Here, we find that both years of schooling and water endowment are highly significant and have the minus sign as expected.

²⁹ To check for collinearity, tolerance statistic was calculated. First, one of the independent variables is regressed with the remaining independent variables. The tolerance statistic is calculated as (1 minus R square). If there is absolutely no collinearity, the tolerance factor will approach 1; if there is a high degree of collinearity, the tolerance factor will approach zero. We find that water endowment has a tolerance factor of 0.8; all other variables have much higher values of tolerance factors. Though inclusion of water endowment introduces some degree of collinearity, it contributes to improving the model specification as seen from the change in adjusted R square. Hence, dropping it could lead to a mis-specified model. The models are also checked for heteroskedasticity using a White test. Normalized residuals were saved and these were used as regressors against the dependent variable. In all the cases reported in the table, the homoskedasticity assumption was not violated.

Table 12
Explaining household expenditure on water

Independent variables	Dependent variable			
	Direct costs (relating to water quantity)	Cost of time spent in collecting water	Expenditure on water quality	Total monthly expenditure on water
Constant	-15.654 (-3.166)	39.856 (4.815)	-43.185 (-2.065)	-18.983 (-0.873)
Years of schooling	2.130 (7.903)	-1.165 (-2.583)	5.616 (4.925)	6.581 (5.550)
Household size	0.730 (1.630)	-1.026 (-1.368)	-1.632 (-0.861)	-1.928 (-0.978)
Owner Dummy	5.534 (2.313)	0.597 (0.149)	23.513 (2.323)	29.644 (2.816)
Female Dummy	-4.714 (-2.095)	-2.593 (-0.688)	-11.379 (-1.195)	-18.686 (-1.887)
Chennai city Dummy	7.057 (2.566)	4.809 (1.045)	27.223 (2.340)	39.089 (3.231)
Water endowment	0.244 (14.333)	-0.128 (-4.491)	0.092 (1.275)	0.208 (2.776)
R square	0.765	0.224	0.272	0.390
N	145	145	145	145

Note: t-statistics are given in parentheses.

Household size should have a positive sign in relation to expenditure on quantity; however, we find it has a negative sign, though it was not significant. While household size is an indicator of poverty, a larger household may also mean that there are more people to collect water.

With regard to expenditure on water quality, we will expect it to be positively associated with income and education: we do find that the coefficient of years of schooling is positive and highly significant; water endowment is also positive but not significant. Household size has a negative sign as expected, though it was not significant.

Households residing within Chennai city, in general, spend more on quantity and quality, but not on time. Recall from Figure 8 earlier that those living within Chennai city are better endowed with water than those living in the rest of the metropolitan area. In general, when the respondent is the owner of the house, they are more likely to spend on both quantity and quality.

From the above details, we can see that the poorest (who have very little water endowment per capita) incur significant costs mainly due to time costs. Subsidizing

water supply will mainly affect the 'quantity' costs. However, as seen in Table 9 earlier, for the poorest households, main expenditure is on time spent collecting water. The main policy issue, therefore, appears to be how the time taken for collecting water can be decreased, for instance, by increasing the number of sources available to the poor. With regard to water quality, giving access to more efficient fuels such as cooking gas may influence household decision to boil water. This relates to water quality as a link to health burden and capability deprivation of the poor.

There could be a number of other costs resulting from water scarcity in Chennai, which I have not considered. I will give two examples. As a result of rationing of water and supplying it intermittently, households will have to store the fresh water in various containers or in over-head tanks or ground level sumps. This provides an ideal breeding site for malaria causing *A-Stephensi* mosquitoes. The respondents in this survey, when asked to rate 14 local public services in Chennai on a scale of 1 to 5 (representing very bad to very good), consistently across all income groups, rated mosquito control as being very bad or bad (see table 1 in Anand 1999c). Also, 84.6 per cent of respondents reported that they incur expenditure on mosquito repellents of various kinds. So long as water supply in Chennai will remain rationed and intermittent, the problem of mosquitoes will remain. A more important cost is also in terms of malaria incidence and the productivity loss related to it. A second example relates to the strain of having to carry water over a considerable distance. I suspect it could have both short term health impacts such as muscle sprains and spasms and long term health impacts in terms of persistent back aches (that restrict various functionings) and in some cases, hernia requiring surgery. These may, thus, require health expenditures not often considered in relation to water supply and also have an impact on productivity. When no distinction is made between those who have a source of water within the premises and those who need to carry it over a significant distance, there could be, thus, a significant underestimation of costs borne by the citizens.

