ENVIRONMENTAL HEALTH PROJECT

ACTIVITY REPORT

No. 26

Coping with Intermittent Water Supply:
Problems and Prospects

Dehra Dun, Uttar Pradesh, India

October 1996

KyeongAe Choe
Robert C. G. Varley
H. U. Bijlani

Prepared for the Regional Housing and Urban Development Office, New Delhi,
and the Global Bureau=s Center for Population, Health and Nutrition,
Office of Health and Nutrition, Environmental Health Division; and
the Center for the Environment, Office of Urban Programs,
U.S. Agency for International Development
under EHP Activity No. 193-CC

Environmental Health Project
Contract No. HRN-5994-C-00-3036-00, Project No. 936-5994
is sponsored by the Bureau for Global Programs, Field Support and Research
Office of Health and Nutrition
U.S. Agency for International Development
Washington, DC 20523

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INFO@EHPROJECT.ORG

ABOUT THE AUTHORS

Dr. KyeongAe Choe is an applied economist specializing in the area of water resources. She was trained at the University of North Carolina. Dr. Choe has published widely in the field of willingness to pay studies and has field experience of surveys conducted in Africa and Asia. At present she works at the Center for International Development at the Research Triangle Institute in North Carolina.

Robert C.G. Varley is an economist and senior public finance specialist at the Center for International Development, Research Triangle Institute in North Carolina. Since 1993, he has been Technical Director for Finance and Private Sector Activity at the USAID-sponsored Environmental Health Project in Washington, D.C.

H.U. Bijlani is an independent consultant based in New Delhi. Formerly he was chairman and managing director of the Housing and Urban Development Corporation (HUDCO) of India. Mr. Bijlani is an authority on environmental and engineering infrastructure and their relationship to improving the habitat of the urban poor.

ACKNOWLEDGMENTS

Many people have contributed to the successful completion of this research. (The authors apologize for any unintended omissions.) The original concept of this study was developed in conversations between David Foster, then of the RHUDO Office in Bangkok, and Rob Varley, then Associate Director for Economics on USAID's Water and Sanitation for Health (WASH) Project, the precursor to the Environmental Health Project. The work was funded by the Urban Programs Division of the Global Bureau's Environment Office(G/ENV) and the Office for Population, Health and Nutrition's Environmental Health Project (EHP). Rob Varley and David Fernandes of EHP managed the project and conducted a start-up workshop in Dehra Dun in September 1995. David Foster was the counterpart in Washington at Urban Programs, G/ENV and was ably assisted by Liz Satow (a one- time resident of Dehra Dun). John Austin of PHN and Tej Mathur of G/ENV had already conducted a detailed reconnaissance of potential sites. The client for the research was the Housing Office of USAID in New Delhi (RHUDO/New Delhi). Earl Kessler, the RHUDO Director, provided overall direction to the activity, while Nabaroon Bhattacharjee, also of RHUDO/New Delhi, was an excellent coordinator and colleague at all stages of the study. During the start-up period when the questionnaire was being field-tested, the team was assisted by Marie Helen Zerah of OEIL/IUP, a Ph.D. candidate at the University of Paris, who had conducted her own separate study of intermittent water supply in New Delhi. Andi Eicher, then of the Yale School of Forestry and whose parents live in neighboring Mussoorie, provided some key assistance with coding and operation of the SAS statistical software at a critical stage after fieldwork had been completed and a mountain of data needed editing. The staff of the Academy for Mountain Environics did an outstanding job, and stuck with what was a far more grueling undertaking than they might have imagined. Special thanks to Dr. Ramamurthy Sreedhar and Rumita Gupta. Editor Chris De Joy did a fine job on a difficult manuscript, and final production was ably overseen by Betsy Reddaway of EHP's Information and Communications Unit. Darlene Summers did the layout and word processing most capably. As always, Dan Campbell, EHP's librarian, was a constant source of seemingly unobtainable materials and support. Finally, we would like to thank Dale Whittington of the University of North Carolina for early encouragement, and Anjum Altaf of the World Bank, who provided advice at the start of the study and a very helpful review of the final draft of the report.

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ACRONYMS

AME	Academy for Mountain Environics
CVM	contingent valuation method
DHS	Demographic Health Surveys
EHP	Environmental Health Project
FIRE	Financial Institutions: Reform and Expansion
RHUDO	Regional Housing and Urban Development Office
UFW	unaccounted-for water
UP	Uttar Pradesh
USAID	U.S. Agency for International Development
WTP	willingness to pay (method or survey technique)
WWD	waterworks department
hh	household
lcd	liters per capita per day
lhd	liters per household per day
m^3	cubic meters
mil.	million
mld	millions of liters per day
Rps	Indian rupees (US$1 = 34 Rps, 1995)

DEFINITIONS

Consumption or Use of Water (in lcd or lhd) **-** Since the amount produced each day varies depending on electricity and aquifer conditions, this is a random variable. Pipe leakage is also a factor in how much water is delivered to public taps. The average lcd reflects a distribution of values that depends on topography, season, downtime, and the diameter of the delivery pipe. This study bases consumption estimates on responses to a consumer survey. These estimates reflect mean or expected usage in the wet and dry seasons.

Demand for Water **-** This is based on the amount, expressed in m^3, that a household or households in a service area will use, on the assumption that they pay a real cost per m^3 consumed. Thus, demand implies a relationship between quantity used and price/cost per unit of quantity. Demand management is a way in which the consumption of water is brought into balance with the supply by the use of price. In practice, Dehra Dun's needs are not being met, and the theoretical standard is simply a target for water supply. Supply is not affected in the short run by price. Currently, demand is very large at the marginal price of zero, but supply is fixed and inadequate to meet demand.

Need for Water **-** Need or entitlement to water is frequently confused with demand. The need for water reflects, in this report, a typical planning assumption that 200 lcd are needed or deemed adequate for design capacity.

Rated Capacity (in mld) **-** The result of multiplying the design discharge of 30 tubewells by an assumed 18 hours of operation per day, and adding available surface water supplies. This is widely quoted as representing the water supply available to Dehra Dun. It is an optimistic estimate and should be discounted by any shortfall in realized discharge (usually measured in m^3/minute), downtime for repairs, and electricity failure. The regular-season capacity of Dehra Dun's water supply is approximately 61 mld.

Real Resource Costs **-** The sum of consumers' financial (cash) costs and their economic (noncash) costs.

EXECUTIVE SUMMARY

Background

This study summarizes the methodology and results of a survey of 1,100 households in Dehra Dun in the northern Indian state of Uttar Pradesh. The report also presents a prefeasibility study of the options available to improve the quality of the water supply. Dehra Dun was chosen as an example of a secondary city (population $<$ one million); it has a population of 290,000. An influx of transient workers in the summer tourist season increases the population to 330,000 at a time when groundwater sources are drawn down, rivers have dried up, and electricity failures result in extended periods without water. Despite having adequate groundwater resources, working tubewells, and an extensive piped network, the water supply is intermittent, of low pressure, and frequently not potable. Ninety percent of the households in Dehra Dun are equipped with a water meter, but hardly any are working or used as the basis for billing. Diarrheal diseases and kidney problems arising from dissolved salts in the water are a significant health problem, especially in the dry season. The low water pressure is partly a consequence of a gravity-fed system and partly a result of the practice of leaving taps open to catch whatever water is available. One of the main strategies for coping with the low pressure and intermittent supplies is to invest in supplementary household storage, filters, and pumping equipment. The other strategy is to procure water by queuing for long periods at public taps. The total costs paid for water by household in Dehra Dun comprise:

Total cost/m^3 = Fees paid to Dehra Dun water works department + {investment in equipment (tanks, pumps, water filters, storage vessels) + time spent collecting water}

Coping costs are those elements within the brackets.

Low water pressure and rudimentary sanitation lead to infiltration of sewage into damaged mains lines. In the poorer sections of the community, with about 10,000 households, residents rely on 400 public taps. Although water is free to public tap users, heavy costs are incurred in the time spent in long queues. Although the overall capacity of the system can supply about 110 liters per capita per day (lcd) to households, this supply is very unevenly distributed among different user groups, geographical areas, and times of the year.

Despite these shortcomings in infrastructure performance, Dehra Dun was selected as a site for estimating the real costs of an intermittent supply (investment in equipment and time spent queuing) and for predicting how much people would pay for a continuous full-service metered supply. The Environmental Health Project (EHP) and the New Delhi RHUDO consulted with the National Institute for Urban Affairs and other central and state agencies before choosing Dehra Dun for the study site. Preliminary surveys indicated the water supply infrastructure was quite good relative to other cities, and that the large educated population made it a suitable site for promotion of a full-service, continuous water supply system. The survey was conducted from October to December 1995 by a Dehra Dun-based NGO, the Academy for Mountain Environics (AME). EHP supplied a supervisory survey economist and an economic/financial analyst who made five visits to Dehra Dun.

Approach to the Study

The survey was based on a random-stratified clustered sample of 1,100 households drawn from the 1995 electoral roll. The data collected from the survey were used to generate both qualitative descriptions of coping strategies and an econometric estimate of the household demand for water. Separate estimates were prepared for households with their own connections and for those using public taps. The so-called willingness-to-pay (WTP) methodology[1] or contingent valuation methods (CVM) are controversial. One important objective of the study was to compare the WTP for improvements in supply by using CVM with indirect estimates based on what consumers are already paying to cope with the consequences of an intermittent supply.

Results

Four hypotheses were advanced to guide the study design, and the following conclusions were reached:

- Customers= willingness to pay for a continuous water supply exceeds the revenues currently received by the Dehra Dun water works department (WWD).

The total revenue received by the WWD for 1994, including nonhousehold (institutional, commercial, and industrial) revenue, was approximately Rps 30 million. The estimated demand curve shows that with effective metering at a price of Rps[2] 4.5/m^3, the WWD could have earned Rps 46 million on the volume they supplied to households. Current payments to the WWD average Rps 2/m^3 while both CVM and coping costs indicate a further WTP of Rps 2B2.5/m^3. Although nonhousehold users are estimated to consume 35% of the supply and face much higher official tariffs, the revenue collected from them is reported by the Dehra Dun WWD to be less than a third of revenue from households.

- Current coping costs (investment in storage and time costs) are at least as great as the amount paid to the Dehra Dun WWD from water billings.

It was estimated that the average coping cost per m^3 consumed was over Rps 10 for the whole sample (weighted by number of connected households and tap users but not by volume consumed). Billed amounts divided by estimated consumption showed a price of Rps 2 per m^3 for those with connections. For these users, total costs (paid to the water company and incurred in coping costs) were over Rps 4/m^3. The time (foregone leisure, work, or caretaking) and inconvenience costs to these connected customers were not estimated.

For public tap users, the only cost estimated was that of the time spent in procuring water. The authors have assumed that even the time of a destitute mother, spent collecting water, could have earned some minimum unskilled wage rate (estimated at Rps 3.5/hour) or be valued for household duties. Public tap users pay no cash to the WWD, but the survey indicates that the real costs in the dry season, arising from queuing and low pressure, are over Rps 50/m^3. The estimation for the public tap users is predicated on the assumption that time is money. Dehra Dun is an urban cash economy. Even the very poor must have some source of cash income. Survey respondents at the public taps gave the figure of Rps 4.4 ($.13) as an average hourly wage rate.

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[1] AWillingness to pay@ is another way of describing demand. A demand curve traces WTP for the marginal unit of consumption. CVM is one particular and direct method for estimating WTP. Coping costs are an alternative, indirect method of estimating WTP.

[*] $1 = Rps 34 at the time of the survey in Oct-Dec 1995

The authors used 80% of that figure (or Rps 3.5/hour) in estimating the value of time spent queuing and collecting water.

Full-service water supply is a commercially viable proposition.

The survey supports this conclusion which is not surprising since the water company would hold a virtual monopoly for a good with an inelastic demand (estimates were -.03 for price and .40 for income elasticity). In practice tariffs have to be negotiated and regulated to address both equity and efficiency considerations. Feasible tariffs were estimated from the demand functions (connected and public tap users) to generate two revenue scenariosCone a flat rate of Rps 3.5/m^3 and the other a two-level tariff of Rp 1/m^3 for public tap users and Rps 6/m^3 for those with private connections. Total revenues from households were estimated to be Rps 61 million and Rps 75 million for these two options. The prefeasibility study assumes that a) metering can be enforced, and b) electricity supplies can be restored to a much higher level of reliability (a factor beyond the scope of this study). A conservative program of providing additional public taps, upgrading treatment facilities, reducing leakages, repairing meters, and upgrading collection procedures would increase available supply by 20 to 25%. The capital cost of these improvements would be less than Rps 20 million.

Preliminary analyses of an upgrading action plan or investment proposal indicate that a commercial return could be earned on capital and that consumers would not be required to pay more for water in real terms than they do already. Among the critical assumptions made were that a) revenues from households would be Rps 61-75 million; b) nonhousehold users would pay what they presently pay ; c) the full cost of electricity (Rps 30 million) would be paid by WWD to the electricity supplier; d) electricity supply would be much more reliable. The major constraint to attracting private capital and procuring experienced staff from commercially run operations is that the size of the investment, and hence potential profits, is low. The possibility of the state or municipality imposing a lease fee on a putative commercial operator and potential debt participation in an upgrading project provide scope for negotiations between the various actors.

The poor, who use public taps, currently pay higher real costs for water than those who are connected.

Average costs for households connected are Rps 4-5/m^3, while for the poor the costs are over Rps 40/m^3. Although there are more than 800 public taps in Dehra Dun, only 400 are located in areas accessible to poor or Aslum@ dwellers. (Each tap serves about 10 households.) Some groups of users showed that the burden of queuing can be substantially reduced with some degree of coordination. The most powerful rationing mechanism for these public tap users is finding the time to queue and wait for the water to come on, and then waiting up to half an hour to fill two 15-liter buckets. A nominal price of even Rps 10/m^3 (.08 Rps/15-liter bucket) would provide a fund sufficient to employ a caretaker to supervise collection and pay a nominal tariff to the water company. As long as tap users do not pay cash for water, they may paradoxically be incurring higher costs. Under the present system, the utility has no financial incentive to maintain or improve public tap supplies.

Other Conclusions

To provide an adequate supply of water for the whole city at reasonable rates, the total amount of water does not need to be much greater than the current amount if water is treated as a scarce commodity and conserved. At present, much water is simply wasted since there is no incentive to conserve it. In the near term, there will have to be a deliberate incorporation of excess capacity in the system as it will take time to overcome existing perceptions and to establish confidence in a regime of continuous water supply, available on demand.

The study demonstrates, beyond reasonable doubt, that the real problem with the public water supply in Dehra Dun is not one of affordability. There has been much controversy about an increase in the official or nominal tariff from Rps 1.5/m^3 to Rps 2.5/m^3, even though there is no evidence that people actually pay water bills in proportion to the amount of water they use. The survey=s demonstration of affordability of an increased tariff has been based on willingness to pay. The results from CVM are consistent with those obtained independently by looking at the costs consumers actually incur in addition to the official water bill. The survey found that the amount that households are willing to pay as a surcharge for better service (as asked in the CVM part of the questionnaire) for an improved supply is Rps 3.6/m^3 on average. Current additional costs incurred by households with connections (for storage and filters) are Rps 2.4/m^3, while it is estimated that public tap users face real costs of over Rps 50/m^3 during the dry season, and Rps 40/m^3 on average throughout the whole year.

There are some households that may be comparatively worse off with a metered system, but those are a minority. That group includes those who either don't pay their bills at present, or who waste large amounts of water because they enjoy high mains pressure and have connections which are effectively unmetered. The population at large would benefit enormously by a more equal distribution of water, even if it is achieved by making everyone pay for the amount of water they use.

While the study confirms the usefulness of CVM, by showing that the results are consistent with revealed demand (as evidenced by costs of coping), this technique is expensive to implement. It is not a viable proposition in a country like India for other than very large projects (for example, water supply and sanitation infrastructure for major cities of more than five million people). CVM is, however, a powerful advocacy tool for water sector reformers. If resources do not exist to use the CVM approach, this study suggests that determining actual coping costs can provide a good estimate of demand or WTP.

Recommendations

A follow-up study should be conducted in the dry season in a larger town.

To verify the usefulness and accuracy of the coping costs approach, a further study should be conducted in a larger secondary town which is more representative of overall conditions in India. The study could utilize the methodology and questionnaires which have been pioneered in Dehra Dun. The study should be conducted at the height of the dry season for the most accurate recall of information. Such a city may also offer a different type of investment proposition—possibly a higher price for water, a larger overall investment required in sources and supply, and consequently a greater possibility of utilizing the Financial Institutions Reform and Expansion Project (FIRE) funds. The selected city should still satisfy the criterion that state and local governments are willing to consider fundamental reform of the legal basis on which water services are supplied.

A study of institutional users and their demand for water should be conducted.

If the ultimate goal is to introduce a commercial water supply on a pilot basis in Dehra Dun, some additional survey work should be conducted within the context of community participation in urban environmental management. The current "Clean Up Dun" campaign could involve all the actors and stakeholders in the city. It was clear from our survey of institutions that it is far more difficult to obtain information on water use from institutional and commercial users. Since they share the same system, however, they cannot be ignored. A study of institutional use and the incorporation of their needs in a system design require an investigation by skilled field engineers. Survey methods such as those applied for households are not suitable for that purpose.

There should be a follow-on survey of environmental health conditions in Dehra Dun.

It was clear that the health consequences of an intermittent water supply draw keen public attention. This is a political issue, and politicians are willing to work on improving health conditions, especially for urban low-income populations. While health questions were asked in the survey, the results were not reliable. A specific health survey requires a separate set of epidemiological and social science skills to generate meaningful results. One conclusion from the survey used in Dehra Dun was that those respondents who were aware of the health consequences of poor water supply had a higher WTP than those who did not. This effect was demonstrable regardless of income level. The authors recommend that a participative health survey be conducted as part of a broader campaign and community effort to improve the urban environment in Dehra Dun. Much of the disease burden in the town arises from poor environmental conditionsCpoor water supply and sanitation, as well as heavy air pollution. Prevention of illness by improved water supply would reduce the burden on government health services. The authors recommend that such a survey be conducted in the dry season to coincide with the period of maximum water shortage. During that period, health conditions of those most severely affected are clear, and the city experiences an influx of transient workers and tourists as well.

Further training and practice in using the survey methodology and demand analysis should be supported by external assistance.

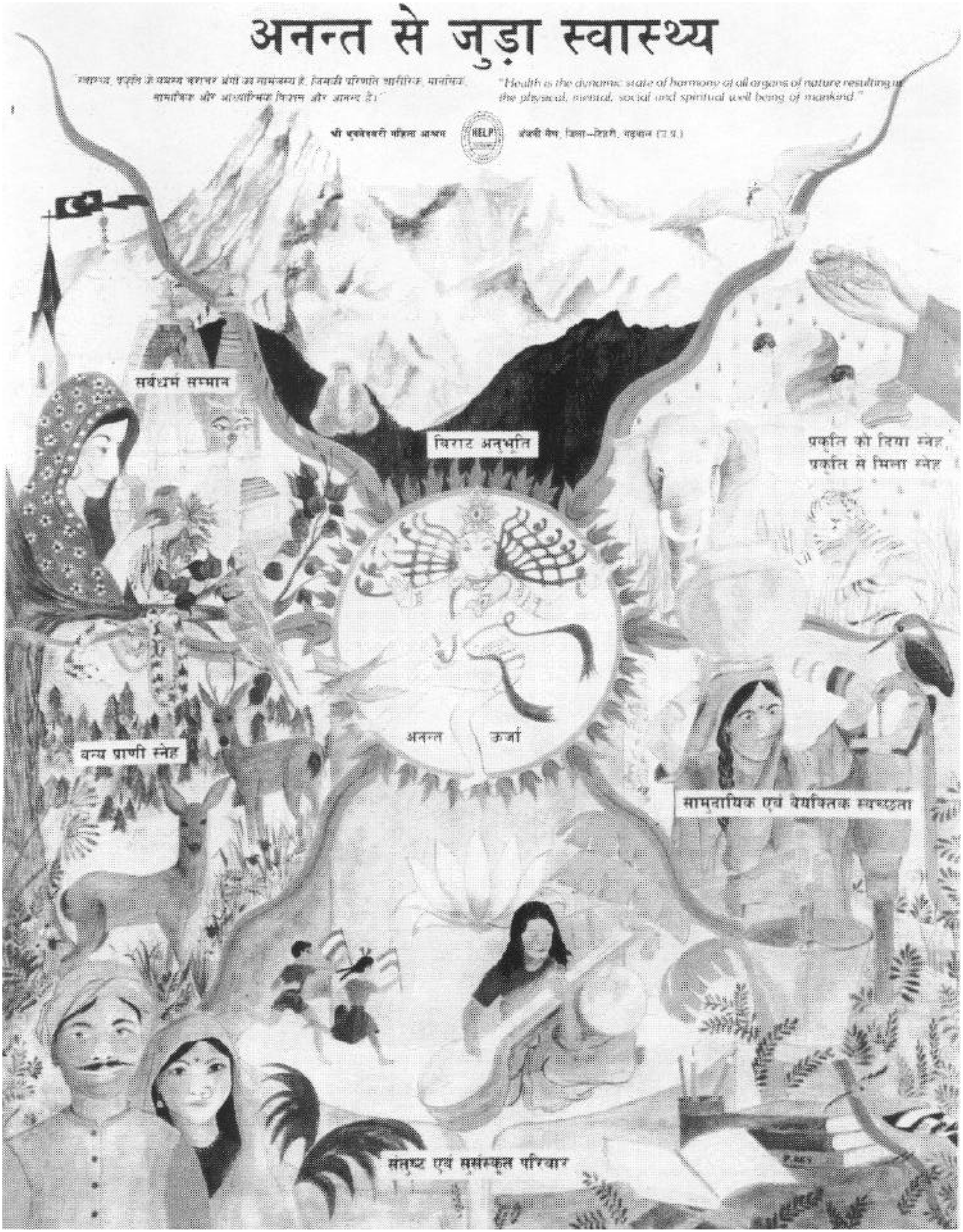
Some attempt should be made to institutionalize the expertise and methodology which were acquired during this project. The questionnaires for the combined coping cost/CVM survey are in both Hindi and English and have been through several rounds of field testing. Data processing routines and statistical software have been set up, but the tight budget for the project made it difficult to do much training outside of enumeration and basic data processing. While the Academy for Mountain Environics (AME) team now requires little external supervision in enumeration and data input, the consultant was called on to interpret the results. Skills in applied coping cost surveys and CVM need to be transferred to those nationals with the appropriate econometric background required for sound application of this technique. This transfer of skills and knowledge may be more appropriately achieved by a long-term, intermittent advisory relationship with a body such as the National Institute for Urban Affairs (NIUA) or an economic research institute.

DIAGRAM DESCIPTION

The illustration is a reduction from a poster which is used by the Academy for Mountain Environics to present its vision of the relationship between nature, man, environment, health and religion.

Translation (counter-clockwise) is roughly as follows:

1. All religions are equal.
2. Love of wildlife.
3. An enlightened and contented family.
4. An unpolluted community and individual hygiene.
5. If you tend to nature, nature will look after you.
6. Realization of the splendor of the universe.
7. Infinite energy (Siva).
8. Eternal health (Ananth).


अनन्त से जुड़ा स्वास्थ्य
"स्वास्थ्य, प्रकृति के समस्त चराचर अंगों का सामंजस्य है, जिसकी परिणति शारीरिक, मानसिक, सामाजिक और आध्यात्मिक विकास और आनन्द है।"
"Health is the dynamic state of harmony of all organs of nature resulting in the physical, mental, social and spiritual well being of mankind."
श्री भुवनेश्वरी महिला आश्रम
HELP
अंजनी सैण, जिला–टिहरी, गढ़वाल (उ.प्र.)
सर्वधर्म सम्मान
विराट अनुभूति
प्रकृति को दिया स्नेह, प्रकृति से मिला स्नेह
अनन्त ऊर्जा
वन्य प्राणी स्नेह
सामुदायिक एवं वैयक्तिक स्वच्छता
संतुष्ट एवं सुसंस्कृत परिवार

1 INTRODUCTION

More than a third of India's urban population has no access to safe drinking water, and the majority of urban residents struggle to cope with both low and intermittent water supply conditions. By the beginning of the 21st century, the country's urban population will have expanded by one-third, to 320 million, further exacerbating India's water supply problem.