7 Conclusions

Will Chennai's water supply position improve and will all households get more water? The answer depends on whether water supply is seen as a hydrological/hydro-geological problem of there being not enough quantity around or a political and economic problem of some people not having enough water and how allocation of water is determined. As already discussed, the state government's decision to improve the performance of the Metro Water Board, may depend on the dynamics of whether the same party is incumbent at the state as well as local governments, and the prospects of its winning local elections. There is scope for further research on exploring these issues from an interest groups and rent seeking perspective. For instance, the budget-constrained bureaucrats may see water scarcity as an opportunity to increase the budget of the water utility and to increase their regulatory power. Some interest groups who benefit from maintaining the traditional institutions such as property rights to ground water or farmers' riparian rights to surface sources may resist the regulation encroaching on their domain. The government may find itself in a transitional gains trap (Tullock 1993: 66) while it tries to re-allocate water to different users. A situation of water scarcity may also increase the power of the government in as much as it enables the government to re-distribute privileges among the various interest groups with less resistance. Scarcity may also give an opportunity to strike new alliances with other interest groups to

promote new projects (which may in turn increase the resources at the command of the government or to apportion blame in case of failure of the projects). At the same time, if scarcity persists too long, there is a danger of alienating voters. Thus, a government's decision to improve the performance of a service such as water supply depends on a number of factors and one has to be careful in drawing any policy conclusions.

Though water conservation is emphasized from time to time, the overwhelming focus has been on bringing more water to Chennai. The discussion on water balance sheet and entitlements indicates that while source development is an important aspect, attention is also needed on delivering the water to the end users and improving access to water. Increasing the quantity of supply will have some welfare impact but this is likely to accrue disproportionately to those who already have water connections than to those who do not have access to such connections. The research reported in this paper is a small step to apply the entitlements and capabilities approach to understand inequality in access to urban water supply.

The water balance sheet concept can be useful to enhance the transparency of a water utility. Just as water utilities submit annual financial accounts, they could present information on simple water balance sheets. I have also indicated a possible model to develop the water balance sheet into a computable general equilibrium model. As already mentioned, one should be careful not to fall into the trap of the mechanics of the model and lose sight of the more important institutional and political aspects.

The analysis of ground water regulation and market response discussed in this paper suggests that imposing quantity restrictions on private sector activity in the form of licensing may actually exacerbate grey market activity for water pumping. It is likely that because of the regulation, the quantity of supply from the private sector is lower than what it should have been; the consumers may have paid higher prices; or both. This does not mean that the private sector is a doyen of virtue and that the government should adapt a policy of laissez-faire and delicense water trade. There is a need to develop a framework or enabling regulation that takes into account the various incentives for different actors rather than considering ground water extraction in isolation.

Though I have briefly explored some costs to consumers and their expenditure on water, I have included here only two hidden (or indirect) costs, namely, those relating to water quality improvement and the cost of time in collecting water. Health impacts are likely to be important, and need to be explored further. There is a need to explore how consumers influence public policy concerning the provision of various services. Though voting behaviour can give some indication of preferences of citizens, it may be difficult to isolate what consumers expect in relation to specific aspects of water supply and sanitation. There may be some relevance in exploring consumer preferences more directly, through consultation or surveys. Some issues in this regard are explored in a forthcoming paper.

Appendix 1

Household survey in Chennai and interviews

The data for this study comes from a household survey undertaken by me as part of my doctoral research during June to September 1996. Details of the survey design and diagnostics are provided in Anand (1996) and Anand (2001) The questionnaire covered a number of issues including household attitudes toward environment and public services; water consumption and expenditures; willingness to pay issues. The questionnaire design was based on two focus group discussions in Chennai in June 1996.

The sample households were drawn using a multi-stage cluster sampling method. My aim was to sample 200 households. The target sample was distributed to the 3 different parts of the metropolitan area (Chennai City, 9 towns and rest of metropolitan area) using population-proportionate sampling (PPS) method. Then, in each part, spatial clusters were identified. For example, in case of Chennai city, the city is divided into 10 Zones by the Corporation of Chennai and I used these 10 zones as clusters. In the next stage, in each zone, clusters were created using Census wards or divisions. In the next step, in each selected ward, clusters were created using street networks. The blocks so created are sometimes known as super-blocks. Then in that block, all the housing units were numbered and using random sampling, the sample households were identified. In all, I interviewed 148 households representing different parts of Chennai. These households represented different socio-economic groups, about 43 per cent of respondents were women. All age groups were represented. Some summary statistics from the survey are reported below.

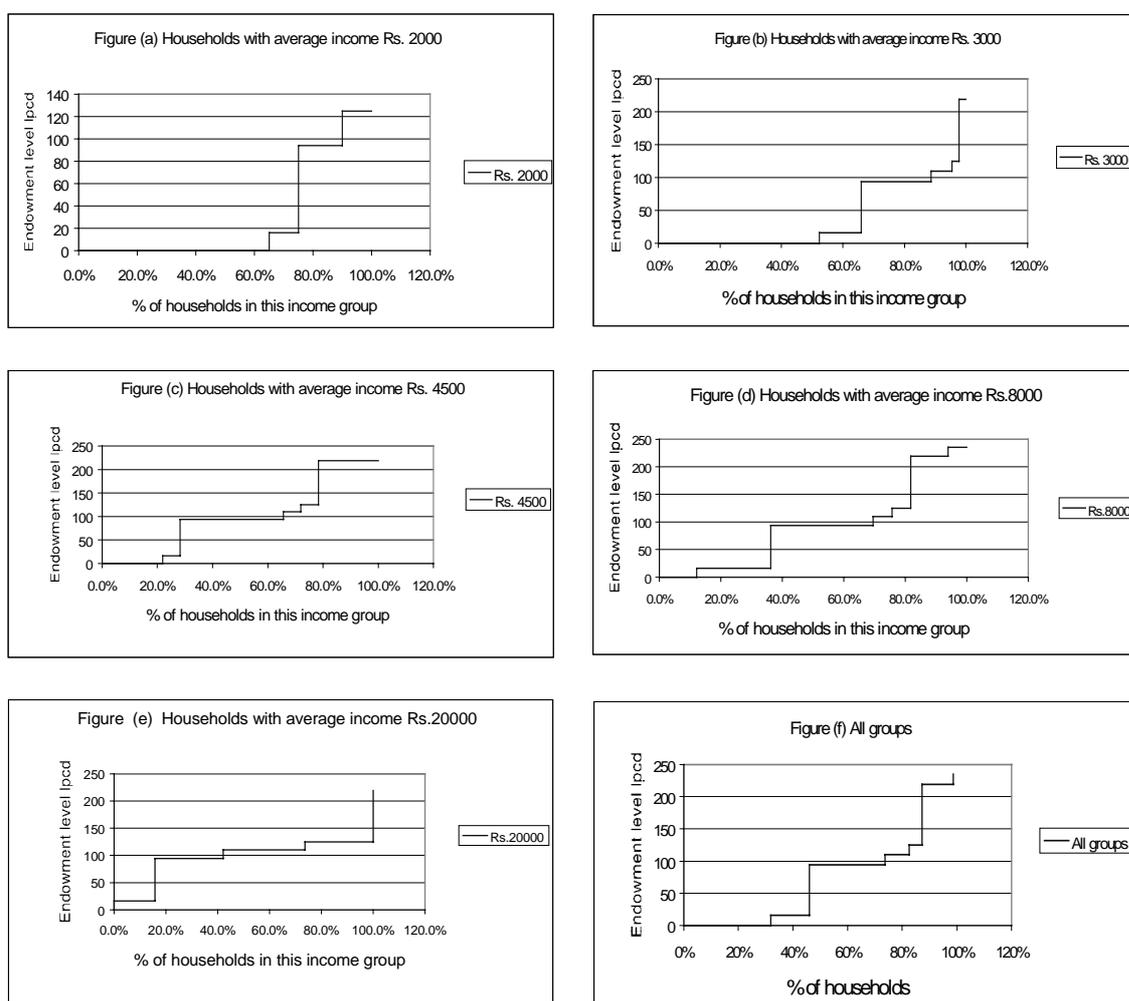
Male; Female %	56.8; 43.2
Average age of respondent, years	43.1
Average years of schooling	10.2
Average household size	5.08
Average number of rooms in house	3.17
Owners %	66.2
Those living in hutments (slums) %	18.9
Having water connection %	48.6
Having a toilet %	87.8
Having electricity %	97.0
Having TV %	93.2

In addition, I had in-depth interviews with officials of the Metro Water Board, the Corporation of Chennai, researchers at the Central Groundwater Board, Chennai, Institute of Water Studies, Chennai; three wholesale water tanker operators; a private company engaged in bottled water production; several water tanker drivers of both public sector and private sector. I had also used participant observation method to understand water transactions and benefited from discussions with retail water vendors.

Appendix 2

Water endowment levels of households in different income groups

The following figures use the data in Table 5. Each curve is constructed as a ladder showing the cumulative percentage of households in that income groups having different levels of water endowment. For example, figure (a) relates to households in the lowest income group. Among these, the first 65 per cent of households have zero water endowment. The next 10 per cent of households have 16 lpcd; the next 15 per cent have 94 lpcd; and the top 10 per cent have 125 lpcd (see Table 5). On the other hand in figure (e) (relating to the richest group), there is no one without water endowment. The first 16 per cent households have 16 lpcd; thereafter everyone has 94 lpcd or more.



Note: Y-axis represents water endowment in litres per capita per day.

Also note: in figure (a), the upper limit is 140 lpcd whereas in all the others it is 250 lpcd.

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