The investment required to rehabilitate and expand India's urban water supply services is well beyond the public sector's financial capacity. Therefore, the public sector must devise innovative financial arrangements, not only to meet future demand, but to maintain the current level of service for such a fast-increasing urban population. Whether the public sector decides to utilize debt markets or private-sector participation as viable financial alternatives, its ability to recover the costs of these alternatives, as well as sustain water supply, will ultimately be gauged by consumers' willingness to pay for water service.

As a means of measuring Indian consumers' willingness to pay for water, the Environmental Health Project (EHP), in collaboration with the local NGO Academy for Mountain Environics, undertook this study in Dehra Dun, India, beginning in 1994. The client for the study was the Regional Housing and Urban Development Office (RHUDO)/USAID/New Delhi.

1.1 Background

A full-service water supply system delivers potable water at the consumer's tap, on demand, at high pressure and continuous flows. The provider of such a system usually meters consumer consumption to manage scarce resources, unless supplies are abundant. Tariff-based revenues and fixed levies are commonly used to finance investments in and operation of the system. These fees may also be used to cross-subsidize sewerage services. (Capital subsidies are more common than operational subsidies.)

Most full-service water utilities or authorities in developed countries charge users based on the volume of water they use; other things being equal (such as the tariff band), higher consumption will cost more. The pressure available in such systems is not only convenient for individual consumers, but also helps to prevent waterborne diseases that can infiltrate low-pressure supply lines. High-pressure delivery, however, causes higher water losses than low-pressure systems do, because of proportionally greater leakage from broken pipes. Consequently, efficient full-service systems require that a rational policy be in place for controlling the costs of leak detection, reducing the risks of waterborne diseases, and controlling production costs and lost sales revenues.

India's cities have no full-service water supply utilities or waterworks departments. Currently, municipal utilities provide water to households on a partial-service basis. Most low-income city dwellers are not connected to main supplies, and those who do receive piped water receive it intermittently, at low pressures, and usually in a nonpotable condition. In some cases, industrial and commercial businesses that use water in their production processes develop their own water sources and supply their employees' and local residents' needs as well.

Because urban Indians view their water supply service as unsatisfactory, they are reluctant to pay their water bills and delinquency is high. As a result, municipal water utilities cannot collect enough revenue for the system operation and maintenance, and the quality of service deteriorates still further. Water planners and public officials often misinterpret this poor cost recovery as an indication that prices are too high, rather than as an indication of unmet demand and dissatisfaction.

India=s secondary cities (those cities with a population of less than one million) cannot provide a full-service water supply because, although state regulations protect the municipal waterworks departments from private competition, government fiat determines the water tariffs, which are insufficient to cover system costs. Water supply service in these cities is characterized by regulated rates, nonmetered consumption, and the separation of operational and investment financing from pricing.

There is a heavy burden of waterborne diseases in Uttar Pradesh state. Demographic Health Surveys (DHS)[3] for the state indicate that infants commonly suffer two to five episodes of diarrheal disease a year. WTP studies consider the costs of health damage only to the extent that consumers both recognize and are willing to pay for preventing them.

Very few studies have addressed the actual costs of coping with intermittent water supply. To date, the only such study available is a by-product of the World Bank=s work in Pakistan that primarily addresses the direct estimation of consumers= willingness to pay for water (Altaf et al., 1992). The current study attempts to go a step further and assess willingness to pay based on revealed coping costs. Analyzing coping costs is an alternative way to estimate demandCat the present level of consumption consumers pay both a tariff and/or coping costs. The coping costs represent an alternative estimate of how much additional money people would pay for an improved service. The current study compares the two measures of demand based on fieldwork conducted in Dehra Dun from September 1995 to March 1996.

1.2 Purpose of the Study

This study was conceived as the first stage in promoting and facilitating reform of the environmental management system in India=s secondary cities. *The main hypothesis the study was designed to test is that consumer demand is sufficient to support a full-service water supply system without the need for government intervention to subsidize low-income groups*. This can be broken down into the following four sub-hypotheses:

- the willingness to pay for reliable supplies exceeds the current level of payments to the waterworks department (WWD);
- the current coping costs of intermittent water supply alone are as great as the amount paid in tariffs to the WWD;
- a full-service water supply system is commercially viable in Dehra Dun; and
- the poor currently pay more for water than the rich.

The results of this study may be used by Indian nongovernmental organizations (NGOs) and their partners inside and outside of government to convince private-sector investors that secondary cities present an untapped market for high-quality, higher-priced, water supply services.

[3] A USAID-sponsored survey of health and demographic conditions which has been conducted for India and many other countries by Macro International Ltd.

1.3 Approach to the Study

1.3.1 Study Methods

The consultant conducting the fieldwork for this study used a household survey instrument and established economic methodologies to estimate a demand function for water supply.

The consultant surveyed 1,100 households in Dehra Dun to estimate demand by two methods:

- Indirect method: to determine consumers' coping costs. Under this approach, we observe how much people spend on water and the types of economic and behavioral changes they have made to cope with an unreliable water supply.
- Direct method: We use this method to determine consumers' willingness to pay more for improved water service. Under this approach, one asks individual households how much they would pay in addition to current fees for a full-service water system. Since this method *directly reveals consumer demand through a structured series of questions,* it constitutes a direct method called the contingent valuation (CVM), or willingness to pay (WTP), method.

To acquire a stratified, clustered, random sample of consumers, the 1995 electoral roll for Dehra Dun was used as a sampling frame. The survey team sampled households from the voters list by designing a three-stage random sampling strategy.

A five-part questionnaire was used to acquire the following information from respondents:

- demographic characteristics,
- existing water situation, consumption, and coping costs
- knowledge and perception of their sanitary conditions,
- socioeconomic characteristics, and
- willingness to pay for improved water service.

The Academy for Mountain Environics administered the household survey. AME is an NGO advocating innovative solutions to the problems of community development in the region. Specifically, it focuses on the diversity and complexity of Himalayan Mountain ecosystems. Unfortunately timing constraints required that the study be conducted in the regular season when the water supply situation is not a big problem for residents.

1.3.2 Selection of a Study Site

USAID/EHP chose Dehra Dun as the study site after carefully considering several alternatives. Major criteria used for selecting the study site were the prevalence of political attitudes favoring reform, the availability of a water source for future expansion, the fact that more than 90% of existing water connections are metered (though the meters do not necessarily work), and the intermittent nature of the water supply. In addition, since the purpose of this study is to promote reform, EHP selected a site that appears favorable to commercialization and privatization. EHP, in consultation with RHUDO/New Delhi, applied the following criteria, in order of importance:

- the water distribution system should be sound and adequate for the area it serves, and relatively new (no older than 10 years), so that transmission losses are not abnormally high;
- the water supply source must be adequate for the population for at least the next 5 to 10 years; and
- the state government and local municipality would be willing to consider commercializing the water supply should the survey show that people are willing to pay for it.

2 AN OVERVIEW OF DEHRA DUN

2.1 General Description of the Study Area

The city of Dehra Dun is the headquarters for Dehra Dun District in Uttar Pradesh, which is located in northwest India in the Dun Valley. Because of Dehra Dun=s uphill location, maintaining an individual groundwater source in the city is very expensive. Most consumers have no access to water other than through the municipal piped system. Some large institutions operate their own tubewells, which they also use to serve their employees= residences. Dehra Dun does not have door to door vending but purchases of water in bulk, by tanker, are common.

Dehra Dun=s rainy season occurs during summer, from late June to September. Approximately 90% of the area=s annual rainfall occurs during this time (mainly in July and August), leaving the rest of the year with very little rain (about 30 mm per month). Consequently, the groundwater level falls for most of the year.

In 1995, Dehra Dun=s population totaled 290,000 (approximately 58,000 households). Because of its attractive location and climate, Dehra Dun harbors three groups of Afloaters@ as well: seasonal labor immigrants who settle in slums; tourists; and students. This floating population also contributes to Dehra Dun=s water demand.

Once these three floating populations are taken into account, Dehra Dun=s population during the dry season exceeds 322,000.

Industries operating inside Dehra Dun=s municipal boundary include several pharmaceutical companies, two cement factories, eight lightbulb factories, and several ice cream/ice cube factories. To the west of the city a great deal of industrial growth is taking place and the idea of building a railway line is being entertained. Dehra Dun is academically strong as well. Major research institutions include the Forest Research Institute, the Indian Military Academy, the Doon School, and the Indian Institute of Petroleum. Although these institutions have developed their own water sources, either from rivers located outside of Dehra Dun or from their own tubewells, they compete against each other for already scarce groundwater.

2.2 Socioeconomic Profile of Sample Households

The average household in Dehra Dun consists of a family of five living in a single-family house.[4] Monthly household income averages Rps 4,850 ($143)[5], from one person=s earnings. Household heads have about 12 years of education on the average. Almost everyone in the city has electricity, and more than 80% of sampled households have plumbing and kitchen facilities in their houses. Most Dehra Dun households have flush or pour-flush toilets in their homes.

A typical household pays about Rps 175 for monthly utility bills, including water, electricity, and garbage collection, on average. Households that use gas incur total monthly bills of almost Rps 243.

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[4] The socioeconomic data cited are based on a weighted sample distribution, due to a sampling distortion that occurred during the field interviews.

[5] US$ 1 = Rps 34 at the time of the study (1995).

PART I: Overview

About 13% of households in the sample have a family income of less than Rps 2,000, while 10% of the sample earn more than Rps 8,000 per month. Most (60%) earn between Rps 2,000 and Rps 6,000 per month. Generally, renters earn slightly less than home owners.

About 59% of the sample households own their homes and 41% rent. Other than their lower income level, renters do not differ significantly from owners in terms of their socioeconomic characteristics, although a higher percentage of owners (10%) than renters (3%) operate commercial activities on their premises. About 7% of all sample households run commercial activities from home, which implies that many of Dehra Dun's residential water connections are incorrectly registered.

Of the households sampled, 50% have individual water connections, while 30% share a connection with other families and 18% use public taps. Appendix A1 is a socioeconomic profile of the sampled households.

3 OVERALL WATER SUPPLY CONDITIONS AND CONSTRAINTS

3.1 Supply Conditions

3.1.1 Water Sources

Dehra Dun is spread out over 32 square kilometers. Its sources of water are 30 tubewells, with a maximum capacity of 52.12 millions of liters per day (mld), and the Bindal River, which provides up to 9 mld. Thus, supposedly a total supply of 61.12 mld should be available during the regular season. This is equivalent to 163 liters per capita per day (lcd) for a total population of 375,000 (290,000 in Dehra Dun and 85,000 in adjoining rural towns).[6]

The total regular-season capacity of Dehra Dun's 30 tubewells should actually be 64 mld, based on their pumping rate of 59,550 liters per minute. However, one of the tubewells has been abandoned since 1986, and most suffer from deficiencies in pressure gauges, depth gauges, or booster pumping stations. In the dry season, electrical failures further compound tubewell operation.

Dehra Dun's tubewells are 120 m deep on average, with the depth of static groundwater at about 70 m during the regular season and 110 m during the dry season. Four of the tubewells are less than 60 m deep, and are therefore inoperable during the dry season. This alone constitutes a 7% loss of daily production during the dry months. The WWD has proposed drilling four more tubewells to compensate for this loss.

3.1.2 Water Treatment and Distribution

The Dehra Dun WWD operates four water treatment facilities, but their capacity totals only 40 mld, well short of the city's total daily water production. At the same time, only six of the tubewells have working chlorinators.

Once treated, water is distributed through the WWD's main pipelines from Dehra Dun's 11 overhead tanks, which vary in capacity and staging. According to the WWD, during the regular season it distributes water from the overhead tanks for six hours a day: three hours starting at 5 a.m., and another three hours starting at 5 p.m. (During the dry season, distribution is reduced; see Section 3.4.) Between these two three-hour periods, the WWD recharges the tanks from its tubewells for nine hours at a time.

[6] Based on a data sheet prepared by D. D. Dimri (chief engineer of Jal Sansthan, Dehra Dun WWD), and Darshan Singh (chief engineer, Garwal Region, UP Jal Nigam in Dehra Dun), from 23 March to 31 March 1995.

3.1.3 Water Losses

Dehra Dun=s water supply is made available through a 689-km piped system that covers the entire city. The WWD says it has extended distribution mains about 10 to 15 km per year, but that amount is insufficient to stem significant water losses that occur from old pipelines. Unfortunately, no reliable data are available regarding the exact quantity of water lost, nor have any maintenance plans been developed to reduce pipe leakage. According to the WWD, its annual physical losses are 22%. This figure is considerably lower than what is reported in studies of other water supply systems both in India and other developing countries. Losses are typically 40 to 50%; these usually include administrative losses.

Since the WWD distributes water via gravity from overhead tanks of various heights, water pressure weakens at the end of the distribution lines and becomes uneven depending on the topography. Because the old pipelines leak significantly, the WWD cannot increase the water pressure any further. Also contributing to low water flows is the high calcium deposition.

3.1.4 Sewage Infiltration

Though most of Dehra Dun=s residents are connected to the municipal water system, only 25% are served by a sewer line. More than two-thirds of the residents discharge their wastewater to the street, and 80% of households use pour-flush or flush toilets. The existing five sewage pumping stations supposedly pump sewage to a nearby river; however, three out of five pumping stations do not function properly. In addition, Dehra Dun has no wastewater treatment facility. The lack of proper sewer lines causes groundwater contamination and sewage infiltration into low-pressure water supply lines.

According to the survey results, the residents of Dehra Dun are very concerned about water-related diseases. Because of the high calcium content of local water, people suffer a high rate of kidney stone disease. The survey shows 21 of every 10,000 residents suffered from kidney stones during the past year.

3.2 Consumer Coping Strategies

Dehra Dun=s households have adopted a mixture of strategies to cope with the city=s intermittent water supply. These comprise two components: purchasing water storage tanks, motor pumps, and so on; and the economic, noncash costs of walking, waiting in line, and hauling water from public taps when water is unavailable through private taps. Economic costs also include wage losses due to sickness from poor water quality, time spent boiling water for safety, and management of the on-site storage subsystem. By adding up all the financial and economic costs, one can estimate the real resource costs of intermittent water, enabling one to estimate how much people should be willing to pay for improved water services. (See Chapter 5.)

The estimation of demand for public tap users is predicated on the assumption that time is money, even for the very poor. We have not attempted to value time spent by the higher-income households who have connections because the volume of water consumed is much higher, which reduces these costs on a per cubic meter basis. It is also more difficult to characterize the labor status of household membersCsome are retired and some are well paid professionals, with many gradations in between. The poor (by definition) have very low productivity, and may not have the option in the short-run to trade hours of queuing at a tap with hours of paid labor. However, even transients and slum dwellers are part of the urban cash-economy. The wages available for casual labor may be low, but they are not zero. The poor have to work hard to cope in Dehra Dun; they have no choice but to secure some form of money income (or alms). According to survey respondents who were public tap users, the hourly wage rate was about Rps 4.4 (13 cents) per hour. For the purpose of valuing time in the demand calculation, a value of Rps 3.5/hour or 80% of the wage rate was used.

From the interviews, it was evident that the demand for water effectively tied up one household member and prevented him or her from undertaking even casual wage employment for that time. One could argue this prevented Aqueuers@ from entering the labor force, and the marginal value of the time spent queuing should be valued at more than the wage rate. However, the unit of analysis for consumption and employment decisions should be the whole household. Freeing up a mother=s time for domestic caretaking could enable a young family member to enter the unskilled labor force. Collecting water directly reduces the time a woman can spend engaging in cottage industry (such as the preparation of snacks) or piece work such as assembly, laundering, and sewing/repairs. It is impossible to be precise about the appropriate figure to use for the long-term value of time spent queuing. However, whether one chose 80% or 40% of the wage rate of tap users would make no qualitative difference to the conclusion. The real price paid for water, on a volumteric basic, is very high, and the long-term implication of freeing up time would be to increase cash income for the household.

The consumer coping costs bring demand into equilibrium with a supply that varies from day to day according to unrelated circumstances at the WWD and the power company. One hypothesis is that coping strategies may ultimately cost consumers more than an economic tariff based on the supply costs of a full-service water system.

3.3 Seasonal Factors and Production Variation of Municipal Water

Two major factors account for Dehra Dun=s intermittent water supply:

The dry season, which reduces the availability of groundwater two to three months before the rainy season begins in late June, and
Electricity breakdowns, which occur most frequently during the dry season.

During the dry season from April to early June, the WWD pumps for a shorter period per day than it does during the regular season; hence, service during this time is reduced from the normal six hours a day to only three hours on average.

Part of the high dry-season demand results from users washing frequently to cool down from the heat. Seasonal populations also stress the water supply (see Chapter 2, Section 2.1), as do electricity shortages, operations budgets, declining well yields, and adherence to fixed pumping schedules.

Electricity failures and fixed operating budgets cause irregularity in Dehra Dun=s water supply during both the dry and wet seasons, although blackouts are more serious during the dry season. (Power shortages can cause stoppages to the water supply that often last more than two days.) Unpredictability of supply and a lack of metering further worsen losses by encouraging waste. Water is stored for security but thrown away and replaced with fresh water if the supply is still available. Unequal distribution among households results from differences in installed capacity (pipe diameter and number of connections) and topography, which is the primary determinant of pressure in a gravity-fed system.

Some users whose topography and connections allow it use copious quantities of water in their gardens, while other, less fortunate consumers (about 20% of connected households) receive less than the recommended bare-minimum rations of 20 lcd. This wastage of water comes as no surprise, as it is a natural consequence of an effective Azero price for water.@ This is the case in Dehra Dun, where users pay no additional charge for each additional unit of water they consume.

Other than the design criterion of 163 lcd, no measurement-based figures are available to determine individual household water consumption since the meters are inoperative (only five working meters were found among the 1,120 households surveyed). Tubewell-based production is only an estimate and does not account for the frequency of electrical failures and fluctuating discharge based on the various capacities of Dehra Dun=s tubewells. Even if the incentive to measure production existed, most of the tubewells lack proper measuring devices.

As Dehra Dun=s dry season progresses, the city=s static water level falls, and in some cases pumps are no longer able to produce their design discharge. Anecdotal evidence indicates that the city=s main storage tanks do not get filled to capacity during the dry season.

The following estimates of water supply available during Dehra Dun=s regular and dry seasons represent rough estimates of average production per day, given the limited data available:

Regular season (2 x 9 hours of pumping from 30 tubewells) = 61.12 mld (according to the WWD)
Dry season (1 x 9 hours of pumping from 26 tubewells, resulting in 7% capacity loss from 4 unutilized tubewells) = 26.28 mld

Taking into account the fact that the duration of the dry season is one-quarter of a year, this gives an overall weighted average for the year of 52.41 mld, or about 19 million m^3 annually [365 days *(61.12 mld x 0.75 + 26.28 mld x 0.25) (the weights of 0.75 and 0.25 correspond to 9 and 3 month periods)]. The reported storage capacity of the water tanks is a little bit more than 10 million liters.

3.4 Constraints on the WWD

A number of factors limit the effectiveness of the WWD, and, in turn, of Dehra Dun=s water supply. A look at the department=s Finances and Management reveal the constraints under which the WWD operates.

3.4.1 Revenues and Expenditures

The WWD=s revenues for the fiscal years 1990 to 1994 have remained flat.

Table 3.1
Revenues, 1990B1994

Fiscal Year	Revenues (Mil. Rps): Sales (water tax + excess consumption charges)	Other	Total
1990-1991	11.710	5.858	17.568
1991-1992	11.945	7.182	19.127
1992-1993	12.063	7.763	19.826
1993-1994	11.786	7.465	19.251

Dehra Dun=s water supply system had 43,138 connections as of March 31, 1995. Of those, 41,341 are fitted with meters, most of which are inoperable. The types of connections are shown in Table 3.2.

Table 3.2
Types of Water Connections

Connections	Metered	Unmetered
Residential	34,782	1,758
Nonresidential	6,465	0
Bulk use	94	0
Total	41,341	1,758

In December 1994, Dehra Dun WWD proposed to increase the water tariff from Rps 1.5 per m^3 to Rps 2.5 per m^3. Some local residents were disturbed by the new rate because, according to them, they received less than 30 minutes of water per day from the municipal distribution line. From October 1995 to February 1996, consumers staged several strikes against both the water tax increase and the city=s unreliable water service. In response, the WWD in March 1996 reverted to the original rate and promised to reimburse those charges collected in excess of the Rps 1.5 rate during the previous year.

Table 3.3 shows the taxes charged under both the original and revised tariff rates.

Table 3.3
Tariff Rate Structure

Name of Tax/Charge	Basis/Unit	Original Tariff Rate	Proposed Tariff Rate
Water tax	Annual rental value of the property	12.5%	12.5%
Sewerage tax	Annual rental value of the property	3%	3%
Excess water consumption charge (through metered connection)			
a) Residential use	per m^3	Rps 1.50	Rps 2.50
b) Nonresidential use	per m^3	Rps 4.00	--
-commercial	per m^3	--	Rps 12.00
-industrial	per m^3	--	Rps 15.00
-other institution	per m^3	Rps 2.50	Rps 7.50
Minimum water charges for 15 mm connection			
a) Residential use	per month	Rps 12.50	Rps 40.00
b) Nonresidential use		Rps 40.00	--
-commercial	per month	--	Rps 150.00
-industrial	per month	--	Rps 200.00
-other institution	per month	--	Rps 100.00
Bulk use (20 mm connection)	per month	Rps 500.00	--
Development charge	per m^2 of plot area	--	Rps 7.50

As Table 3.3 indicates, the WWD is supposed to apply per-cubic-meter tariff rates for Aexcess consumption.@ Yet the department actually bills customers on estimated consumption, not metered readings. Most of the meters are broken because of deposits that have accumulated in them from poor-quality water passing through the water pipeline. In addition, the residential meters, which average about 15 years in age, have not been well maintained.

The consultant found that WWD has not registered all its consumers, nor has it automated its billing process. Thus, the WWD has difficulty tracking down unpaid bills and unbilled water consumption. According to the household survey, approximately 14% of sampled consumers had not received water bills during the past year. The average billed cost of water for the survey sample was Rps 2.0/m^3 (Rps 33/month average bill, family of five consuming 107 lcd for 30 days/month). If the total WWD revenues received are divided by estimated production (19 mil. m^3/year), the average price paid (before losses) is only Rps 1/m^3. Adjusting for lower dry-season supply,[7] non-payment of bills, water losses, and correction factors the average cost per m^3 paid by those who actually pay their bills was estimated to be as high as Rps 2.9/m^3.

[7] Assuming dry season consumption is 60% of wet season and removing the 1.25 correction factor described below.

3.4.2 Electricity Arrears

The WWD receives an indirect electricity subsidy from the state government to run Dehra Dun=s water supply system but nonetheless owes the state money. The department=s electricity arrears as of 31 March 1992 are as follows:

Table 3.4
Electricity Arrears of the WWD, 1992B1994

Fiscal Year	As per Bills Verified (Mil. Rps)	As per Bills Received (Mil. Rps)	Grants Received from Govt. (Mil. Rps)
As of 31.3.92	35.371	49.090	--
1992-1993	27.167	33.287	4.465
1993-1994	28.338	38.568	1.500
Total	90.876	120.945	5.965

Source: D. D. Dimri, Dehra Dun WWD, and Darshan Singh, Garwal Region, UP Jal Nigam, Dehra Dun.

Based on WWD data, the department owes a cumulative Rps 85 million to the Uttar Pradesh electricity board.

3.4.3 Expenditures and Cash Flow

The WWD=s average operational cost has steadily increased during the past three fiscal years (see Table 3.5), while revenue collections have remained flat. Almost all revenues from water sales have been used to pay personnel salaries, and little has remained for repair and maintenance. Approximately 25% of residential water sales revenues were collected through billing excess consumption from 1993-1995, while 75% were collected by charging the flat rate water tax, which is 12.5% of rentable value.

Table 3.5
Estimated Operational Cash Flow of the WWD, 1993B1995

	FY 1993-1994	FY 1994-1995
Water Sales Revenue (Tax + Excess Consumption Fees)		
From water sales (billed/collected)	Rps 13.9 mil.	Rps 17.3 mil.
- residential	Rps 9.6 mil.	Rps 11.4 mil.
- commercial/industrial and bulk rate	Rps 4.3 mil.	Rps 5.9 mil.
From other sources (meter rent, sewer tax)	Rps 5.4 mil.	Rps 6.1 mil.
Total sales revenues	Rps 19.3 mil.	Rps 23.4 mil.
Operating Costs		
Personnel	Rps 13.8 mil.	Rps 16.8 mil.
Repairs	Rps 2.8 mil.	Rps 3.6 mil.
Electricity	Rps 28.3 mil.	Rps 30.0 mil.
Total operating costs	Rps 44.9 mil.	Rps 50.4 mil.
Net operating profit	Rps (22.30) mil.	Rps (23.50) mil.
Other Sources of Cash		
Cash increase in payables to electricity bills	Rps 28.3 mil.	Rps 30.0 mil.
Cash increase in accounts receivable (arrears)	Rps (3.3) mil.	Rps (3.5) mil.
Net Operating Cash Flow	**Rps 2.7 mil.**	**Rps 3.0 mil.**

The WWD=s operation and maintenance budgets are determined by what is politically and administratively feasible. Since revenues never actually cover costs and debts accumulate, the cost of water is not fully reflected in accounting statements.

The true costs of water in Dehra Dun are higher than the nominal tariffs charged to users for Aexcess@ consumption. Water tax and nominal tariffs charged during the time of the survey were Rps 2.5/m^3. Including the Rps 30 million in unpaid electricity bills for 1994B1995 increases the cost per cubic meter produced from Rps 1.23 (= Rps 23.4 million/19 million m^3 per year, where 19 million m^3 represents the weighted average for the year) to 2.65 (= Rps 50.4 million/19 million m^3 per year). When energy subsidies and a capital charge for equipment depreciation and replacement are included, the true costs of the present system probably exceed Rps 5/m^3. Including the social costs of intermittent water supply, such as increased health risks or time spent queuing, would raise the cost even more.

Since the WWD has made few capital improvements, the department currently has no loan payments to meet. Even if the WWD had to pay the capital costs of constructing the eight tubewells installed since 1990, the debt payment would be no more than Rps 0.05 million per year for each tubewell. This would not significantly affect the WWD=s average production costs.

The WWD does not use a commercial accounting framework; that would require a balance sheet and profit/loss statements. WWD financial reports fail to account for depreciation of the building and water distribution network, which means that costs are grossly underestimated.

The WWD operates by short-term matching of available cash flow (from taxes/fees) to operating costs. Its initial customer billings are largely from the water tax, which uses property rental value as a proxy for water usage. Excess-water charges are levied on the assumption that some customers have exceeded their entitlement. In practice, the WWD collects excess-water charges late in the year, when cash available to pay its staff salaries and maintenance costs has run out. The collectors appear to have some means of assessing either water usage or the likelihood that the billed household will pay up.

Even without accounting for depreciation and maintenance, the WWD incurs a large loss each year. As implied earlier, the WWD reconciles its cash flow position by not paying its electricity bill to the state-owned electricity company (which also suffers from undersupply, regulated tariffs, and intermittent supply). The WWD does pay some nominal amount for electricity from any cash left over at the end of the year. The WWD=s finances operate according to political cycles, and are driven by an overarching goal of meeting the payroll each month. No systems appear to be in place for prioritizing maintenance expenditures or for planning and financing future investment needs.

3.4.4 Administration and Management Status

Dehra Dun=s water supply system is the responsibility of two entities: the WWD and the State Water and Sewage Board. The WWD is responsible for maintaining and operating the system, while the board provides overall management. Because the WWD has insufficient funds and technical expertise to do so, the board provides the department with major capital improvements and technical support.

The WWD has a staff of 495, of whom 400 work in Dehra Dun and the rest in adjacent rural towns. Most of the Dehra Dun staff members work under the WWD division responsible for maintenance and repairs; only about 6 staff members work in the department=s accounting division. An imbalance in allocation of staff members across divisions causes inefficient use of human resources, as well as poor management of metering and billing. The WWD concentrates an unnecessarily high number of staff (253) under its Tubewell/Distribution Division, for example. About 123 employees work in the WWD=s Repair Division. On average, they report repairing only five water meters daily. Despite its large staff, the WWD claims it has too few staff to perform bimonthly meter checks and billing.

More efficient staff allocation and better management and training are among the highest priorities for improving Dehra Dun=s water supply service. Otherwise, almost all revenues collected from water sales will continue to be spent on poorly allocated, untrained staff.

3.5 Unaccounted-for Water and Its Implication for the WWD=s Financial Performance

The city=s system incurs two types of unaccounted-for water losses (UFW): physical losses, which result from ineffective engineering management that leads to pipe leakages, and administrative losses, which stem chiefly from inadequate collection procedures.

The consultant estimated the physical losses in Dehra Dun=s water supply system by interviewing various Jal Nigam officials. The system=s physical losses are estimated to be anywhere from 20% to 33%. No studies are available to corroborate these estimates, nor has any scientific analysis been done on the subject. Currently active Jal Nigam officials insist that the losses total approximately 22%.[8] WWD=s administrative losses are manifested chiefly in revenue losses from unbilled and uncollected charges. The WWD lost more than Rps 28.74 million in unbilled water consumption in fiscal year 1994-1995. The department lost another Rps 2.55 million in billed but uncollected charges that same year. Thus, the amount the WWD lost in uncollected charges last year exceeded the Rps 17.3 million it did collect.

[8] Independently, the consultant asked a retired Jal Nigam engineer to assess various data on water supply, and he came up with a figure of 23.8%.

Had the WWD corrected its administrative losses during fiscal years 1993-1994 and 1994-1995, the additional revenue from enforcing nonresidential collections alone could have increased the WWD=s revenue by Rps 1,880 (Rps 12.33 million/6,559 connections) and Rps 2,807 (Rps 18.41 million/6,559 connections), per connection, for each fiscal year, respectively. In the meantime, the marginal revenues from UFW losses for residential connections would have increased collections about Rps 254.5 (Rps 9.30 million/36,540 connections) and Rps 283 (Rps 10.33 million/36,540 connections) per connection, under each respective fiscal year.

In terms of quantity of water, the above figures could mean that the WWD collected revenue for only 33%, or 20.27 mld, of its claimed total water production in fiscal year 1994-1995. In other words, total UFW, including both physical and administrative losses, could be 67%, or 40.85 mld.

In order to attain sustainable cost recovery, the WWD must correct this imbalance. The most urgent problem concerns billing and revenue collections. Focusing on billing and revenue collections for nonresidential connections would be the most efficient way to increase revenues, since the marginal revenue potential of commercial connections significantly exceeds that of residential connections in Dehra Dun. Once the problem of administrative water loss is corrected, the WWD=s total revenue should increase by Rps 48.62 million (Rps 17.33 million current revenue collected + Rps 2.55 million billed but not collected + Rps 28.74 million unbilled and uncollected) per year at the current tariff rate, sufficient to cover all daily maintenance and operation costs, including the electricity bills (which are presently left unpaid).

4 CONSUMER USAGE AND PAYMENT PATTERNS

4.1 Supply Conditions

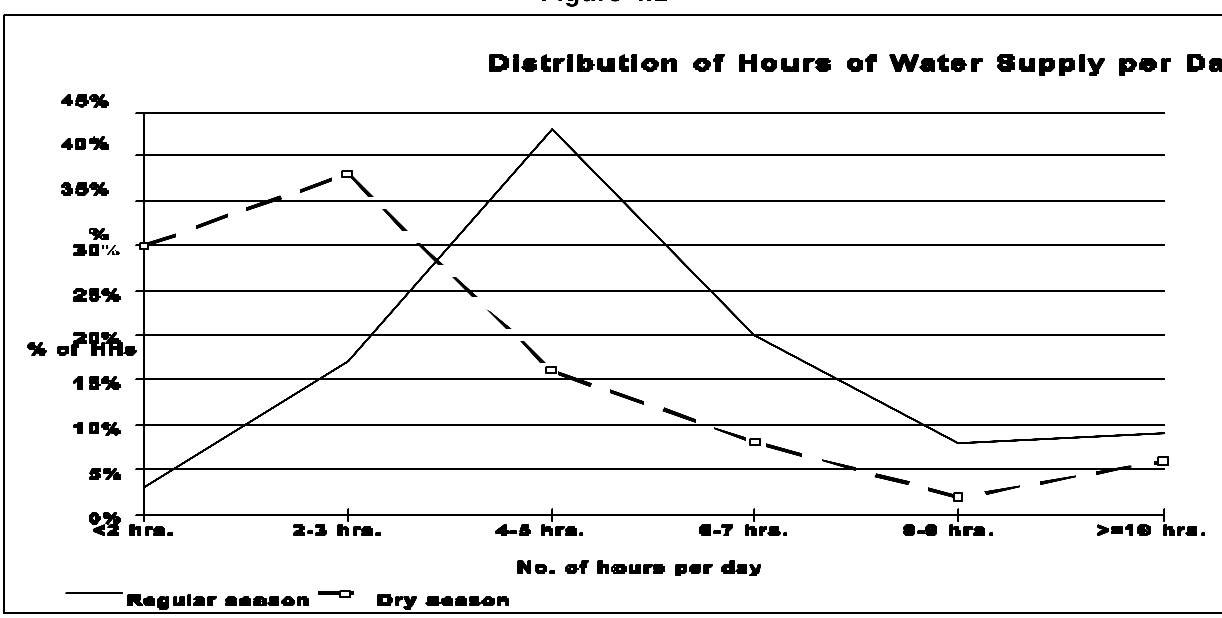
4.1.1 Means of Household Access

Dehra Dun households access water in one of five ways, the major ones being by ownership of a connection to the municipal supply or sharing a connection. As noted in Chapter 2, 50% of the sampled households own their taps exclusively, 30% share an individual water connection with their tenants (28%) or with neighbors (2%), and 18% rely on public taps. Still others (2%) use tubewells developed and provided by their employers, Dehra Dun's large research institutions.

4.1.2 Hours of Water Supply per Day

In the regular season, most connected households in Dehra Dun (63%) receive water for four to eight hours per day, half starting around 5:00 a.m., and half starting at about 5:00 p.m. Depending on house location, number of overall connections on the distribution line, and topography of the neighborhood, each household receives water for various hours at different levels of pressure. Figure 4.1 shows the seasonal percentage of water distribution among households by hours of supply, based on the survey's findings. During the dry season, the hours of water supply are half those of the normal period: Most connected households (68%) receive water less than four hours per day during the dry season.

Figure 4.1



4.1.3 Water Pressure

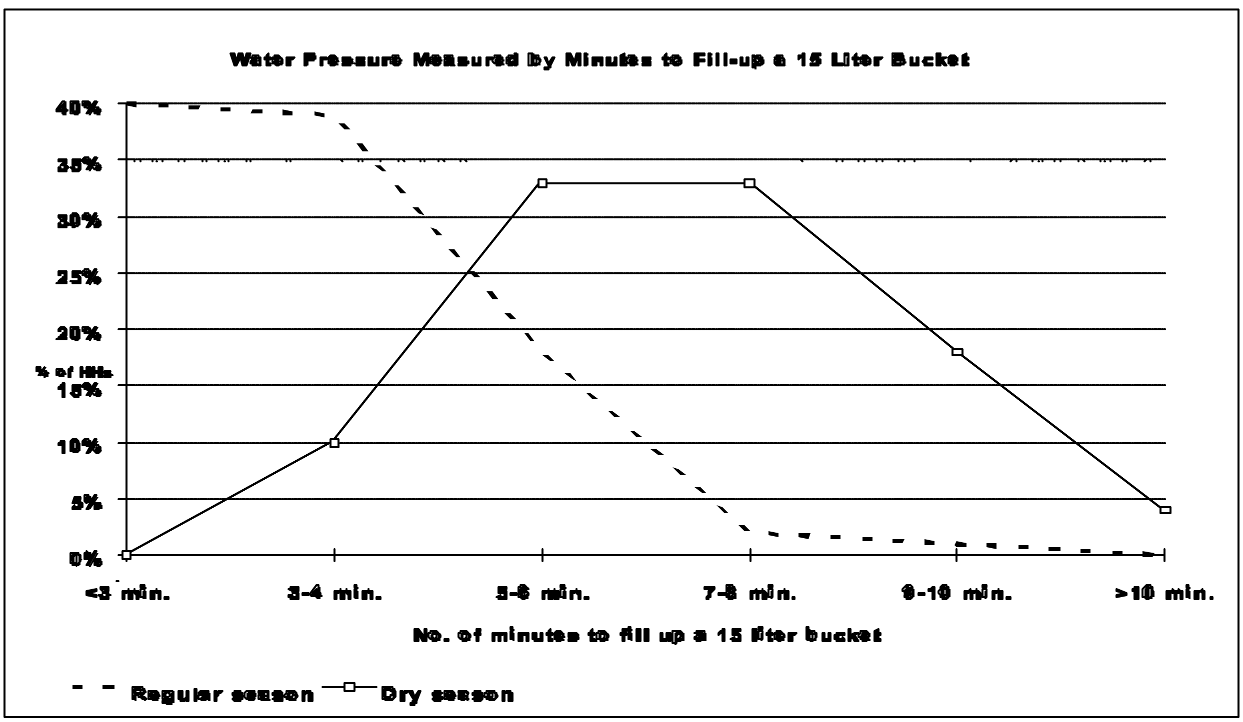
It is reported that during Dehra Dun's dry season, water pressure decreases significantly, to less than half of that of the normal season. On average, survey respondents said it takes about three minutes to fill up a 15-liter bucket during the normal period, compared with seven minutes during the dry season (see Figure 4-2).

Consumers' satisfaction with water pressure is based on the time required to collect water during the regular season. Most households responding to the household survey said they are content with the existing regular-season water pressure; less than 20% said they are not. Those who are currently dissatisfied reported that filling-up takes more than five minutes per 15-liter bucket. Considering the fact that during the dry season 75% of the sampled households spend more than five minutes filling each bucket, the majority of households would be dissatisfied with water pressure during the dry season (if asked at that time).

4.1.4 Water Quality

Less than 5% of the sampled households said they are very satisfied with existing water potability, while almost 30% said they are dissatisfied with the water quality for drinking purposes. Those respondents who said they treat their water before drinking it explained that they do so only as a precaution. Interestingly, the percentage of households who said they are very satisfied with their water quality was highest among those who acquire their water from major institutions' tubewells, implying that the water distributed through big institutions' tubewells is of better quality than the water distributed through the municipal water supply system.

Figure 4.2



4.2 Water Consumption and Payment

4.2.1 Water Consumption

In the household survey, respondents were asked to recall their regular-season water consumption both directly from the tap and from water storage tanks. By adding the water consumption levels from these two sources, the consultant estimated Dehra Dun's average water consumption to be about 107 lcd during the regular season, or 14 cubic meters per household per month.[9] This estimate would be 86 lcd without multiplication by the correction factor of 1.25 derived from metered readings.

As shown in Table 4.1, however, significant differences exist among regular-season consumption levels depending on water source access. Households using individual piped connections exclusively for their own use consume 137 lcd during the regular season, while those who rely on either public taps or a neighbor's tap consume only 46 lcd. These differences in water consumption patterns are reflected in consumers' strategies for coping with limited water supplies (see Chapter 5).

Table 4.1
Water Consumption and Monthly Payment, Regular Season

Type of Water Source	Water Consumption (lcd)		Avg. Water Bill (tax + use, Rps/m)	Average Connection Charge Paid (Rps)
	lcd	m^3/hh/ month		
Individual piped connection	137 lcd	19	51	5,500
Connection shared with tenants	104 lcd	13	22	6,000
Neighbor's tap or public tap	46 lcd	5	3	n/a
Tubewell from major institutions	70 lcd	8	0	n/a
Average	107 lcd	14	33	5,600

[9] In order to estimate consumers' water consumption level, enumerators were instructed to check every meter. At the same time, enumerators were instructed to ask respondents to recollect their household's daily water consumption by estimating their volume of water storage as well as the number of buckets they fill from taps before storing water. The results showed that out of 916 households with individual connections, only five meters were working. Because basing water consumption levels on such a small number of meters would produce inaccurate data, the estimation of water consumption in this report is based on the data reported by respondents. However, after comparing the five actual water meter readings with reported water consumption, the team adjusted the sample by applying a factor of 1.25 to account for respondents' recollection errors. Since this is such a small sample consumption could easily be more or less than 86 lcd. A comparison of actual consumption, measured from the five working meters, and estimates based on recall, revealed, however, there was a tendency to under-report.

The 107-lcd figure applies to all types of households on the electoral roll, including those who receive water from institutional sources and public taps; however, those supplied by public tap may be underrepresented in the sample because their numbers include some transients who are not registered voters. Thus, 107 lcd constitutes a weighted average of usage for the regular season.

If Dehra Dun households were to use all the water the WWD supplies, regular-season consumption would be 47.67 mld (61.12 mld - 13.45 mld, with 13.45 representing 22% of 61.12, or the amount of physical water loss estimated by the WWD). In contrast, estimated total consumption using the household survey results is 290,000 x 107 lcd = 31 mld, where 290,000 represents Dehra Dun's urban population. Based on these two estimates, the nonresidential consumption is 16.67 mld (47.67 **B** 31 mld), or 35% of total consumption (16.67/47.67 mld).

Based on the average water pressure and the daily hours of supply noted earlier, the maximum water consumption level during Dehra Dun=s dry season is 77 lcd on average, or 22.3 mld. Thus, water consumption during the dry season amounts to less than 72% of regular-season consumption.

If the same ratio can be assumed to hold in the dry season as in the regular season, the availability of water to non-residential consumers during the former period is (47.67 - 31) mld x 72%, or 12 mld.

4.2.2 Bill Payment Process

As noted in Chapter 3, currently the WWD issues two types of water bills to connected households: a water tax bill charging 12.5% of users= property rental value, and an excess-water-consumption bill charging Rps 1.5 per cubic meter of water used. The WWD sends out the tax bill annually and the consumption bill biannually. The survey results indicated, however, that the WWD=s billing period is not always consistent; respondents said they sometimes receive a tax bill for a 6- or 9-month period, and a consumption bill for anywhere from 3 to 12 months. According to the survey estimates, the average total monthly charges from both types of bills are approximately Rps 33 per household (implying Rps 2/m^3 or 6**4**/m^3 average cost).

As shown in Table 4.1, users of public taps or a neighbor's tap consume water almost free of charge. Only a few of those who use a neighbor's tap pay a monthly flat fee for their consumption. Households with individual connections exclusively for their own use tend to pay the highest bills (Rps 51 per month), since this group pays both tax and consumption bills. (Households who share their connections with other families pay significantly lower water bills [Rps 22 per month], partly because most of these households include renters who do not pay tax bills.)

Based on the survey results, two types of inequality occur in water billing. First, more than half of households with individual connections complained that they have been paying for more water than they consume, while about 25% admitted they pay for less than they consume. This comes as no surprise, since the WWD bases its bills on guesswork. Some respondents said they hardly receive any water because of technical reasons, but still receive and have to pay water bills.

The second type of inequality in water billing occurs among public-tap users, who generally belong to low-income groups, which pay no direct water fees. One can justify this inequity as a social cross-subsidy. Indeed, the general attitude among water utility officials indicates that government officials feel they are serving social justice by providing water free of charge to a socially marginal group of households. However, as mentioned earlier, to determine the true social cost of cross-subsidization to all groups, one should examine carefully the opportunity cost of time lost by poor households.

Currently, the Dehra Dun WWD charges an average of Rps 5,600 and takes more than six months to establish a residential water connection. Private contractors, on the other hand, can provide a hookup more quickly and for a much cheaper rate (see Chapter 5, Section 5.1.2). Among the households surveyed, 10% of those with individual connections have no water meter, and are considered to be connected illegally.

5 ESTIMATION OF DEMAND USING COPING STRATEGIES AND COPING COSTS

5.1 Coping Strategies

Dehra Dun consumers' major strategies for coping with an unreliable water supply include increasing their household's water-holding capacity, enhancing water pressure, and purifying water via water tanks, electric pumps, and water filters. Most of the equipment needed to employ these strategies is readily available on the local market.

According to the household survey results, the percentage of households who own various water-related equipment differs significantly by income (see Table 5.1). The majority of households in the highest two monthly income levels (Rps 8,000 to Rps 12,900 and greater than Rps 13,000) own at least one water tank and either electric pumps or water filters. Meanwhile, most of the households in the lowest two monthly income levels (less than Rps 2,000 and Rps 2,000 to Rps 3,900) own none of these items. The households in the middle two income levels (Rps 4,000 to Rps 7,900 per month) generally own water tanks and some water filters; very few of them own the more expensive, electric pumps, however. The shading in Table 5.1 shows the major strategies adopted by the families in various income classes.

This ownership pattern indicates that it is relatively inexpensive for Dehra Dun residents to improve their water quality by using manual filters. The survey also shows that the next most popular coping strategy is to increase the quantity of water available by obtaining storage tanks, while the least-used strategy is to improve water pressure and flow reliability via electric pumps and roof tanks.

In addition to income level, consumers' coping strategies vary by water source. To examine these differences, the consultant visited residents in each of the three source groups: households with individual piped connections, households using public or neighbors' taps, and other households.

5.1.1 Households Using Individual Piped Connections

One individually connected family the consultant visited had three storage tanks: one at the ground level with a capacity of 1,000 liters, and two on the roof, each with a capacity of 500 liters. The ground-level tanks store water directly from the municipal distribution line. From these tanks, the family can electrically pump water to the rooftop tanks. The family obtains sufficient water pressure by opening its taps (water flows down from the roof tanks). To prevent overflows, the household installed a device called a stop-control ball cock. The family has also been using a manual water filter for more than 10 years for drinking purposes.

Recently the family purchased a new electric water filter and installed it on one of the taps in the kitchen. Family members said they invested nearly Rps 12,500 to purchase and install their equipment, enough to buy two more piped connections from the municipal water system. The family is quite satisfied with its current arrangement. The rooftop water tanks fill up automatically twice a day, and water is always available at a continuous flow and an adequate pressure. The household's electric water filter assures higher quality.

Table 5.1
Durable Equipment Owned to Cope with Intermittent Water Supply by Consumer Income Level[10]

Equipment Owned	Monthly Income (Rps 000)					
	<2.0	2.0-3.9	4.0-5.9	6.0-7.9	8.0-12.9	>13.0
Tanks, electric pumps, and water filters	0%	0%	3%	13%	22%	38%
Tanks and electric pumps	1%	1%	4%	9%	22%	25%
Tanks and water filters	1%	3%	20%	27%	21%	13%
Tanks only	2%	22%	39%	37%	26%	8%
Water filters only	0%	3%	10%	4%	6%	12%
None	96%	71%	24%	10%	3%	4%
Total	100%	100%	100%	100%	100%	100%

Unfortunately, not every Dehra Dun family can afford such a luxurious arrangement to cope with an intermittent water supply. Indeed, only 6% of the surveyed households own all three types of durable equipment available to enhance the reliability and quality of water serviceCwater storage tanks, electric pumps, and water filters. Furthermore, only 16% of respondents with piped connections have an electric pump for conveying water to rooftop tanks; without a pump, water pressure is generally too weak to fill them.

More than two-thirds of the households using individual connections (either exclusive or shared) own at least one storage tank (see Table 5.2), but most of them have no electric pump. About one-third of the households connected to the municipal system have neither a water tank nor an electric pump. They store water in drums of various shapes and sizes or buckets for daily use. The average volume of tanks among respondents who do own them exceeds 850 liters, but those without tanks average only 170 to 200 liters of water storage capacity (two and a half buckets per person on average).

[10] Shading indicates most common solutions for respective income classes.

Table 5.2
Durable Equipment Owned to Cope with Intermittent Water Supply by Type of Water Connection

Equipment Owned	Individual Piped Connection: Exclusively for own use	Individual Piped Connection: Shared with other families	Other: Public or neighbors= taps	Other: Tubewells	Total
Tanks, electric pumps, and water filters	9%	5%	0%	0%	6%
Tanks and electric pumps	9%	3%	0%	0%	5%
Tanks and water filters	16%	20%	2%	3%	14%
Tanks only	37%	30%	0%	0%	27%
Water filters only	5%	7%	2%	42%	6%
None	24%	35%	96%	55%	42%
Average water storage capacity (lit.)	690	570	105	50	530
HHs with water tanks	880	850	370	380	870
HHs without water tanks	200	170	100	50	150

Regardless of the kind of equipment consumers use, everyone in Dehra Dun is vulnerable to power failures that can leave residents without water for days.

5.1.2 Households Using Public Taps

Dehra Dun has about 822 public taps to serve residents who have no individual piped water connections. From the household sample, the consultant estimates that about 23 families use one tap (only 400 or so of the public taps are heavily utilized by households). Some public taps are used infrequently, partly because they are located in middle- to upper-class residential areas where every household has its own water connection, and partly because the taps are on main streets, where shopkeepers occasionally rely on them[11]. Conversely, taps in low-income areas are used regularly. Thus, while the number of public taps appears to be sufficient, their location may not be optimal.

Tap location also affects users= coping behavior. In some places, families leave empty buckets in line at their tap well before it starts flowing. Usually small children accompany the buckets to keep an eye on them.

At one point, the consultant encountered a women in her 50s who sat beside a public tap in a middle-class residential neighborhood. The woman said she lived in a nearby colony where she shares a neighborhood tap with two dozen or so other residents. Usually she waits in line at her neighborhood tap in both the morning and the evening, fetching two buckets of water per trip. On this particular day, too many empty buckets were already in line at the local tap, and she needed extra water a bit earlier than usual. Rather than queue up there, she interrupted her household chores to come out to this nearby tap. She said she had been sitting at the tap

[11] In addition to the household survey, another survey, conducted by the Academy for Mountain Environics, was carried out to estimate total water discharged through Dehra Dun=s public taps. (See Appendix CCPublic Tap Survey.)

for a couple of hours, waiting for it to start flowing. (Because flows are irregular, public-tap users hardly know when a tap will begin flowing or how long its water will last.)

Some public-tap users reported that they can easily spend almost half a day fetching water, with each trip taking an hour (5 minutes to get to the pubic tap, 20 minutes to wait in line, another 20 to fill up two 15-liter buckets, and 15 more minutes to return home with two heavy buckets). In addition, a family of four must make at least four (average six) trips a day for its daily water needs.

Because residents are prohibited from using water while at the tap, they must store what they collect in drums, pots, and buckets to meet their daily needs. One of the people the consultant spoke with was totally frustrated with the opportunity cost of fetching water and wished to use the time earning money instead. In response, he hired a private contractor for about Rps 3,000 to provide him with an individual water connection. He said hiring the contractor was much faster and cheaper than having the municipality provide the connection. (The WWD usually takes more than six months to establish an individual connection, the charge for which it bases on the consumer's property size.)

In one slum area the consultant visited, a different picture emerged. There, about 10 households were clustered along the riverbank. The location of their homes was strategically chosen so that residents could access water easily; one public tap is available within 30 meters of the houses. Because the tap is visible from the clustered buildings, families can look out the window to determine whether a line has formed, thereby alleviating the need to queue up; only the water pressure slows down attempts to draw water in this neighborhood.

In another neighborhood, one person was assigned as keeper of the public tap. He was responsible for scheduling and monitoring tap usage to avoid queues. He was also charged with collecting user fees to turn in to the WWD.

Scheduling at this particular tap was set up such that once a family draws all the water it needs for the day, it informs the tap keeper so that he can alert the next users as to the tap=s availability. He supervises use of the tap from his small shop nearby.

In this case, users treated the public tap as common property rather than a free public utility. According to the household survey, about one-fifth of Dehra Dun=s public-tap users fall into this category.

Though coping strategies differ among tap users and tap locations, one hardship that public-tap users usually have in common is that they have very few resources other than their time. As shown in Table 5.2, only 4% of public-tap users have storage tanks or water filters, and none have electric pumps. Those without tanks average only 100 liters (or 20 liters per person) of storage space.

Although public taps generally are located within a 34-meter radius of users' homes, the average time spent to fetch water is about a half hour per trip, or 2.9 hours per day, as estimated from the household survey results. During the dry season, the average time spent fetching water increases to 3.7 hours a day.

5.1.3 Households Using Other Types of Water Sources

About 2% of the sampled households do not get their water from Dehra Dun=s piped system. As mentioned previously, these households include employees of major institutions or educational facilities in the city that operate their own tubewells. These institutions do not share their water source with other institutions or neighborhood areas.

As usual with large institutions, Dehra Dun=s have their own electric generators by which they can draw water continuously. Therefore, residents who rely on their tubewells suffer less from intermittent water supply than do other consumers. As with other water sources, however, dry-season water shortages affect the tubewells significantly. Since groundwater levels drop and water demand per capita increases during the dry season, local institutions are forced to supply water for almost twice as long during this period as in the regular season.

Because the respondents belonging to this category of water users are tenants, they usually do not invest in equipment such as water storage tanks. (Their average water storage space is only 50 liters.) However, 42% of them improve their water supply by using water filters.

5.2 Coping Costs

The coping costs include the time spent in line waiting to fetch water, which can amount to several hours a day. Consumers lose the chance to use that time to engage in income-generating or family-caretaking activities. These activities all bear economic values that can be represented in a demand function. These coping costs provide a lower bound to willingness to pay for water. Any excess of willingness to pay for water, over and above the tariff plus coping costs represents Aconsumer surplus.@ Estimating this with any precision is made difficult by the fact that existing arrangements do not allow consumers to consume what they needCpart of their consumption is the cost of maintaining reserve stocks. The marginal tariff cost of these reserves is, however, zero since water is not metered. However, the marginal cost of storage capacity is not zero; it is the amortized cost of further investment in storage. This will tend to be Alumpy.@

It is still a prevailing attitude among the poor in India that water is given by God and should be free to all. Even those who do pay their water bills do not consider water to be an economic commodity, but rather think they are paying Aextra@ to help fund the government. However:

- in order for consumers to receive water, some party (usually a government body) must manage extraction, storage, and distribution, and have financial resources available to do so;
- the poor believe water should be provided free, but they are unaware of the significant economic costs they already bear through coping costs.

5.2.1 Explicit Costs of Coping with Intermittent Water Supply

Dehra Dun consumers incur two types of explicit costs to cope with an intermittent water supply: the major capital investment required to own various water-related equipment, and the monthly maintenance cost of operating that equipment.

Survey respondents were asked to estimate the current price of the water-related equipment they own, and to report any equipment maintenance and operation costs, including electricity bills but excluding regular monthly water bills.

Capital Investment Costs

Dehra Dun market prices for electric pumps and all types of water filters average Rps 2,900 and Rps 1,070, respectively. Electric water filters cost more than six times as much as manual filters; less than 2% of the sampled households own electric filters.

The price charged to install a water storage tank is based on the unit volume of the tank in liters. The unit price includes materials, pipes, and labor charges. Prices for syntex, cement, and ground tanks are Rps 4.1, Rps 1.4, and Rps 3.0 per liter, respectively. Small water containers such as jerricans, drums, and banta are priced at Rps 2 per liter.

On the average, survey respondents invest about Rps 2,300 for equipment to cope with intermittent water supply conditions. Significant differences in the amount of capital invested occur between households with and without individual piped connections. As summarized in Table 5.3, households using public taps, neighbors= taps, or tubewells incur very few capital costs (only about Rps 266 to Rps 480 Rps), since very few of these households own storage tanks or water filters. Sampled households currently pay about Rps 24 per month for their equipment[12].

Individually connected households who do not share their water source incur almost 10 times as much in *explicit* coping costs as households without individual connections (Rps 32.2 versus Rps 3.3 to Rps 5.9 per month).

Maintenance and Operation Costs

Not all the sampled households incur regular maintenance and operation costs in coping with intermittent water supply, largely because their coping strategies mainly entail increasing the capacity of their water storage space, requiring only a one-time investment. If such consumers do sustain recurrent operation and maintenance costs, the costs comprise chiefly electricity for electric pumps, fuel for cooking, and filters for treating water. Thus, the regular maintenance and operation costs of coping with an intermittent water supply are low relative to depreciation of equipment, at a minimum of Rps 4.5 per month for all surveyed households.

Table 5.3
Capital Investment Costs of Coping with Intermittent Water Supply (Rps)

Type of Expense	Individual Piped Connection		HHs without Individual Piped Connection		Total (weighted average)
	Exclusively for own use	Shared with other families	Public or neighbor=s taps	Tubewells	
Average costs of owning:					
electric pump and water filter	2,900	2,900	n/a	n/a	2900
water filter	1,260	820	810	810	1070
tanks	2,230	2,180	900	420	2210
other small containers	135	205	220	95	110
average costs for all equipment	2,620	1,970	266	480	2300
Explicit costs (avg./month/hh):					
capital investment	32.2	24.3	3.3	5.9	23.6
regular maintenance and operation	5.4	3.9	2.9	3.2	4.5
Total	37.6	28.2	6.2	9.1	28.1

[12] Assuming a 12% real interest rate based on the current market price of those capital investments the team estimated monthly payments for the next 10 years. However, the actual monthly payment would be lower than the estimated amount, since most of the households surveyed installed their equipment a few years back at lower prices. A real discount rate of 12% was used to annualize costs.

Adding the monthly installment of capital as well as maintenance and operation costs, households with individual connections incur Rps 28 to Rps 38 per month; households without individual connections spend Rps 6 to Rps 9 per month in direct costs to cope with intermittent water supply.

5.2.2 Implicit, or Opportunity, Costs to Cope with Intermittent Water Supply

About 18% of Dehra Dun residents use public taps. These households generally belong to a low-income class (monthly income averages Rps 2,000), and cannot afford the capital investment or access credit to finance equipment purchase. As a result, they bear the costs of intermittent water supply in terms of time they spend fetching water. The opportunity cost of the hours spent fetching implies loss of wage income. Based on 80% of hourly wage rates among public-tap users, the opportunity cost of time spent fetching water equals about Rps 3.5 per hour. Since this group of households averages nearly three hours per day collecting water from public taps, their loss in wage-earning potential equals almost 10 percent (Rps 190) of their monthly income. Considering that almost one-fifth of Dehra Dun's population is affected, the real social cost of intermittent water supply is high. Table 5.4 summarizes the opportunity or time costs of using public taps. Since public-tap users consume only 5 cubic meters of water per month per household, they are paying almost Rps 38 per cubic meter (= Rps 190/5 m^3 per month), more than 15 times the current excess consumption tariff rate.

Table 5.4
Implicit Costs of Time Spent to Fetch Water

Distance to the Tap	% of Respondents	Average Number of Minutes Spent for Each Trip, Regular Season	
<10 m	19%	Traveling	10 minutes
11 to 25 m	44%	Queuing up	19 minutes
26 to 50 m	30%	Filling up buckets	6 minutes
>50 m	7%	Total time spent to fetch water (hours per day)	
		In regular season	2.9 hours
Average Number of Round Trips per Day	6	In dry season	3.7 hours

5.2.3 Unit Costs of Coping with Average Intermittent Water Supply

Table 5.5 shows estimated costs of coping with an intermittent water supply. The real price includes the monthly cost of durable equipment, monthly maintenance and operation costs, and the implicit costs of time spent to fetch water but not the official charges. Figure 5.1 shows these costs on a volumetric basis.

Households with individual piped connections pay an extra Rps 2.10 to Rps 2.11 per cubic meter in addition to the current water tariff rate. Households using public taps pay the highest real price for water, more than Rps 40 per cubic meter. The water consumption level (46 lcd) of the households using public taps is significantly lower than that of households relying on individual connections, and indicates a lifeline consumption level, for which people are willing to pay a relatively high marginal price. The consultant estimates that Dehra Dun residents pay an average real price per cubic meter of Rps 10.6.

The dry-season is the only period in which there is a water crisis. In the dry season, coping costs reveal a high demand or willingness to pay for marginal consumption. When supply is very low (*at least* 25 percent lower than during the regular season, maybe as much as 50%), an enormous excess demand emerges at the zero price for marginal consumption. In the dry season, the only way users can obtain more water is to spend more money on storage capacity or time in line to get a bigger share of the available supply. This, however, is self-defeating for the community as a whole, as supply is fixed.

For public-tap users, the time spent fetching water increases about one hour during the dry season, and daily water consumption per household is reduced by 28% overall (see Section 4.2.1 in Chapter 4). The average coping costs for public-tap users increases during the dry season, from Rps 43.65 to Rps 53.34 per cubic meter. The burden of this increase falls mainly on the poor, who must rely on public taps.

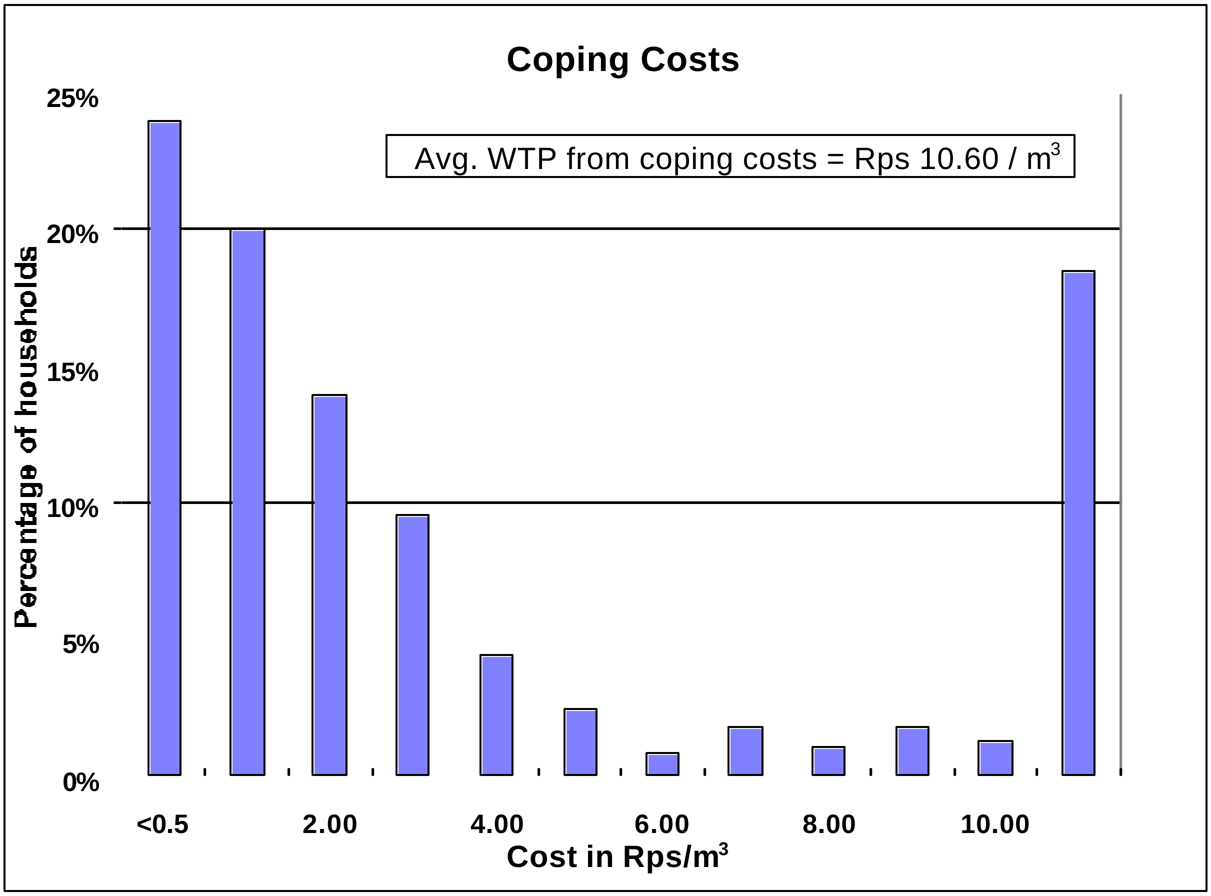
Although the high willingness to pay for additional water is most pertinent in the dry season, the wet season is also factored into the demand curve by considering annual demand as the basis for pricing. Fortunately, the nature of a metered water supply system is such that the costs, if incorporated in a single volumetric tariff, can be spread over the whole year.

Table 5.5
Costs Paid to Cope with Intermittent Water

	Individual piped connection		**HHs using...**		
Type of Expense	exclusively for own use	shared with other families	public taps or neighbors	others (rely on TW)	**All HH**
Explicit costs: (monthly payment for capital + Rps/HH/month M&O)	37.6	28.2	6.2	9.1	28.0
Implicit costs:					
opportunity costs of time spent (Rps/HH/month)	n/a	n/a	190.0*	n/a	190.0*
Total monthly coping costs (Explicit + Implicit costs): (Rps/HH/month)	37.6	28.2	196.2	9.1	62.60
Average coping costs paid Rp/m^3 (regular season)	2.11	2.10	43.65	1.23	10.60

* The opportunity costs of time value is estimated by excluding the households using neighbor=s taps, since they do not need to queue at public taps to fetch water.

Figure 5.1


Coping Costs
Avg. WTP from coping costs = Rps 10.60 / m3
25%
20%
15%
10%
5%
0%
Percentage of households
<0.5
2.00
4.00
6.00
8.00
10.00
Cost in Rps/m3

6 ESTIMATION OF DEMAND USING WILLINGNESS-TO-PAY BIDS

The contingent valuation method (CVM) for determining demand is often referred to as the willingness-to-pay (WTP) method. Respondents are asked their willingness to pay an additional surcharge for an improved water supply. The value captured from WTP is contingent upon the market scenarios offered to respondents. Thus, the market scenarios should be carefully designed and informed by the theory of consumer demand.

During the WTP survey, the consultant asked Dehra Dun consumers to place a value on the surcharge they would pay to obtain a continuous water supply. The consultant described in detail the components of a full, continuous water supply so that consumers would treat water as an economic commodity with clear attributes. The hypothetical system the consultant outlined would enhance the existing Dehra Dun water supply in three ways:

improve quality, by enhancing water purification and repairing leakage,
increase quantity, by adding more tubewells and overhead tanks, and
improve reliability, by adding additional power generators.

6.1 Service Options Offered

In order to estimate consumers= demand for improved water supply, the consultant used two different types of WTP scenarios according to the respondents= major water source:[13]

Type A, for households using individual piped connections, and
Type B, for households without individual connections but using other sources, such as a neighbor's tap, a public tap, or an institutional tubewell.

In order to trace a demand curve and to control bias, the consultants asked each respondent 1 of 25 elicitation questions based on one of five different hypothetical surcharges (Rps 30, Rps 60, Rps 90, Rps 120, or Rps 150) and one of five different service plans (A1-A4 and B, see Table 6.1). Questions were assigned randomly and evenly among the respondents.

The exact wording of the elicitation question was carefully stated to make clear that the increased tariff would not be posed as a government-enforced fee but rather as a consideration in analyzing the feasibility of various project investments.[14]

[13] Originally three scenarios were developed, the third of which was meant for households using public taps in Aslum@ areas. However, only seven respondents acknowledged living in slum areas, and most of the households using public taps were captured from regular residential areas using scenario type B.

[14] See Appendix A4.

The referendum question was followed by an open-ended question to estimate the WTP bids as accurately as possible.[15]

6.2 Average WTP Bids for Improved Water Supply, by Service Options

The average WTP for additional services of respondents with existing piped connections varied from Rps 40 to Rps 44 per month based on service type, while that of respondents without individual connections was about Rps 21 per month.

Three percent of the households submitted zero WTP bids because they are currently satisfied with their water arrangement. About 2% refused to pay any amount because they think water should be provided free. (These refusal bids were not included in calculations of average overall WTP bids.)

About 55% of the respondents said they think the private sector can provide water service more efficiently than the government, while 30% said they believe the government is the better provider in terms of financial and administrative efficiency. The rest (15%) indicated that a joint venture between the government and the private sector would be a more efficient way to provide the service than now exists. Table 6.1 summarizes WTP bids results.

6.2.1 Respondents with Individual Piped Connections

Government versus Private-Sector Provision of Service

Respondents with individual piped connections were willing to pay slightly more for private-sector provision (services A2 and A4) than for government provision (services A1 and A3). Differences in average bids were marginal (Rps 43 versus Rps 41 for private sector and government, respectively). Respondents who received a questionnaire offering service A1 (256 households) bid 42 Rps per month, on average, for @full service by the government.@ When these same respondents were asked whether they preferred private provision to government provision, about 50% answered yes. Those who preferred private service provision were then asked how much they would be willing to pay for such service, to which they answered 55 Rps per month, on average, or Rps 11 more than they would be willing to pay for full, government-provided service.

- Service A1: full continuous service provided by government
- Service A2: full continuous service provided by a private enterprise
- Service A3: double increase of no. of hours supply provided by government
- Service A4: double increase of no. of hours supply provided by a private enterprise

[15] The consultants found that the point estimates of WTP bids reveal more information on household demand than do discrete choice data. See Choe et al. (1996).

Table 6.1
Average WTP Bids Based on Service Option Offered

	To HHs with Existing Piped Connection				To HHs without Piped Connection
	Service A1	Service A2	Service A3	Service A4	Type B
	Full service by government	Full service by private sector	Partial service by government	Partial service by private sector	Full service by government
Total Respondents	256	261	260	261	82
Respondents with Legitimate WTP Bids	247	256	255	255	65
Standard Deviation	20	20	18	21	18
Average WTP (Rps/month)	**42**	**44**	**40**	**41**	**21**
Respondents Who Refused to Pay for Water	9	5	5	6	16
If Service Level/ Provider Changes to...	Full service by private sector	Full service by government*	Full service by government	Full service by private sector	Full service by private sector
Total respondents	124	147	100	87	27
Average revised WTP bids	**55**	**44**	**56**	**61**	**22**

The results of the initial and follow-up questions confirm that households in Dehra Dun value private-sector provision of water more than government provision, and that more than half would support the private-sector provision of improved service. Table 6.1 summarizes these results.

Full versus Partial Service

Based on the survey results, households with individual piped connections would be willing to pay, on average, Rps 43.0 per month as a surcharge to receive a full, continuous water supply (services A1 and A2). The respondents' WTP bids for partial service improvement (services A3 and A4) were Rps 40.5 per month on average. Controlling the level of service, the average WTP bids for private-sector provision were always slightly higher than those for government provision.[16]

About one-third of the respondents who were assigned service A4 (partial service, by private enterprise) preferred full service by a private enterprise. This subsample of households revised its bids from Rps 45 to Rps 61 per month. Figure 6.1 shows the distribution of the WTP bids for improved service provided by the government.

[16] The difference between WTP for full and partial service is small but statistically significant. The wording of the questions is shown in Appendix A4. One interpretation or conjecture about this difference being so small would be that consumers are mainly concerned with quantity of water available, and not quality.

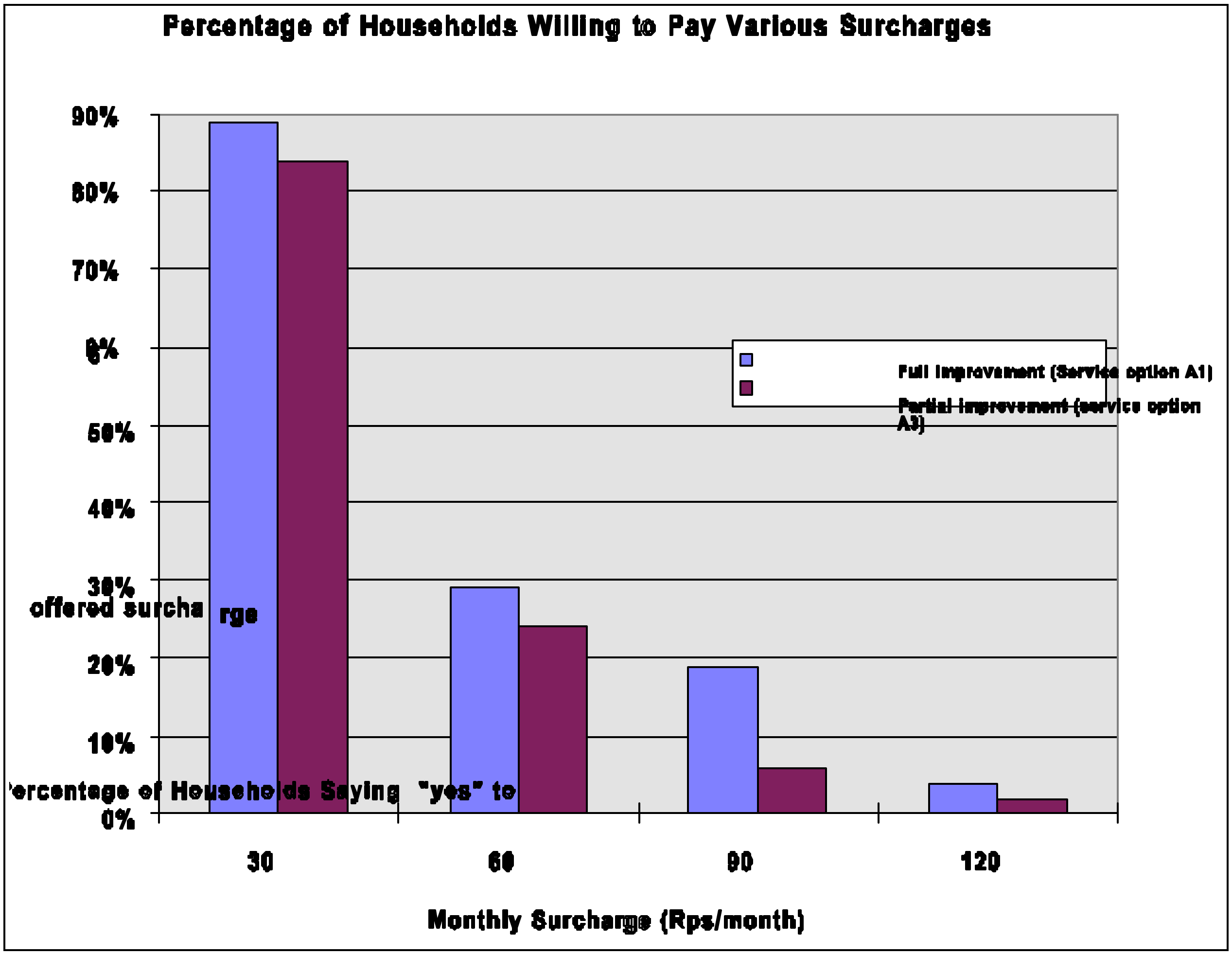


Figure 6.1

6.2.2 Respondents without Individual Piped Connections

Approximately 40% of the 82 respondents without individual piped connections said their willingness to pay for a full-service water supply is zero. One reason for this response was that more than half of these respondents receive water from a tubewell and tend to be satisfied with this arrangement. This high percentage of zero WTP bids reduces the average WTP bids of this group.

Another reason for the zero willingness to pay was that those households relying on public taps tend to think water should be provided free of charge.

By each type of water source, the consultant estimated the average WTP bids as follows:

HHs using neighbor's tap = Rps 28/month (with 10% unwilling to pay)
HHs using public taps = Rps 19/month (25% unwilling to pay)
HHs using tubewells = Rps 12/month (70% unwilling to pay)

6.2.3 Conclusion

The survey results revealed that, among the four service options proposed, full service provided by the private sector would garner the highest percentage of households willing to pay at different monthly surcharges (90.91% and 37.04% would be willing to pay monthly surcharges of Rps 30 and Rps 60, respectively, versus 88.89% and 29.17% for the next most preferred service option, full service by the government). This indicates that full service by the private sector would offer the highest potential revenue to the provider among the four service options offered. Additionally, a monthly surcharge of Rps 45 would be the margin at which about 50% of households would agree to pay for such service.

Willingness to pay for improved water service was significantly higher among respondents who were aware of the relationship of health to sewage seepage and low water pressure than among those who were unaware of this relationship. The average WTP of aware consumers was Rps 42 per month, compared with Rps 28 per month for those who were unaware. This finding suggests that potential service providers should undertake public health education in order to realize the full economic value of providing a water supply system.

6.3 Determinants of WTP Bids for Improved Water Supply

In order to understand the factors that determine demand for an improved water supply (among Dehra Dun consumers), the consultant conducted a multivariate analysis. (The model estimation procedure and results are reported in note to file which is available on request from the Environmental Health Project.) Further details of the results and methodology are described in Appendix A2.

Results of the analysis revealed the following about consumer demand for improved water supply in Dehra Dun:

1. Both household income and education were statistically significant determinants of respondents' WTP bids. An increase in monthly household income of Rps 1,000 corresponded to an increase of Rps 1.3 in WTP bids. Respondents with 10 years of education would be willing to pay about Rps 8.5 more than those without education, other factors being controlled.

2. Initially, the consultants hypothesized capital investments to improve household water supply and quality would have a negative relationship with demand for improved water supply, given that, in enjoying these improvements, the households had to some degree already solved the problems inherent in intermittent water supply. However, the survey results showed the opposite. Respondents who own water-improvement equipment gave higher WTP bids than those who do not own such equipment. One could infer from these results that the former group understands the convenience and benefits of having continuous water supply as a result of using water-enhancing equipment, and therefore tends to value an improved water supply more than those without such equipment. This tends to contradict earlier hypotheses by Altaf,[17] et al., that existing investments would reduce WTP for an improved supply. However, the confounding variable, income, makes this interpretation tentative.

3. The greater the number of hours of water supply respondents currently receive from the municipal water supply system, the less willing they would be to pay for improvements, controlling other factors. Statistically, the impact of hours of water supply is significant, but the magnitude of impact is very small: one hour of increased water supply resulted in a decrease of Rps 0.86 in WTP bids.

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[17] Altaf et al. 1992.

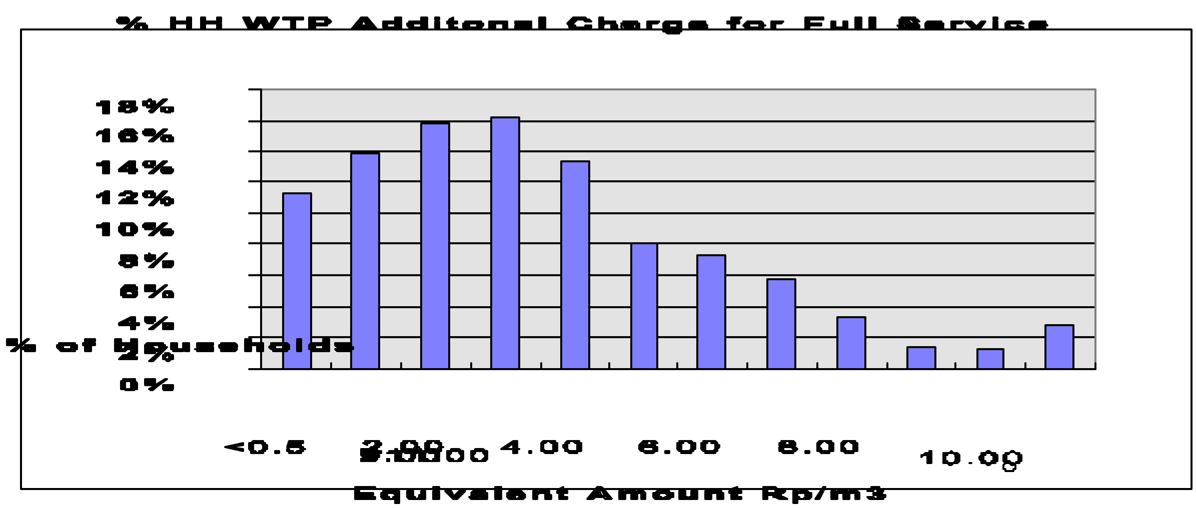
4. The number of families with whom individual-tap users share their tap was not significant in determining tap users' WTP bids. At the same time, households' monthly water consumption level was not significantly related to their demand for improved service.

5. The provider of service was not a significant factor in determining demand for improved service; however, the degree of service (full versus partial) was. The availability of a full, continuous water supply was highly significant in explaining respondents' demand for improved service. Given the option of partial service, respondents' WTP bids were lower by about Rps 2.8 per month.

6.4 WTP Bids by Volume

Even though about 85% of the study population would pay a monthly surcharge of Rps 30 for better service, that does not mean that all the households would be willing to pay the same unit price per unit of water. Figure 6.2 shows the distribution of respondents' WTP bids per cubic meter of water. At Rps 0.5 per cubic meter, more than 90% of the population surveyed would be willing to add to their current monthly water bills. Around Rps 3.00 surcharge per cubic meter, more than 50% would still be willing to pay the additional surcharge.

Figure 6.2

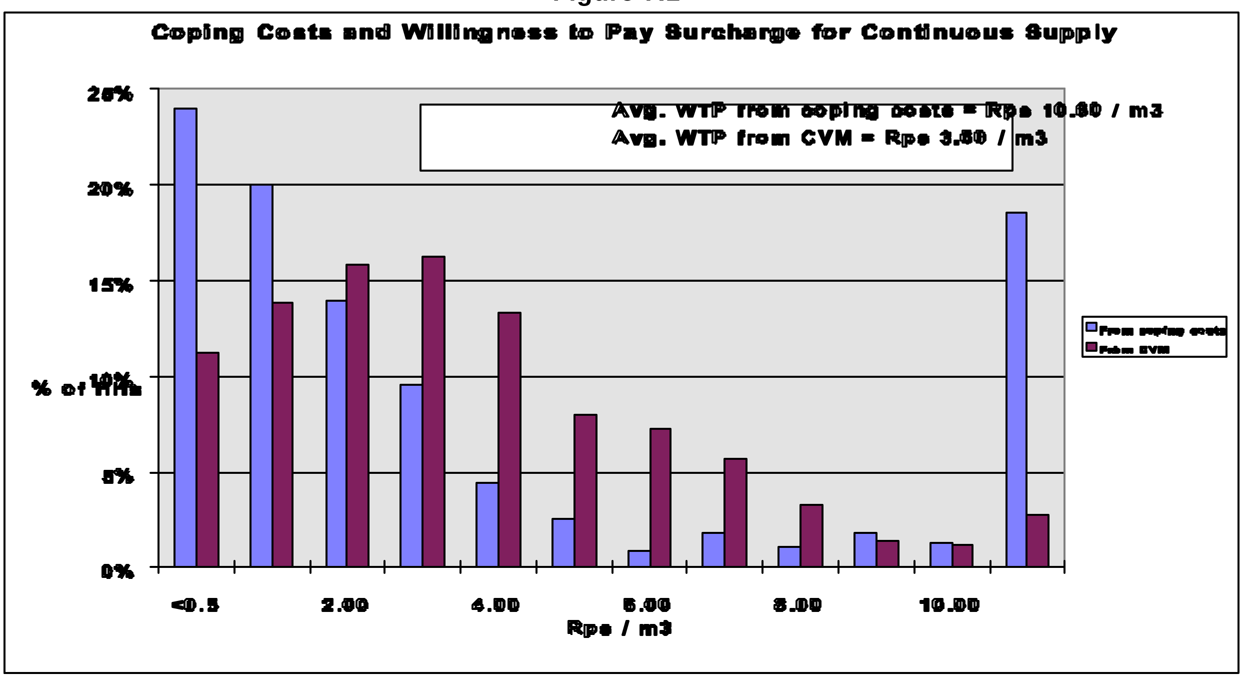


7 THE VALUE AND THE PRICE OF WATER

7.1 Comparing Unit Prices of Water Estimated from Two Methods

The consultant estimated consumer WTP for improved water supply in terms of unit price (Rps per cubic meter) using two estimation methods: coping costs and the contingent valuation method (CVM). Figure 6.2 showed the distribution of WTP bids for a unit of water. In estimating the demand function the coping cost estimates are added to existing payments to derive total WTP. Figure 7.1 shows the distribution of WTP and coping costs (m^3 amongst households). The unusually high percentage of households willing to pay Rps 11 or more reflects the low supply available to public-tap users and the high price they pay in terms of time spent fetching water.

Figure 7.1



The average WTP for improved service for the households with individual taps is close to the actual coping costs. From CVM, the average additional WTP per cubic meter for full-service water is Rps 2.22, while from coping costs, the average paid is Rps 2.11.[18]

Table 7.1 summarizes the estimates of what consumers would be willing to pay as a supplemental charge to obtain a continuous supply of water which is potable and of adequate pressure. Unfortunately there is no easy way of estimating what they are spending at the moment since water is not metered. Some people receive high bills based on rentable value but live in areas with poor pressure, and if they pay their bills, they are paying a large amount per cubic meter. Given that there are habitual nonpayers, smaller properties, and higher pressure in other households, it is clear that the nominal tariff is of little use in describing individual cash payments to the water company. As shown in the table below, the current tariff paid is simply the estimated average amount paid per cubic meter (total electricity bill divided by total estimated consumption). Some people pay nothing, and some people pay much more than this average.

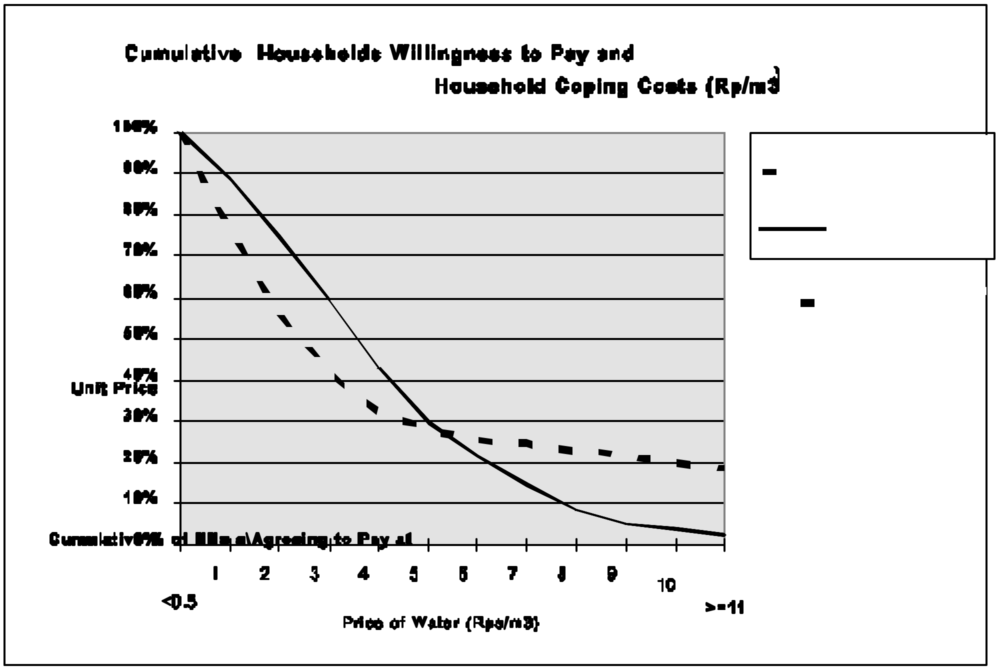
Table 7-1
Summary of Survey Results

Type of Cost	Individual Connection	Public Tap Users	All
CVM Estimate of average WTP for additional service	2.22	4.2	3.6
Coping Cost Average	2.11	43.65	10.6
Currently Paid to WWD in cash	2	0	1.6
Average Real Cost of Water estimated from CVM	4.22	4.2	5.2
Average Real Cost estimated from Coping Costs	4.11	43.65	15.8

Figure 7.2 displays the cumulative percentage of households willing to pay for additional service at different prices from both methods.

[18] Economic theory suggests that consumer surplus (represented by WTP less the tariff paid) should be greater than or equal to coping costs (see Appendix A2).

Figure 7.2



The survey indicated that more than 70% of respondents would be willing to pay an additional Rps 1.0 per cubic meter for improved service on top of the official tariff rate, which was Rps 2.50 per cubic meter at the time of the survey. More than 50% of the respondents already pay an extra Rps 2.0 per cubic meter to cope with the intermittent water supply.[19] At the same time, if the service level improved to full, continuous water supply, more than 70% of the respondents would be willing to pay an additional Rps 2.0 per cubic meter for the improvement. Seventy percent of the respondents represent most households with residential water connections. Therefore, generalizing the sample results to the overall population, Dehra Dun consumers as a whole would be willing to pay more than Rps 2.00 per cubic meter in additional charges for improved water service as described in the CVM study.

7.2 Variation in the Willingness to Pay for Water

Figure 7.3 shows the estimated demand curve for consumers with their own or shared connections, and is derived from econometric analysis of coping costs data collected in the regular season. (Econometric analysis and demand estimates are reported in Appendix A3.)

[19] The survey on willingness to pay indicated that more than 70% of the sampled respondents were ready to pay Rps 2.00 per cubic meter in addition to the prevailing tariff at the time of the study. It is a different matter that later on, political protests about the new tariff of Rps 2.50/m^3 led the Jal Nigam to revert to the old tariff of Rps 1.50/m^3.

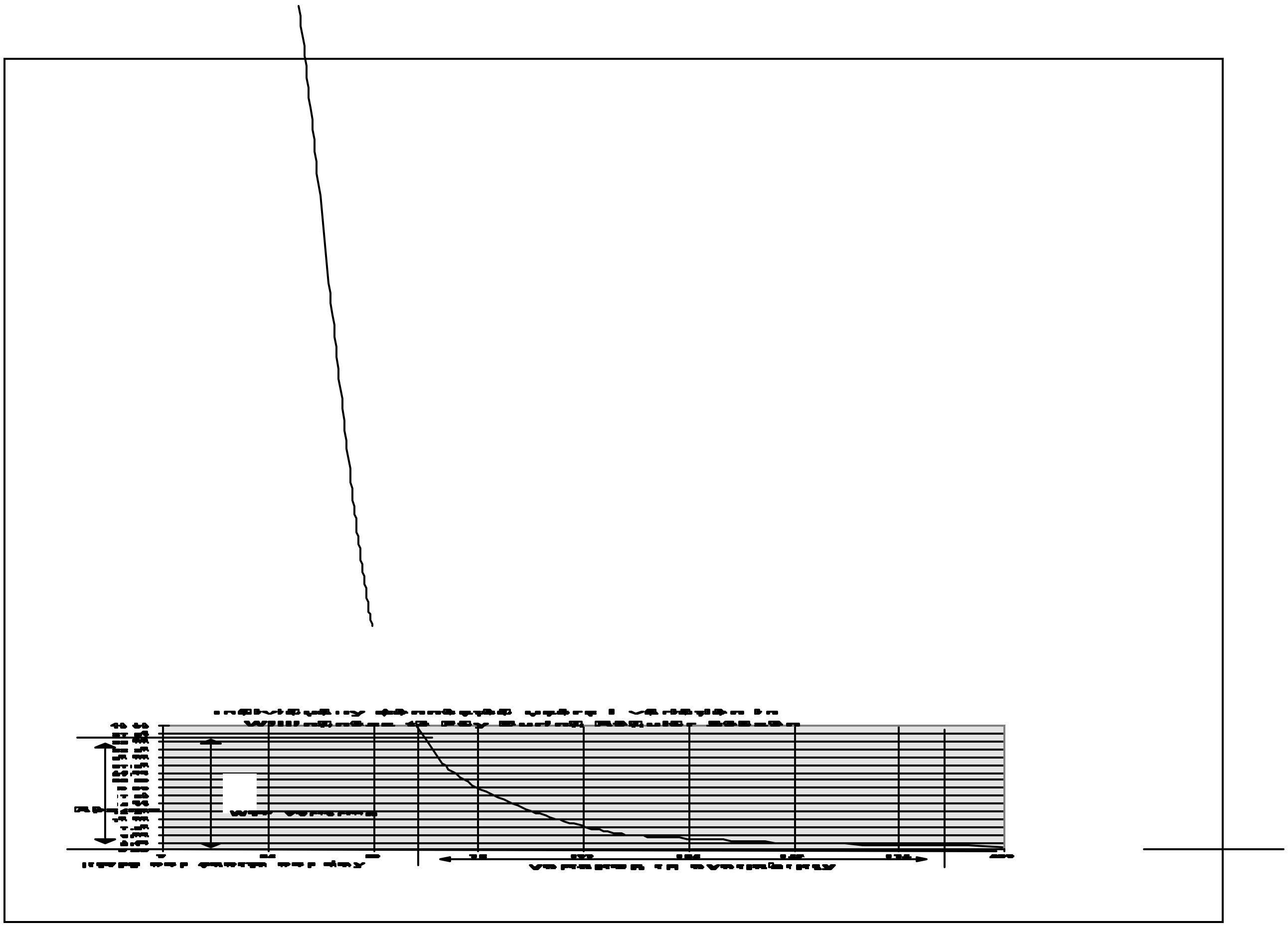


Figure 7.3

The functional form of the demand curve is shown in the equation below. This expression specifies that the demand for water is of a particular functional form (log-log) and that there a number of different independent variablesCthe variables are selected according to the theory of consumer demand. We are specifically interested in the relationship between quantity demanded and price per cubic meter. If we just plotted quantity against price the scatter of observations would reflect the influence of all these other variables. Multiple regression analysis enables us to separate the effect of these variables. The dummy variables[20] allow the simultaneous estimation of separate demand curves for public tap-users and those with independent connections.

[20] A dummy variable assumes a value of A1@ or A0@ depending on whether or not a condition is fulfilled. So when a tap user is interviewed, $W_2 = 1$ and $W_1 = 0$.

$$LnQ = a + (b + c_1*W_1+c_2*W_2)*LnP + d*LnY + e_1*W_1 +e_2*W_2 + f_1*S + f_2*T + g_1*U + g_2*V + u$$

where
Q = monthly water consumption (m3/month/hh)
W_1 = sharing individual water connection
W_2 = public-tap users
P = average total coping cost paid per m3
Y = monthly household income (Rps.)
S = size of family
T = home ownership
U = number of hours water flows per day through taps
V = water pressure measured by discharge rate (liters/minute)

Since water billing in Dehra Dun is based on estimated consumption rather than metered consumption, average price paid cannot be calculated from regular water bills. Instead, average total price paid per m^3 of water is calculated from the sum of monthly water bill and monthly coping costs divided by estimated consumption level of each household. The variable P is acting as a proxy for the WTP in excess of what is paid to the water company for a particular level of expected consumption.

The average water availability was estimated to be 107 lcd for the whole population. To understand why people are willing to pay more for water by investing in coping strategies such as storage facilities, one must consider the variation in day to day availability. Just looking at total availability for the year conceals the costs imposed on consumers by variation. Even though *average* availability for connected households may be 140 lcd there is tremendous variation both between households and over time. If supplies are disrupted so that effective availability (through running down storage) is only 60 lcd, consumers will be willing to pay Rps 40/m^3 for marginal consumption (see Figure 7.3). Similarly if supply is abundant, willingness to pay for marginal consumption would fall to less than Rp 1/m^3. In the dry season the variation in the value of water from day to day is even more extreme as supply varies about a lower average. In making decisions on what to invest in the way of storage, consumer expectations of shortages are more important than average availability. It seems likely, given the shape of the demand curve (inelastic), that most of the benefits from investing in storage are felt in the dry season.

With a fixed tariff and metering, and assuming no electricity break-downs, securing a reliable supply requires fixing the tariff to correspond to a level of demand (or willingness to pay) which is below supply capacity. For instance for a tariff of Rp 1/m^3 demand is nearly 200 lcd compared to availability of about 164 lcd. Some days there would be insufficient capacity to meet demand. A charge of Rps 6/m^3 would assure reliability. This tariff will keep demand down to just over 100 lcd**C**well within anticipated capacity of 164 lcd. Because the costs of unreliability are so high it makes economic sense for consumers to sacrifice average consumption over the year for increased certainty of obtaining a fixed supply every day.

7.3 Setting a Tariff and the Price Elasticity of Improved Water

To estimate how the price of water will affect consumer consumption levels, one needs to estimate the price elasticity of the demand function. The price elasticity is the gauge for setting a socially, as well as financially, feasible tariff structure.

Experts have not yet reached a consensus on the proper estimation methodology to use. (Debates persist regarding (1) which measure of price is an appropriate explanatory variable for the water demand function;[21] (2) which method provides unbiased and consistent parameter estimation;[22] and (3) sample selection biases, if segmentations exist in consumer markets, such as the absence of pricing for public taps.) We do not consider that these methodological issues would substantially affect the qualitative conclusions about the desirability of metering.[23]

In order to account for differences in market segmentation and their effect on price and quantity, the econometric analysis uses dummy variables for price elasticity (effect on slope) and types of water source arrangement (effect on intercept). For both cases, the base becomes the exclusive users of individual water connections.

The average values of each variable and the results of the model estimation are presented in Appendix A3. The explanatory variables were all significant and had the expected signs with the exception of the dummy variable for shared connections and water pressure. Seven of the eight coefficients had significance levels (t-statistic) of 1%. Over 66% of the observed variation in water use was explained by the regression equation. The F-value indicates that the estimated model is highly statistically significant.

Using the conventional Ordinary Least Square (OLS) model, the price elasticity for individually connected users was -0.31 and for public tap users, -0.05. This implies that for a 10% increase in the price of water, there is a 3% decrease in water consumption for households with individual connections, and a 0.5% decrease for households relying on public taps.

Household income has the largest impact on water use: water use increases 4.1% as household income increases 10%. Charging a premium to high-income households would effectively reduce water use, since high-income households normally consume higher than normal amounts of water. An alternative would be an increasing block rate tariff schedule, to circumvent the problem of water consumption levels in high-income households.

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[21] See Shin 1985, Opaluch 1982, Nieswiadomy 1992.

[22] See Bachrach and Vaughan 1992.

[23] Keeping in mind the primary objective of the effort, the above three estimation issues are taken into account in the following manner:

(1) Per-unit price measurement: choosing marginal vs. average price to reduce endogeneity issues. Other empirical data correlate metered water billing with the quantity of water consumed; however, water consumption in Dehra Dun is not metered, and thus is uncorrelated with actual consumption. Because of this unmetered billing practice, the potential estimation bias from using average price is less problematic. Therefore, the team's model uses average price per cubic meter of water, which is calculated by adding monthly water bills to coping costs.

(2) Often instrumental variable (IV) estimators or 2 stage least square (2SLS) estimation techniques are applied to correct simultaneity bias that results from using increasing/decreasing block rate schedules. However, there is neither consensus in the water demand literature on this issue, nor block rate schedules in Dehra Dun. Following the conventional manner, this study uses the OLS estimation technique.

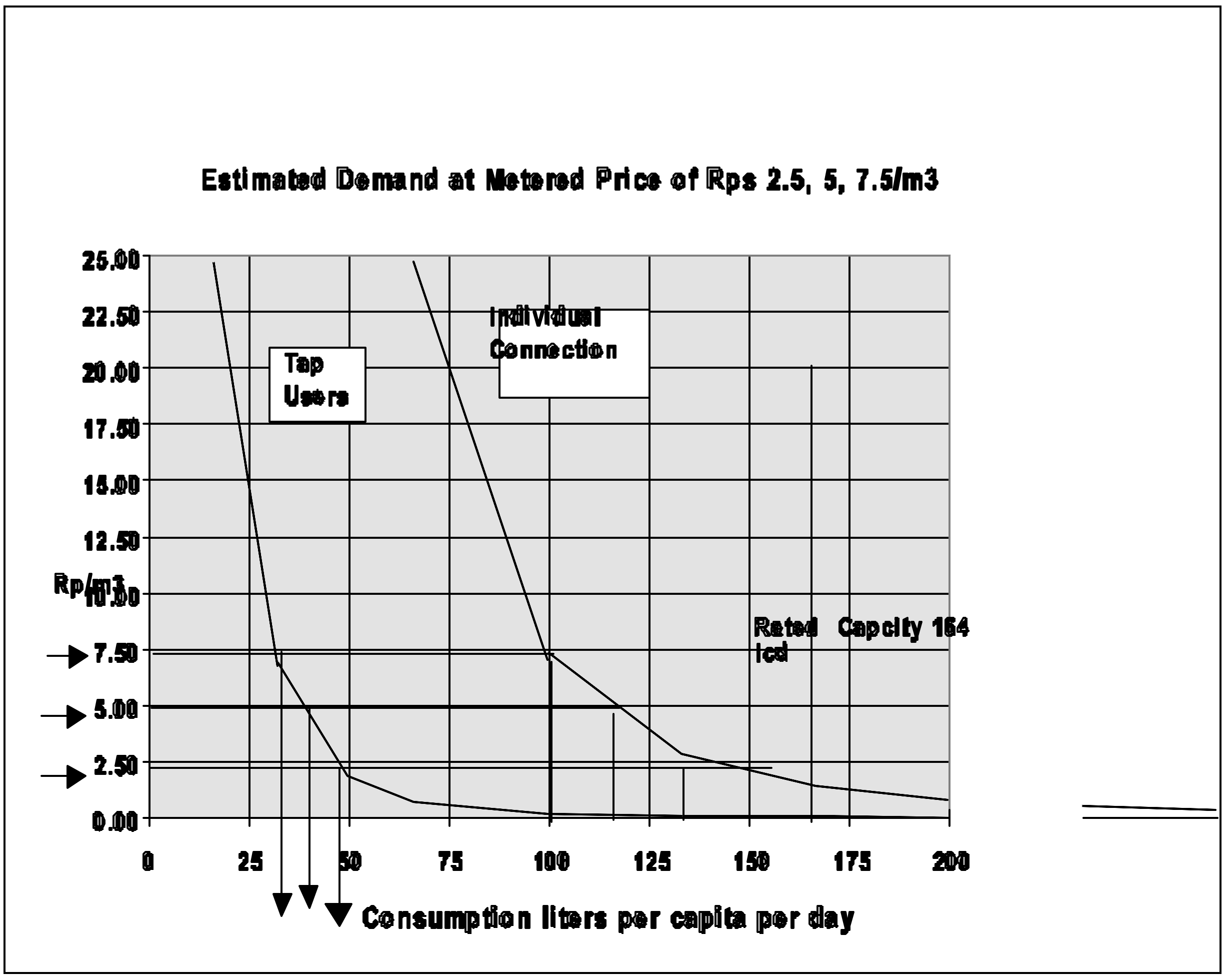
(3) Market segmentation within one locality often causes analysts to exclude a certain segment of consumers from demand function estimation. For example, due to the zero price of water for public tap users, this group of consumers would not be analyzed for its demand along with other groups. In this study, the unit price of water is based on real resource cost, rather than just on tariff. Thus, the public tap sample has an observed data point for a price-quantity relationship.

Whether a consumer has an exclusive or a shared connection does not affect water consumption in Dehra Dun; however, the number of hours of water supply is an effective mechanism for controlling water consumption. The model indicates that a one-hour increase of water flow increases consumption by 2%.

The graphical presentation of the demand functions (see Figure 7.4) shows that at a metered tariff equal to that charged at the time of the survey (Rps 2.5 per cubic meter), individually connected users and public-tap users would have demanded approximately 20 cubic meters and 7 cubic meters of water per month (133 lcd and 47 lcd), respectively, during the regular season. This compares with survey respondents' actual water consumption levels of about 18.5 and 4.9 cubic meters per month (123 lcd and 33 lcd), respectively. This shows that metered consumption at the current official tariff would be lower than the quantity demanded at present. The pattern of consumption when water is metered and reliable will, however, be very different to the situation described for the survey population. Although total consumption is approximately the same, there is much waste and widely differing levels of consumption under the existing system.

Water scarcity is especially significant for public-tap users, as the smaller the water supply, the longer they must wait in line at the tap. In order to secure the minimum lifeline quantity of water, public-tap users are already paying more than Rps 40 (a real resource price) per cubic meter during the dry season.

Figure 7.4



7.4 Pricing Water and Social Equity

The conventional approach to determining water tariffs in countries with regulated utilities is to estimate the water system=s total capital or operating and maintenance costs and government taxes, and allow for a profit ranging from 3% to 6% of production costs. Planners often presume that 4% to 5% of average household income would be an Aaffordable@ amount for consumers to pay for water, but they design the tariff structure without considering the impact of price on water consumption. The equity of rate changes should also be considered in order to achieve a socially acceptable tariff rate.

Table 7.2 shows the effect that increasing tariff rates would have on consumers= monthly water consumption and expenditures under four price scenarios. The table is not meant to be an exhaustive analysis of the effect of a new tariff, but rather is intended to indicate the impact of higher tariffs on social equity.

As shown, households relying on public taps in Dehra Dun now spend, on average, 6.7% of their real income for 3.9 cubic meters of water a month during the regular season. In contrast, individually connected households spend only 1.6% of their income for more than four times as much water.

If Dehra Dun=s water supply system were improved and consumers could obtain water at an economic tariff without incurring further real resource costs for storage and queuing, both individually connected and public-tap users would spend approximately an equal percentage of their income on water. For instance, under scenario 1, at a tariff of Rps 2.5 per cubic meter, both public-tap users and individually connected users would have to spend about 0.87% of their income on water. As the tariff rate increases to Rps 5.0 and Rps 7.5 in scenarios 2 and 3, the percentage of income spent on water would increase to about 1.41% and 1.88% for both user groups.

Although under the above scenarios, public-tap users and individually connected users would spend approximately equal percentages of their income on water, they would continue to consume unequal amounts. For example, at a tariff rate of Rps 5.0 per cubic meter, both groups would spend about 1.41% of their income on water, but public-tap users would consume no more than 5.5 cubic meters per month, only a third of what individually connected consumers would use.

Table 7.2
Affordability and Social Equity Analysis of Different Tariff Rates

Parameter	Public Tap	Individual	Total
Current intermittent service: unequal % of expenditure/water consumption			
Average income (Rps/month)	1,969	5,908	4,862
Average coping costs (Rps/m^3)	33.2	2.32	10.5
Average water bill paid (Rps/m^3)	0.6	3.8	3
Average total price paid (Rps/m^3)	33.8	6.12	13.5
Estimated quantity of water consumedm^3/mo/hh)	3.9	15.9	8.4
Average monthly costs for water (Rps/mo/hh)	132	97	113
Average percentage of income spent on water (%)	6.70%	1.64%	2.33%
Scenario 1: equal 2.5 rate/equal% of expenditure and unequal water consumption			
At tariff of Rps 2.5/m^3 for all users	2.5	2.5	2.5
Estimated water consumption (m^3/mo/hh)	6.8	20.8	14.1
Monthly water expenditure (Rps/mo/hh)	17	52	35.25
Estimated percentage of income spent on water	0.86%	0.88%	0.73%
Scenario 2: equal 5.0 rate/equal% of expenditure and unequal water consumption			
At tariff of Rps 5.0/m^3 for all consumers	5.0	5.0	5.0
Estimated water consumption (m^3/mo/hh)	5.5	16.8	11.4
Monthly water expenditure (Rps/mo/hh)	27.5	84.0	57.0
Estimated percentage of income spent on water	1.40%	1.42%	1.17%
Scenario 3: equal 7.5 rate/equal% of expenditure and unequal water consumption			
At tariff of Rps 7.5/m^3 for all consumers	7.5	7.5	7.5
Estimated water consumption (m^3/mo/hh)	4.9	14.9	10.1
Monthly water expenditure (Rps/mo/hh)	36.8	111.8	75.8
Estimated percentage of income spent on water	1.87%	1.89%	1.56%
Scenario 4: Different tariff rates/ensuring life-line water consumption			
Tariffs to allow 9 and 16 m^3/mo/hh	1.0	6.0	4.2
Estimated water consumption (m^3/mo/hh)	9.0	16.0	12.0
Monthly water expenditure (Rps/mo/hh)	9.0	97.0	51.0
Estimated percentage of income spent on water	0.46%	1.64%	1.05%

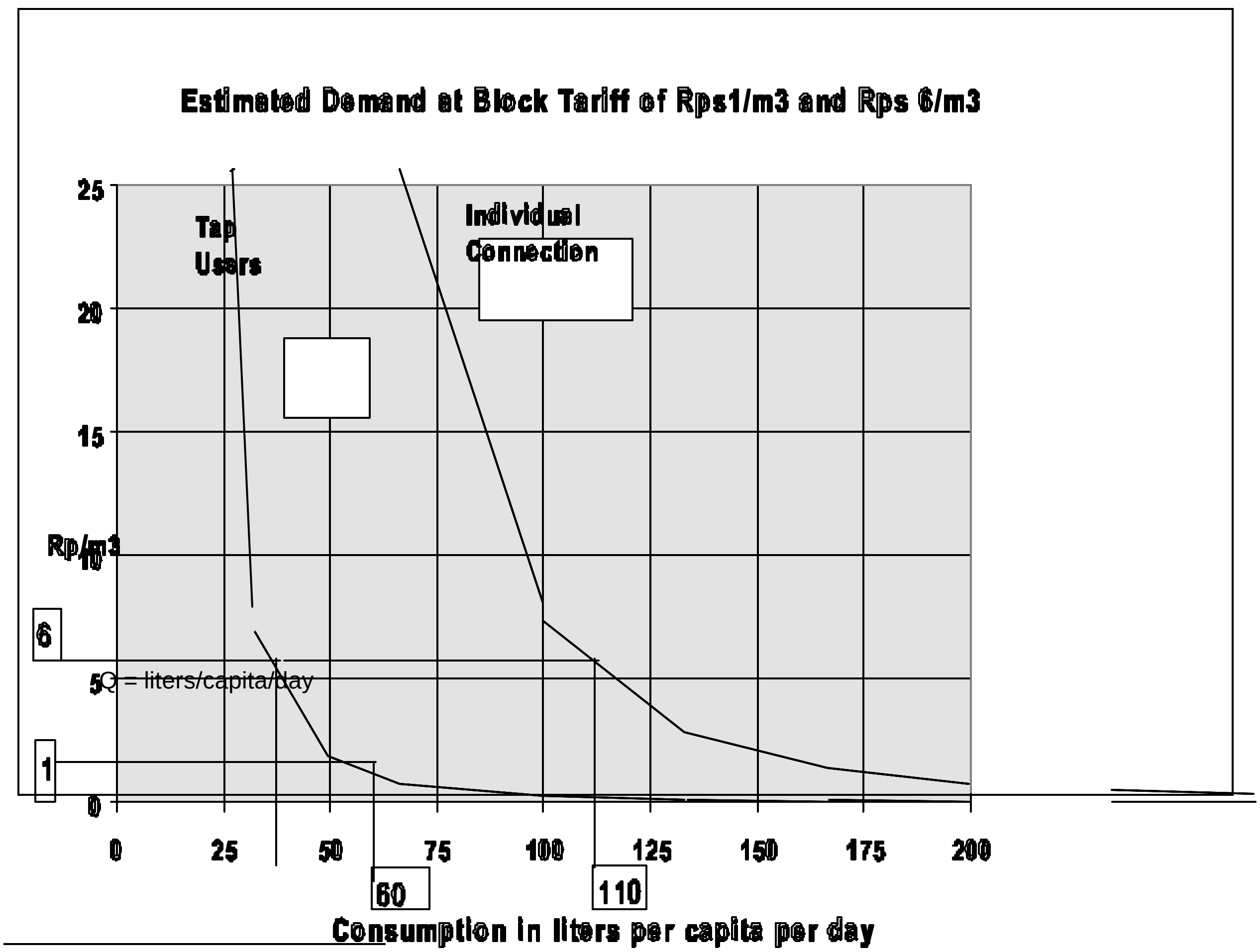
In order to allow the minimum level of lifeline water consumption needed for urban life, the minimum use of water would need to be at least 60 lcd (or 9 cubic meters per month per household). Considering the minimum lifeline water consumption for public-tap users and the maximum allowable water supply without augmenting the system's currently rated capacity, an increasing block rate tariff schedule as shown under scenario 4 in Table 7.2 would be suitable. Increasing block rate structures are economically justified when volume-related costs rise along with either systemwide or individual-account volume increases.

The total average production available for domestic consumption under scenario 4 would be about two-thirds of daily production, which would equal about 36.4 mld (52 mld x 0.7). After subtracting system physical losses (12%),[24] the average lcd available for the entire Dehra Dun population (290,000) would be as follows:

110 lcd = 36.4 mld x 0.88/290,000, or 16m^3/mo/hh

At each level of water consumption under scenario 4 with present capacity unenhanced, households= maximum willingness to pay for water would be Rps 6.0 and Rps 1.0 per cubic meter for individually connected and public-tap users, respectively. These quantity and price relationships are shown in Figure 7.5.

Figure 7.5



[24] Currently, the Dehra Dun water system suffers physical losses of about 22%. In order to increase the efficiency of water supply without major system augmentation, repairing system leaks would be essential. Thus, a 12% in physical loss is assumed on the premise that there would be some improvements in leakage control, even without major new investments.

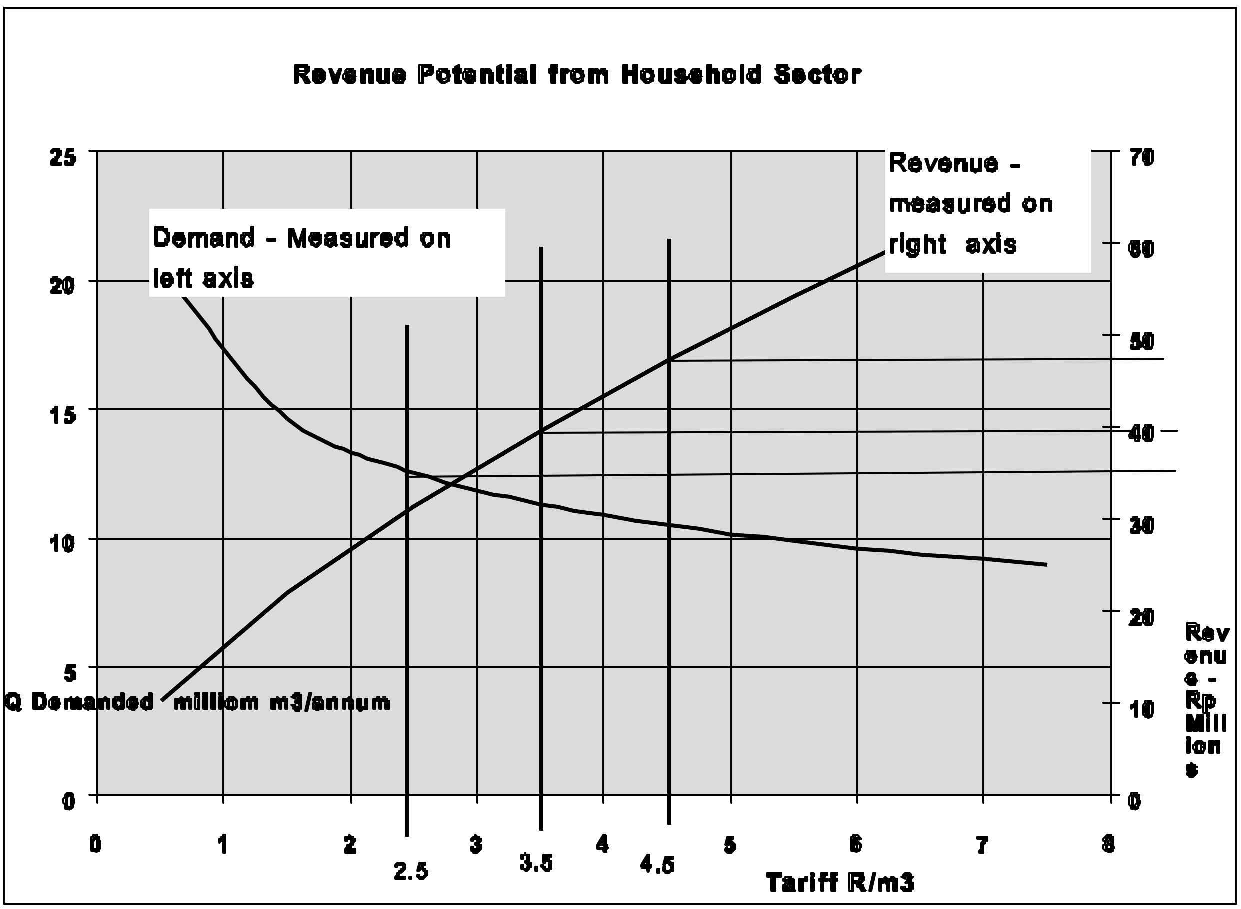
7.5 Pricing Water and Financial Feasibility

With a tariff rate of Rps 2.5/m^3, the yearly revenue from Dehra Dun=s water supply system could be as high as Rps 32 million from residential connections alone, if improved, continuous service were made available. According to the current demand estimates and price elasticity, without augmenting the rated capacity, the annual revenue could rise to Rps 45 million a year by controlling individual household water consumption through pricing (see Figure 7.6). However, it is important to note that this revenue potential would only be available once intermittent supply conditions had been improved to provide continuous supply. This is a sort of chicken and egg situation as continuous supply can only be ensured if bills are paid and electricity is continuous.

Currently, Dehra Dun=s water supply system can provide up to 11 million cubic (105 lcd) meters per year for domestic water consumption (excluding nonresidential and physical water losses). This amount would be demanded at a tariff of Rps 3.5 per cubic meter, which would generate annual revenues of Rps 40 million. (See Figure 7.6.) Since the price elasticity of water is low over the relevant price range (-0.03), the demand function estimates indicate that this increase in price would hardly affect the quantity demanded. A monopolist could in effect charge what he wanted but in practice the price will be decided by the interplay of three factors

(a) the price must be sufficient to cover costs and provide a return to capital
(b) demand at this price should be significantly lower than delivery capacity to provide a margin of reliability
(c) social acceptability and so-called Aaffordability@ considerations

Figure 7.6



If the original tariff rate of Rps 1.5 per cubic meter were applied to a metered system, the total quantity of water demanded would far exceed the system=s rated capacity (14.5 million cubic meters versus 11 million cubic meters). In such a case, the system would have to be expanded in order to meet demand. The two most plausible scenarios are:

(a) A flat rate of Rps 3.5/m^3 for all consumers would generate c. Rps 40 million (about 104/m^3)
(b) A block tariff of Rps 6/m^3 (about 18K/m^3) for these with connections and Rps 1/m^3 for those without would generate Rps 55 million.

If the administrative losses from the nonresidential connections were fully recovered, however, the total revenue generated from both residential and nonresidential connections would be approximately Rps 60B75 million annually (Rps 40B55 million from residential use and about Rps 20 million from nonresidential connections). A range of revenue estimates from Rps 60B75 million should be used for planning a full service system.[25]

[25] In its study of consumer coping costs under intermittent water supply conditions, the team attempted to estimate the demand for improved water service from commercial and institutional users by administering an additional survey for nonresidential users. Commercial/institutional consumers generally could not clearly specify the amount of water they consume, nor the costs they incur for coping with the intermittent water supply. Generally, commercial/institutional water consumers include several people who are managing the financial/technical aspects of their organization. Therefore, it was difficult for one interviewee to come up with a full picture of how much the entire organization had spent for water. Another difficulty was that estimating water consumption was almost impossible due to inoperative meters in most of the institutions.

8 IMPROVING THE WATER SUPPLY

The water supply system in Dehra Dun was originally selected for study because it appeared to have a significant potential for improvement. It was not intended that the study of demand conditions would be an end in itself, but that it would provide a more solid basis for encouraging private-sector participation. It is hoped that the estimates provided in this study, combined with the preceding demand analysis, will be sufficient to interest investors in conducting a full-scale feasibility study.

Section 8.1 summarizes a number of simple, low-cost investments that could, when combined with a commercial financial and managerial structure, provide a continuous full-service water supply. Section 8.2 presents a cursory cash flow analysis based on pre-feasibility estimates on demand and cost parameters. The physical investments alone would be insufficient because of shortcomings in the institutional framework. Section 8.3 summarizes the major institutional and financial governance issues that would have to be addressed before trying to attract private capital for developing urban infrastructure in secondary cities such as Dehra Dun.

The improvements enumerated below could also constitute an action plan. Some aspects of this plan would require the participation of consumers, especially public-tap users, and would require consensus among a broad coalition of interests in Dehra Dun. This coalition must be able to negotiate with an interested private sector partner.

8.1 Physical and Operational Improvements and Costs

8.1.1 Increasing the Number of Public Taps

The survey showed that the costs of an intermittent water supply fall most heavily on Dehra Dun's public-tap users. To alleviate that burden, every group of 10 households should have one jointly owned and metered public tap. One of the households from each group would be responsible for collecting payment for the water from the other households in the group and managing access so as to avoid queues.

To reduce the average time public-tap users currently spend fetching water from 3 hours to 1.5 hours per day on average, it would be necessary to increase the number of public taps in various areas by installing 330 additional taps. The cost of providing the additional public taps and associated piping and meters would be about Rps 1,500 per tap. Thus, the total cost for installing the extra taps would be about Rps 500,000. Maintenance is estimated at Rps 50,000/year.

8.1.2 Providing Working Meters on All Water Connections

In order to recover administrative water losses and modernize the WWD's billing system, all water consumption must be metered. Although the Jal Nigam claims Dehra Dun has 41,380 individually metered connections and only 1,758 unmetered, the survey results show that almost all of the meters are inoperable and need replacing. At a cost of Rps 230 per connection, the total cost to meter or re-meter all 43,138 connections would be Rps 9.92 million. It is important to note, however, that this expenditure would constitute only a one-time expense, not a yearly expense. With proper maintenance, the life span of a water meter should exceed 10 years at an annual cost of less than Rps 2 mil (assuming a 15% financing rate). Maintenance cost would be 5% or Rps 460,000/annum.

8.1.3 Repairing Supply System Leaks

As noted in previous chapters, Dehra Dun=s water supply system suffers from leakage; however, the consultant could find no information to show where and to what extent leakages occur. In March 1995, an inspection authority was established to improve the municipal water supply system. The authority was also charged with determining the cost to conduct repairs and revive defective or out-of-order systems. It came up with the following estimates:

Pumps for raw-water pumping station	Rps 50,000
Pumps for clear-water pumping station	Rps 50,000
Pumps for zonal pumping station	Rps 100,000
Pumps for tubewells	Rps 500,000
Chlorinators	Rps 100,000
Total	Rps 800,000

The authority should also allot Rps 200,000 to repair any leaking pipes, which would bring the total for repairs to Rps 1 million. Annual maintenance at 10% of capital cost would be Rps 100,000. The city=s existing gravity-fed system may not be supplying all customers with adequate pressure, but it was outside the scope of this report to estimate the cost of installing supplementary pumping stations to increase pressure significantly.

8.1.4 Improving the Water Quality

Last year, the People=s Science Institute, a nongovernmental organization, conducted water sampling in Dehra Dun. PSI=s study was designed to encourage adequate chlorination and disinfection treatments for pathogenic organisms, specifically in the summer months.[26] Its results suggest that Rps 2 million should be provided to improve the city=s existing filtering plants and add further chlorination plants. Maintenance would be Rps 200,000 per annum.

8.1.5 Meeting the Demand for Water by Augmenting the Current Water Supply

As mentioned in Chapter 3, because of unaccounted-for water losses, both physical and administrative, Dehra Dun=s per capita water consumption is well below system design capacity of 163 lcd.[27] With the improvements discussed above, once leakages are plugged, physical losses should fall to 12%, which is within a permissible limit for a developing country.

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[26] AME report, Dehra Dun: An Overview Report, June 1995.

[27] The household survey results indicated that Dehra Dun=s average per capita water consumption is 125 lcd. This is also reflected by the fact that if physical losses are 22%, as noted in Chapter 3, the net available water physically is 127 lcd, which corroborates the survey results.

By reducing physical losses to 12% and accounting for true water consumption through proper metering and billing, enough water could be secured to provide Dehra Dun with a continuous supply. Reducing physical losses would increase capacity from 107 lcd to 144 lcd.

163 lcd x 88% = 144 lcd

Also, by enforcing strict metering and billing, the water provider could reduce revenue losses. Curbing administrative water losses would not directly increase the per capita water supply; it would minimize the wasteful use of water that occurs as a result of loose controls and poor billing procedures.

Dehra Dun=s existing water supply should be augmented by 9 mld via additional tubewells, more overhead tanks, and power connections. This would raise the total water supply (or availability for consumers) to 60.12 mld, or 200 lcd. The additional equipment needed and its cost are estimated as follows:

4 tubewells at Rps 1.5 million/tubewell	Rps 6.0 million
3 overhead tanks at Rps 500,000/tank	Rps 1.5 million
4 power connections at Rps 500,000/connection	Rps 2.0 million
Total	Rps 9.5 million

The city=s water draw-off patterns currently are unknown, and a detailed study of them would be necessary before an investment in the above items were made. Such a study would be needed to determine seasonal differences in draw-off patterns, as they vary widely during the summer and winter months.

8.2 Investment Prospects and Cash Flow Projections

8.2.1 Finance of Infrastructure

An attempt to break the vicious circle of low quality service and prices too low to provide a high quality service will have to proceed by a process of trial and error. There are few examples in the rest of India to emulate. However if Dehra Dun itself can solve its water problems in a way that is beneficial to all, this example would inspire other cities to experiment with innovative mechanisms for providing public infrastructure services. This study has concentrated on the empirical estimation of demand using cutting-edge economic techniques. These would be neither practicable nor necessary for other townsCthe purpose of the analysis was to persuade the capital markets that it is worth experimenting, on a very modest scale, in a favorable location, with new ways of organizing and financing water supply.

At the inception of this project discussions were held with USAID=s Financial Institutions Reform (FIRE) project about the criteria to use for selecting a location in which to conduct a demand study for water which compared WTP estimates with those derived from coping costs. The FIRE (Financial Institutions Reform and Expansion) Project is a major new USAID project directed by RHUDO New Delhi. The project seeks to promote the supply of higher quality and more efficient urban infrastructure services, through marketing new debt instruments and deepening local Indian capital markets to attract private overseas investors. FIRE is managing $125 million of USAID guaranteed loans and technical assistance, training and evaluations will also be implemented over the period 1995-99. FIRE is committed to working with HUDCO Ltd (Housing Finance Corporation) and ILFS Ltd (Infrastructure Leasing and Financial Services). Besides leveraging HIG funds by guaranteeing loans, the envisaged mechanisms would create contractual bonds between US private investors, an Indian Financial Institution swap partner, and the housing financial intermediaries HUDCO and ILFS. The

NIUA (National Institute for Urban Affairs) is also receiving support from USAID and will act as the advocate for policy change, and coordinator for technical assistance for the FIRE Project. The study will involve participation within the scope of formal FIRE agreements and memoranda of understanding, and using other contacts with states, municipalities, the private sector and prototypical urban and peri-urban communities.

The appropriateness of the FIRE mechanism to support investment in Dehra Dun is only in question because of the small size of the investment that we think is necessary to create fundamental changes in the quality and reliability of water supply. The primary constraints we see are organizational and institutional and do not require subsidized investment - indeed this could exacerbate by prolonging the life of present arrangements. Dehra Dun could however provide a testing ground for FIRE to consider appropriate mechanisms to impact infrastructure in small towns such as Dehra Dun. It may be that a larger investment is necessary to induce private sector participation as well but this will not be successful if metering of water supplies cannot be established. Thus Dehra Dun while it does not fit the scale of the FIRE project could provide an experiment in a smaller scale experiment which tested the plausibility of working out appropriate partnerships between private sector capital, state government and municipal authorities. Demand appears to be suffic9ent to support a continuous supply which would cost less than the present system in terms of real costs per m^3 delivered, and have a positive welfare effect on *all income groups*.

8.2.2 Investment Appraisal

In this chapter we have costed a limited range of improvements which would significantly increase capacity from c 110 lcd to 144 lcd. This margin between the capacity and predicted demand under metered conditions, should be sufficient to ensure a continuous supply. A radical increase in pressure would require much more substantial investment in pipe repairs and would represent a ARolls Royce@ solution. Although even 144 lcd average does not sound much more than at present it would be supplied under different conditions. The problem with the current situation is not a lack of capacity, but excessive waste in response to both unreliable supply, and no incentive to conserve. The cost to the consumer of leaving his/her tap running is zero. Price can be used to encourage conservation and economic use with benefits for everyone if our analysis of demand conditions is accurate.

The following cash flow projections assume that a mechanism can be found to allow the operation of the water supply system to be leased to a private or state owned company which would operate on commercial principles, supplying a metered and chlorinated public water supply. In exchange for the initial investment and possibly some leasing charge, the new operator would be allowed to run the system with tariffs based on an agreed target rate of rate of return on the operator=s capital. A 10 year period is assumed for illustration. The sources of finance and the terms of any agreement between state, municipality and investor can be considered independently of the project cash flow. We describe a limited program of investment as the major problems to be overcome in order to provide a continuous water supply are managerial and financial, not the physical state of the water mains and sources.

A cash flow for a private investor to carry out the improvements and operate the water supply system for 10 years is shown below. It assumes of course that finance is 100% equity; debt participation at market long term interest rates would increase returns to the equity investor even more. The estimates have been prepared by an engineer but they are not based on a full engineering feasibility studyCthis would cost much more. These estimates are what engineers call Apre-feasibility@ or project identification level estimates. A sensitivity analysis is applied using two different levels of total revenueCRps 60 million and Rps 75 million corresponding to the two tariff options discussed earlierCa flat rate of Rps 3.5/^{m3} or a block tariff of Rps 3.5/^{m3} for public tap users, and 6.0 Rps/^{m3} for those with household connections. Constant prices and real interest rates are used for the analysis.

Table 8-1
Capital and Annual Costs of Improvement (1996 Rps)

Capital Costs	**Rps**
Public Taps	500,000
Meters	9,920,000
Repair of Leaks in pipelines	1,000,000
Chlorination Plant	2,000,000
Additional Tubewells, Main Tanks and Power Connections	9,500,000
TOTAL	22,920,000
Annual Costs	
Maintenance	1,285,000
Electricity	30,000,000
Salaries under new management	8,000,000
Other Administrative Costs	1,000,000
TOTAL	40,285,000

Assuming a one year investment period before transfer to commercial management, the cash flow would be as follows:

Table 8-2
Cash Flow, Rps Millions, 1996 Constant Prices

Scenario	**Base Case**		**All Costs Increased 20%**	
	Year 0 Investment	Cash Flow Years 1-10	Year 0 Investment	Cash Flow Years 1-10
Scenario 1 (a flat rate of Rps $3.5/m^3$	-22.92	19.715	-27.5	11.66
Scenario 2 (a two-stage block tariff)	-22.92	34.715	-27.5	26.66

This would represent a return of 86 or 151% for the two options. With the cost increase this falls to 41% and 97%. A more realistic scenario would incorporate a collection ratio and the effects of late collection of revenue. Even assuming a leasing charge of Rps 5 million per year (paid to the state or municipality) and a collection rate of 90%, the investment still shows a healthy return in all except the most pessimistic case (the flat rate tariff + 20% increase in costs + Rps 5 million leasing charge).

Table 8-3
Summary of Results

Type of Tariff	Base Costs	Cost +20%	90% collection rate + 20% increase in costs + Rps 5mn/year leasing charge
Flat rate tariff	86%	50%	<0
Block tariff	151%	116%	69%

We have not introduced the effect of long-term financing in the form of debtCat long term real rates of 8 or 9% the returns to equity would be even higher. Given this is a captive market the key risk factor would be the enforceability of collection. However we believe that a metered continuous supply at increased pressure will be a much cheaper alternative for consumers than any other choices they currently have (including the present system).

8.3 Institutional Arrangements and Financial Governance

8.3.1 Financial Accountability

Revenue generation from the Dehra Dun water supply should be brought under the control of a single organization that is financially accountable to its owners but that has the authority to set tariffs and pursue collections. Such an organization must be regulated in order to prevent the abuse of its position as a monopoly. The organization should, however, be permitted to make a profit; hence, tariffs should be calculated to enable the company to enjoy a commercial rate of return on capital investments consonant with the risk involved. Provisions must also be made for regularly reviewing tariff rates in light of changing costs. The organization=s operational and accounting procedures should be enforced by a professional auditor.

8.3.2 Billings and Collections

Without controls that allow the service provider to cut off nonpaying customers, Dehra Dun=s water supply system cannot be run efficiently. Unfortunately, the thinking among the local communityC that water is a social good, rather than an economic oneCleads to the worst consequences for those with the weakest purchasing power. Under the current system, all users incur very high costs for water, but the impact of these costs on the consumption of other goods is highest among the poor.

8.3.3 Human Resources Management

One of the most serious constraints facing the WWD is its inability to hire and fire employees based on their performance. Currently, personnel are not allocated so as to produce the highest return and, indeed, may be directed to operational work outside the Dehra Dun municipal area. Lifetime employment is supplemented by a tradition of employing a family member to replace an employee who dies. Salary structures and promotions are only very loosely tied to performance.

8.3.4 Public-Tap Management and Coverage

As noted above, the current system of public taps must be supplemented. To prevent abuse under the new system, users should be charged a nominal fee. Since tap users' real costs are currently quite high, such a fee should not constitute a burden. Even a full commercial rate of Rps 6 per cubic meter of water would only amount to Rps 0.18 to fill two 15-liter containers.

Assuming the estimated cost of paying the tap caretaker equals 50% of the unskilled wage rate, or Rps 510 a month, and assuming each family consumes 120 lcd for a monthly consumption of 36 cubic meters for each 10-family tap-user group, the caretaker's fee would cost less than Rps 51 per month. Even though this cost is equivalent to Rps 0.44 per 30 liters (more than the Rps 0.18 for the water delivered at the tap), the fee may be necessary to prevent waste and water trading that might arise if a high-pressure, continuous supply were provided for free.

The total cost of Rps 62 per 30 liters (two 15-liter containers) would amount to Rps 20.7 per cubic meter, which compares favorably with present estimates of Rps 40 based on time spent waiting in line at the public tap. With a ratio of approximately 20/tap, consumption currently is very low (we know, for example, that even during the wet season, the average family of five uses about 500 liters per day, but those serviced by public taps consume 180 liters per day).

Currently, Dehra Dun's taps are not well located for transient users, which increases the latter's coping costs.

The usage charges outlined above would not necessarily leave public-tap users worse off than they are now, because price functions as a way of reducing the severe queuing costs. Without pricing, consumer surplus is bid away by queuing. Put another way, imposing a price allows supply to increase. Allowing consumers to use as much water as they desired at Rps 15 per cubic meter would drastically reduce coping costs, thereby effectively moving the demand curve out at the same time.

9 CONCLUSIONS

The timing of the survey was driven by budgetary considerations. The survey was conducted in the regular season whereas most of the costs of coping with the present system are incurred in the dry season. Not only may recall be affected but variability is much higher in the dry season. The total costs of an intermittent water supply are not spread evenlyCmost occur in a few periods of time when water is not available at all for several days. Implicitly we have assumed the wet season and dry season demand functions are the sameCit is supply which shifts. In retrospect the survey should have been conducted in the dry season as that is the time when WTP for additional water is highest and coping strategies most explicable.

A second limitation of the survey was the difficulty is both estimating supply and non-residential use. We have made the conservative assumption that institutional users would be willing to pay at least as much as households. We were not able to consider the factors that would have to be taken into account if industrial and commercial tariff rates were determined. We have erred in the direction of overestimating rather than underestimating current supply. The study of coping costs yields results consistent with consumer demand theory, and the contingent valuation method. Both estimates (WTP for additional service and coping costs) are of a comparable order of magnitude. For the public-tap users an independent demand curve was estimated.

9.1 The Four Hypotheses

In Chapter 1 the following 4 hypotheses were advanced:

The willingness to pay for a continuous water supply exceeds the revenues currently received by the Dehra Dun water works department

The total revenue received by the WWD for 1994, including non-household revenue, was approximately Rps 30 million. The estimated household demand for water shows that with effective metering, at a price of Rps 4.5/m^3 the WWD could have earned Rps 46 million on the volume it was able to supply to households.[28]

Current coping costs (investment in storage and time costs) are at least as great as the current amount paid to the WWD in water billings.

[28] The WTP would have been even greater than this since WTP is measured by the total area under the demand curve, while revenue is a rectangle - height equal to price, and quantity equal to total demand. The difference between the rectangle representing revenue and the area under the demand curve is a measure of consumer surplus and this could be considerable when demand is inelastic.

It was estimated that average coping costs per m^3 consumed was over Rps 10 for the whole sample (weighted by number in sub-population and not volume). Billed amounts averaged only Rps 2/m^3 for those with connections. For users with connections, total costs (paid to the water company and incurred in coping costs) were over Rps 4/m^3. The time (foregone leisure, work or caretaking) and inconvenience costs to these connected customers have not been computed. They would be in addition to the Rps 4/m^3. However for public tap users the only cost computed was that of the opportunity cost of time. We have assumed that even the time of a destitute mother which is spent on collecting water could have earned some minimum unskilled wage rate (we have costed this labor at Rps 3.5/hour) or be valued for household duties. Public tap users pay no cash to the WWD but the survey indicates that the real cost in the dry season, arising from queuing and low pressure, are over Rps 50/m^3.

Full service water supply is a commercially viable proposition.

The survey supports this conclusion which is not surprising since the water company would hold a virtual monopoly for an essential good with an inelastic demand (estimates were -.03 for price and .40 for income elasticity). Feasible tariffs were assessed using these elasticities to come up with two scenariosCone a flat rate of Rps 3.5/m^3 and the other a two level tariff of Rp 1/m^3 for public-tap users, and Rps 6/m^3 for those with private connections. All revenue scenarios assume that a) metering can be enforced, b) electricity supplies are restored to a much higher level of reliability (by the utility actually paying the electricity bill.) A conservative program of providing additional public taps, upgrading treatment facilities, reducing leakages, repairing meters and upgrading collection procedures would increase available supply by 20-25%. This increase in capacity and average usage does not have to be very greatCthe current problem is that much water is wasted as there is no incentive to conserve it. There would be a deliberate incorporation of excess capacity in the system as it will take time to establish confidence in a regime of continuous water supply. Preliminary analyses indicate that a commercial return could be earned on capital and not require that consumers pay more in real terms, than they do already. The major constraint to attracting private capital, and procuring experienced staff from commercially run operations, is that the size of the investment is low.

The poor, who use public taps, currently pay higher real costs for water than those who are connected.

Average costs for the connected were Rps 4-5/m^3 while for the poor it was over Rps 40/m^3.

9.2 Other Conclusions

The importance of the present study is that it can demonstrate to policymakers, the public, and private investors that the real problem with public water supply is not that people cannot afford a full service system. The results also show that an Indian NGO, when provided with close support and supervision, can conduct what is acknowledged to be a sophisticated methodology. This study used survey and demand estimation methodology, with a random sample of 1,100 households, using local resources for enumeration and data processing.

There are some households who may be made worse off by a metered system but those are a minority, who either don=t pay their bills at present, or who waste large amounts of water because they enjoy high mains pressure and unmetered water. The population at large would benefit enormously by a more equal distribution of water even if it has to be achieved by making people pay for how much water they use.

9.3 Recommendations

Dry season study in a larger town

A further study in a larger secondary town which is more representative of overall conditions in India should be conducted as a follow up, utilizing the methodology and questionnaires which have been pioneered in Dehra Dun. The study should be conducted at the height of the dry season for the most accurate recall of information. Such a city may also offer a different type of investment proposition**C** possibly a higher price for water, a larger overall investment required in sources and supply, and consequently a greater possibility of utilizing FIRE funds. The selected city should still satisfy the criterion that state and local governments are willing to consider fundamental reform of the legal basis on which water services are supplied.

Institutional survey

It was clear from our survey of institutions that it is far more difficult to obtain information on water use from institutional and commercial users. However since they share the same system they cannot be ignored. A study of institutional use is more appropriately conducted as an investigation by skilled field engineers.

A survey of environmental health conditions in Dehra Dun

It was clear that one of the consequences of poor water supply that most excites public attention is ill-health. Health is a political issue and politicians are willing to address health issues, especially for urban low-income populations. While health questions were asked in our survey the results were not reliable**C**a specific health survey requires a separate set of epidemiological and social science skills to generate meaningful results. One conclusion from the survey was that those who were aware of the health consequences of poor water supply had a higher WTP than those who did not. This effect was demonstrable even after controlling for differences in income. A participative health survey should be conducted in Dehra Dun as part of a broader campaign and community effort to improve the urban environment. This survey should concentrate on environmental health conditions as it is clear that much of the disease burden in this town arises from environmental conditions**C**poor water supply and sanitation as well as heavy air pollution. This survey should be conducted in the dry season to coincide with the influx of transient residents for the holiday season. It would be a natural complement to the environmental surveys which have already been conducted in Dehra Dun under the auspices of USAID.

Transfer of skills in survey methodology and demand analysis

The study confirms the usefulness of contingent valuation methods by showing their consistency with revealed demand (as evidenced by costs of coping). Some attempt should be made to institutionalize more widely the expertise and methodology which were acquired during this project. The questionnaires are in Hindi and have been through several rounds of field testing. Data processing routines and statistical analysis software have been established, but the tight budget for the project made it difficult to do much training outside of enumeration and basic data handling. While the local NGO team required little external supervision in enumeration, and data input, the consultant still provided the analytic capacity to interpret the results. Data processing and analysis facilities probably still require some international consultant input. Skills need to be transferred to those Indians with the appropriate econometric background to utilize this technique. Such training might best be handled by a long-term, intermittent advisory relationship with a body such as the NIUA or an economic research institute.

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APPENDIX A1: SUMMARY OF SOCIOECONOMIC PROFILE

Table A1-1
Socioeconomic Profile of Sample Households

Socioeconomic Profile	Renters	Owners	Total
Weighted distribution of tenancy	41%	59%	100%
Average monthly household income	Rps 4,630	Rps 5,000	Rps 4,850
Average family size	4.4	5.3	4.9
Average number of families in a house	1.6	1.2	1.4
Average years of education of respondent	12	11	12
Average number of people working in a family	1.2	1.4	1.3
% of HH that own the following:			
- fan	97%	93%	95%
- bicycle	69%	73%	72%
- motorcycle	71%	73%	72%
- color TV	63%	61%	62%
- washing machine	22%	35%	30%
- refrigerator	67%	68%	67%
- telephone	5%	17%	12%
Ownership of housing:			
- privately owned	0%	97%	57%
- government owned	11%	0	4%
- rented/leased free of charge	4%	0	2%
- rented/leased	85%	0	35%
- unsettled ownership (slums)	0%	3%	2%
Housing type:			
- individual single-family housing	69%	96%	85%
- multifamily apartment building	29%	3%	14%
- commercial building or other	2%	1%	1%
% of HH having commercial activity in house	3%	10%	7%
% of HH having electricity	100%	98%	99%
% of HH with kitchen	88%	83%	85%
% of HH with shower facilities	54%	56%	55%
% of HH with flush (or pour-flush) toilets	80%	79%	80%
Average monthly electricity bill	Rps 100	Rps 142	Rps 125
Average monthly water bill (tax + user charge)	Rps 11	Rps 47	Rps 33
Avg. monthly sanitation /garbage collection bill	Rps 10	Rps 13	Rps 12
Major water source is			
- individual connection exclusively for own family	24%	68%	50%
- individual connection shared with other families	52%	11%	28%
- neighbor*s water connection	3%	1%	2%
- public tap	16%	20%	18%
- other (tubewells from major institutions)	5%	0%	2%

Table A1-2
Water Source Access

Water Source	Weighted Sample Distribution*
Individual piped connection	50%
Connection shared with tenants	28%
Neighbor's tap	2%
Public tap	18%
Tubewell from major institutions	2%
Total	100%

APPENDIX A2:
METHODOLOGY, STUDY DESIGN, AND FIELD PROCEDURES

A2.1 Methods

A large-scale survey method was adopted and executed in order to accomplish the main objectives of the study. The following two estimation methods are used to estimate demand for improved water supply.

a. Indirect Approach

Water consumers in Dehra Dun developed their own strategies to cope with the current intermittent water supply condition. By observing how much people have spent for, and what kind of economic behavioral changes were accompanied to cope with unreliable water supply conditions, consumer's demand for improved water supply services can be indirectly estimated. The method is classified as consumers' demand for a better reliable water supply service is referred from their coping costs.

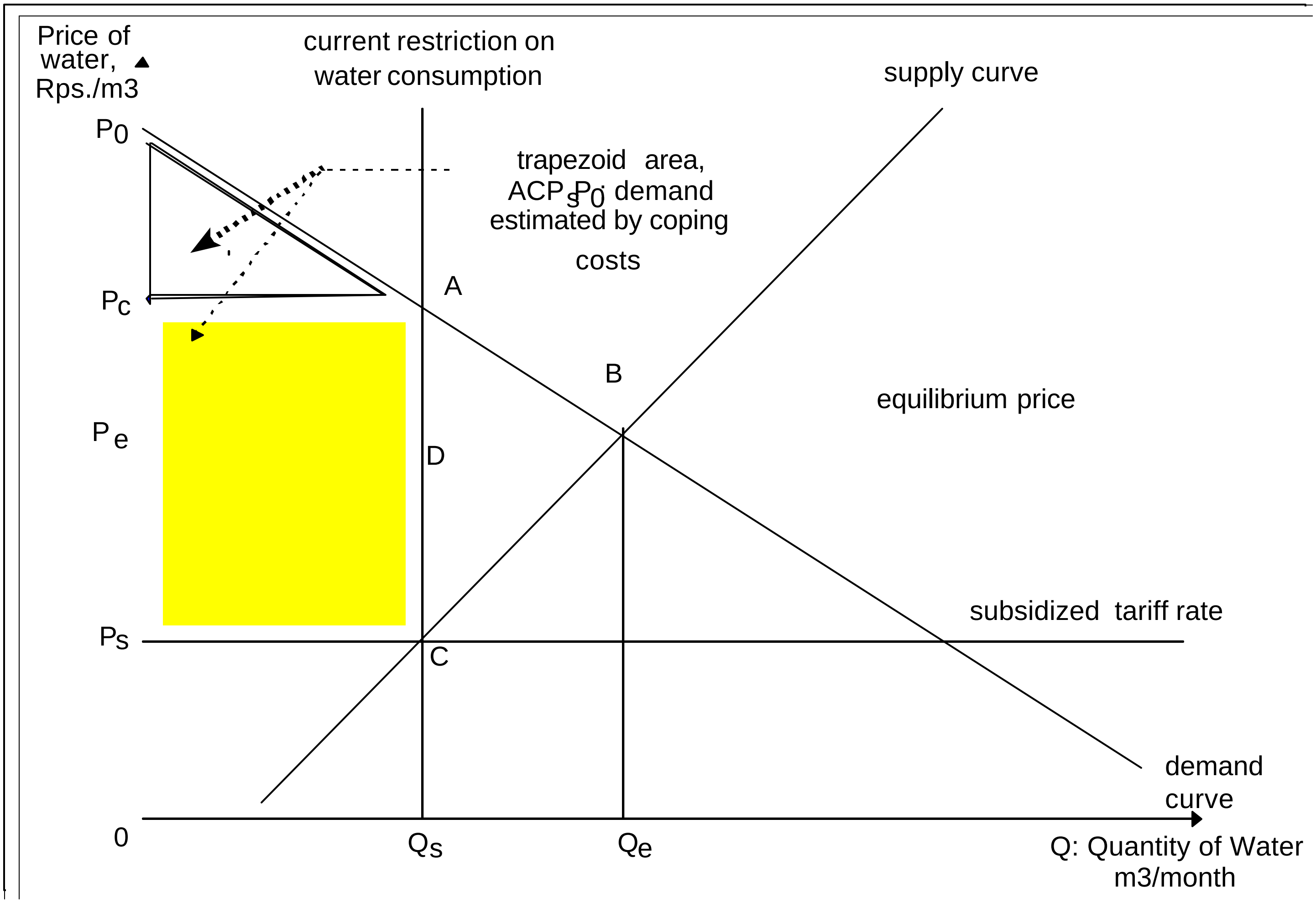
Detailed water consumption data from individual households were observed, collected and recorded during the field survey, including their capital investment, types of coping strategies, and behavioral changes made to cope with intermittent water supply conditions.

b. Direct Approach

Consumers' demand for improved water service can be estimated by asking individual households (directly) how much they value the improved service. Based on consumer theory and contingent valuation methods, carefully designed market scenarios are explained to respondents in order to determine their maximum willingness to pay for the improved water supply. Since consumer demand is *directly revealed through a structured series of questions*, the method is classified as the direct approach. It is often called Contingent Valuation Method (CVM) because the economic valuation of a good or service is "contingent" upon the market scenarios described to consumers, or Willingness-to-Pay (WTP) studies because the method attempts to extract the information on demand (WTP) directly from the consumers.

In order to determine all the factors affecting the demand for improved water service from the WTP approach, other socioeconomic data were collected from each individual during the face-to-face interview.

Figure A2-1: Supply/Demand for Water



Indirect or Coping Cost Approach

The near equivalence of the direct and indirect approaches to estimating demand for water rests on the assumption that consumers' demand for water, which cannot be met due to low pressure or short hours of supply, motivates consumers to invest in storage or additional sources. In Dehra Dun options such as tubewells, shallow wells, and trucked water vendors are all expensive options. On-site storage combined with low pressure intermittent mains supply is the most popular method of coping. This coping involves more than the cash spent on hardware and also requires behavioral changes. The total price of water paid by consumers embeds various economic behavioral changes which in turn require the use of resources. These resources are energy and time expended in carrying water, queuing, and managing on-site subsystems to increase reliability of supply (transferring water from the delivery point or tap, to storage tank).

Following consumer demand theory and remembering that demand is a flow concept (so much consumption per unit of time), we know that consumers will pay more for the first cubic meter of water (to meet a week's demand for a family for instance) than the second and subsequent cubic meters of water purchased for that week. As water consumption increases, the demand for water reaches satiation point, and the consumer is willing to pay less and less for incremental cubic meters of water consumed. (For public-tap users liters/day may be a more appropriate unit of marginal measurement.) Given a fixed income and constant market prices for all other commodities, tracing changes in what people pay for additional units of water reflects the consumer's individual demand curve. The summation of individual demand curves generates a market demand curve. The relationship between willingness to pay and coping cost is shown in Figure A2-1, the inimicable supply-demand diagram.

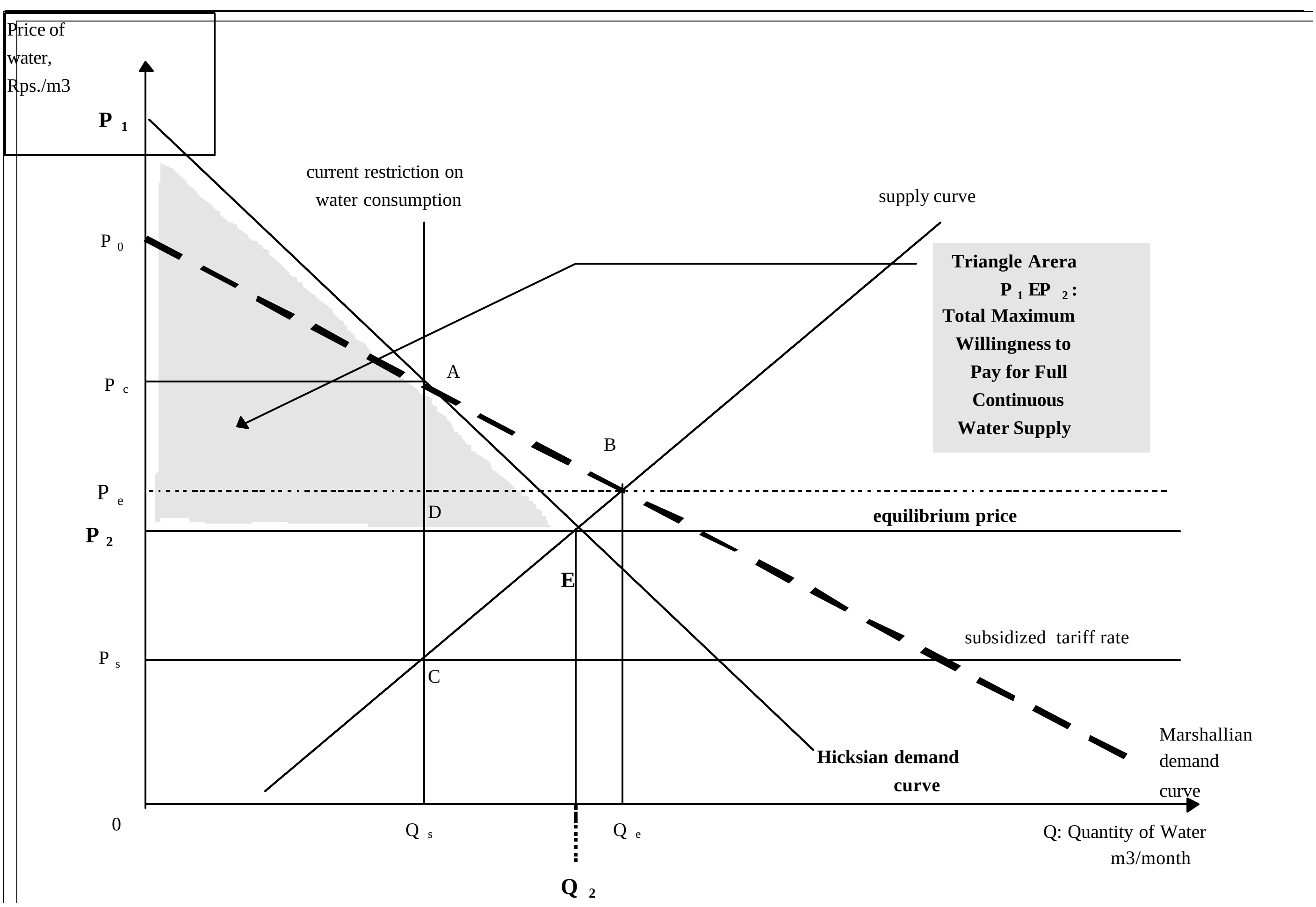
If the supply of water is subject to diminishing returns, the quantity supplied would be indicated by the upward sloping long run supply curve. Supply can be increased by investing in a larger design capacity, and although there may initially be economies of scale, marginal costs eventually rise. The so-called long-term equilibrium price which equates supply and demand is OP_e and the quantity OQ_e. The amount paid by consumers would be the quantity OQ_e multiplied by unit price of OP_e (the rectangle OP_eBQ_e). The area between the rectangle and the demand curve above it (P_0P_eB) is called the "consumer surplus." If one could charge each consumer the maximum they would be willing to pay, then in theory the total revenue could be as much as the entire trapezoid OP_0BQ_e. The difference between rectangle and trapezoid, P_0P_eB is a surplus to consumers as they all pay the same price of OP_e, but most would willingly pay more.

A common situation in water supply utility operation is that the cost of marginal units of water production in the short run are very low and do not influence short-term supply decisions at all. Instead the chosen level of operational supply for the system may be fixed by available resources, such as work hours or availability of electricity, rather than a response to demand and price. This can be represented as a vertical supply curve with supply OQ_s. To insure continuous supply is available on demand would require that the price be set at or above OP_c. In practice the price is often set with respect to what is considered "affordable" or "fair" and not to recover costs. This price is usually below that which rations out available supply (P_c). A natural consequence of a below-equilibrium price is excess demand and hence intermittent supply. In such circumstances the price may have been set at the level OP_s. But consumers now place a valuation of at least OP_c on the last unit of water produced. Since this is in excess of the supply price OP_s the rectangle P_cACP_s represents a fund which consumers will be willing to use to try and increase their consumption of water. Consumers can "spend" their consumer surplus up to the point where expenses equal the surplus, and still think they are better off. In aggregate the behavior is self defeating as the supply is fixed and increased storage reduces supply to everyone else. Coping expenses would be expected to average the total WTP less the tariff ($[\{OP_0+Q_sA\}/2]$-Ops) per m^3.

The investment in coping costs is an individual decision, and consumers with a high demand for water may be expected to have a higher willingness to pay for coping.

The assumption underlying the use of coping costs as an estimate of willingness to pay is that the two are close enough for one to provide a useful estimate of the other. Because consumption is not metered we have no corresponding method for determining WTP directly by CVM methods. If water were accurately metered, supply continuous, and bills regularly paid, we could ask consumers how much the price would have to be reduced for them to increase their consumption. This would also trace out a demand curve. This method is often described as the CVM method since the answers are contingent upon the consumer's responses to hypothetical questions. These questions and the sampling procedure can be designed with great care by incorporating consumer and sampling theory in the design. During the CVM part of the survey, consumers were asked to value a continuous water supply. The components of the continuous water supply were described in detail, so that consumers could understand what they would be paying for. For instance, the improvement plan contained enhancement of three major attributes of water supply:

Figure A2-2: Hicksian and Marshallian Demand Curves



1. improved quality, through enhancing purification of water and blocking leakage,
2. quantity, through more tubewells and overhead tanks, and
3. reliability, through extra power generators

With a full service, there would be no restriction on water consumption level.[1] Consumers' water consumption would be greater than the current consumption level, though it is difficult for consumers to envision exactly how many liters of water they would consume. The CV elicitation technique is designed to estimate consumers' *maximum* willingness to pay for continuous water supply at adequate pressure,

1 The water consumption level would depend on individual consumer's demand at a zero marginal cost.

while maintaining at their current real income level; i.e., consumers are giving up a certain amount of their income in exchange for the betterment, and reducing consumption of something else. The willingness of consumers to pay for the improvement plan, estimates the Hicksian or compensated demand curve. The maximum additional willingness to pay for the improved service would be represented as the area P_1EP_2 in Figure A2-2.

Differences between the Indirect and Direct Approaches

The economic values of water estimated from the two approaches, indicate differences on theoretical grounds:

1. Demand estimated from the indirect approach assumes Marshallian demand curve where changes in the amount paid (the coping cost + average fee) affect real income and thus shift the demand curve by an additional "income effect." The direct approach measures the Hicksian or compensated demand curve. Unless the income elasticity of demand for water is very high, or the ratio of consumer surplus to income is very high, the differences between Marshallian and Hicksian estimates can be ignored for most purposes.

2. Indirect estimates of coping costs (D_c) measure a partial improvement of the water service, since consumers are still subject to the service performance of the WWD even though individually they have developed their own strategy for improving reliability. On the other hand the direct estimates from CVM (D_w) measure demand for a continuous service.

   Thus, the null hypothesis is that

$$H_0: D_w \quad D_c$$

3. Willingness-to-pay bids estimated from the contingent valuation method are bounded by the respondent's income level. Demand estimated from the coping cost could differ because some part of the coping costs is non-cash expenditure, such as time spent for fetching water from public taps. Since markets are never perfect, consumers may not be able to sell their labor in discrete units or have access to credit products. The reasonableness of the assumptions can only be tested by experience. Applied economics is not for the fainthearted.

A2.2 Study Design

a. Sampling Strategy

Initially, five different data sources were identified as a potential sampling framework: census list, property tax registration, water connection list, ration cards registration, and voter's list. After a careful consideration of the purpose of the study, the voter's list was chosen as the most appropriate for the study (among others). The voter's list was supposedly the most up-to-date (1995) and comprehensive list of the residents of Dehra Dun (it included, owners and renters, regular as well as encroachment slum residents, and also included both households with water connection and no water connection). It is anticipated the voter's list should have registered more than 90% of households in the Municipality Boundary of Dehra Dun, reflecting the representative characteristics of various households in Dehra Dun as currently existing.

A total of 157 Polling Booths under 33 wards exist in Dehra Dun. In order to secure the representativeness and generalizability of the findings from the sample for the whole city of Dehra Dun, the following three-stage random sampling strategy was designed.

First stage: Combining land use pattern (old central town and others) and household density within each ward (above or below the average household density, i.e., 3,000 households), four types of distinctive land use patterns were identified (see Figure A2-1).

Second stage: After locating the total 157 Polling Booths (PBs) in 33 wards, about one-third of polling booths were randomly selected from each category of land use pattern. Thus, 52 polling booths were selected.

Third stage: A total of 15,288 households were registered under the 52 selected PBs. Approximately 8.6% of households from each PBs were randomly selected, by considering the size of sample required for the research design plus 10% non-response rate as a safety guard. This resulted in 1,320 sample households for interview.

However, during the main survey, it was found that the difficulties of locating house addresses/household head name were much more significant than expected. Largely due to the way the voter's list was prepared by the election commissioner, enumerators were able to locate only 85% of selected sample households from the list. Thus, 15% of sample households were not found. The final distribution of the completed questionnaires by each PB is reported in Table A2-1.

The voter's list is supposed to capture the slum areas better than any other HH list as the population in the slum areas is considered by Indian politicians as an important group in terms of voting power. According to officers in the electoral office, the slums are included in the voter's list. Since the most of the slums are developed (they have either individual water connection or public tap, electricity, roads, and sometimes even the ownership of land), they cannot be "slums" in a conventional sense anymore. Both the officers in the Revenue Department (for property tax assessment) and those in the Electoral office stated that more than 70% of those "slums" have been upgraded, constructed with cement bricks, and are even paying property taxes. Therefore, what we usually define as "slums" would hardly be seen in Dehra Dun. Even if they can be sighted along the river banks around the city, occasionally the location of those "slums" are the other side of the river bank, which is outside the boundary of Dehra Dun Municipality. It might be possible, too, that 15% of sample households which could not be located can be attributed to the fact that more than 50 households had duplicate house numbers or street addresses.

The seasonal variation of floating population could be another reason why the residents of "slums" in the conventional sense cannot be enumerated as many as expected. During the winter time, seasonal migrants from Nepal usually leave Dehra Dun for other regions with job opportunities.

Table A2-1 Distribution of Completed Interviews by Each Polling Booth

Wards name & ID	ID number of Polling Booth	No. of HH interviewed	Wards name & ID	ID number of Polling Booth	No. of HH interviewed
Category I: Industrial and Agricultural			*(Category III continued)*		
ward 7: Patel Nagar	6	23	ward 11: Rajendra Nagar	8	18
ward 15: Bhandari Bagh	16	23		9	29
	17	11	ward 12: Bakralwala	10	30
	18	13		11	16
Category II: Old city			ward 14: M.K. Pathsala	14	17
ward 17: Chukhuwala	21	15		15	24
	22	14	ward 16: Dalanwala West	19	23
	23	22		20	25
ward 25: Lakhi Bagh	39	20	ward 18: Chander Nagar	24	19
ward 28: Khurbura	43	22		25	23
	44	21		26	21
	45	19		27	32
ward 29: Tilak Road	46	23	ward 19: Vijay Park	28	31
ward 30: Ansari Marg	47	17	ward 20: Mansingh Wala	29	21
	48	29		30	15
ward 31: J. Mohalla	49	20		31	23
	50	25	ward 21: Rajpur	32	13
ward 33: Dharnawala	52	15	ward 22: Idgah	32	27
				34	21
Category III: Residential with HH density <=3000				35	17
ward 2: Vihay colony	2	26		36	15
ward 4: Indira Nagar	4	21	*Category IV: Residential with HH density >3000*		
ward 6: Arya Nagar	5	22	ward 1: Rispana	1	29
ward 9: Race Course	7	15	ward 3: Indresh Nagar	3	37
ward 26: Phaltu Line	40	14	ward 13: Old Dalanwala	12	14
ward 32: Nehru Colony	51	33		13	15
ward 24: Dharampur	37	17	ward 27: Gandhi Gram	41	22
	38	30		42	33
			Total		1120

b. Questionnaire Design

The final questionnaire had five sections. The first section is mainly for identification and screening of respondents, by asking demographic characteristics of the respondent. The second included questions about the household's existing water situation: the type of water source, payment methods, water consumption level, arrangement of water storage space, and the costs of having the extra arrangement. The third section asked about respondents' knowledge, attitudes, and preactices on sanitary health environment, occurrences of water-borne diseases, and water use behaviors. The fourth contained questions about the socioeconomic characteristics of the household, such as education, income, housing conditions, ownership of assets, and experience of taking any loan. The final section asked about the household's willingness to pay for improved water services, including contingent market scenarios and a series of structured WTP bidding questions.

From the pre-test and focus group interviews, it was found that respondents usually have difficulty in measuring their water consumption levels. So many questions were devoted to helping respondents answer about their water consumption levels. The questions regarding the economic costs of supplemental water arrangement to cope with intermittent water supply conditions are carefully designed by taking into consideration existing coping strategies which were identified during the focus group interviews. At the same time, two different versions of WTP sections were designed for different types of water consumers. The detailed design of WTP questions are explained in Chapter 6 of the main report; the questions themselves are given in Appendix A4.

A2.3 Field Procedure

The fieldwork started by selecting qualified enumerators. About 14 enumerators with at least a college education were recruited and trained intensively for five days. During the training session, the performance of each enumerator was evaluated in terms of language skills (switching between English and Hindi fluently), capability in arithmetic calculation, energy, and willingness to work for extended hours including evenings and weekends. At the end of the training, 4 enumerator recruits were dropped, and 10 hard-working enumerators remained.

Three supervisors with graduate-level education were provided from the local survey institution (Academy for Mountain Environics, AME). Each supervisor monitored the fieldwork and quality of survey data for three or four enumerators. Throughout the whole survey period, the supervisors were responsible for checking all the incoming completed questionnaires, interviewing enumerators to rectify any mistakes or inconsistenies in the questionnaires. If any answers were missing or contradictory, then the supervisor returned the questionnaire to the enumerator who was asked to go back to the sample household to correct the problems. All the incoming questionnaires were reviewed by supervisors to obtain high quality data. After all the issues were resolved to a satisfactory level, then the supervisor signed his/her name on the questionnaires and turned them in to a coordinator for final review.

The coordinator (from AME) was responsible for overall administration and supervision of all the fieldwork activities. The coordinator monitored the number of questionnaires administered, by sub-district level, and by different versions of questionnaires on a daily basis, so that random distribution of interviews across different geographical areas could be achieved. The coordinator also reviewed most of the completed questionnaires after the supervisor turned them in with their approval signatures. After the coordinator reviewed each questionnaire, she turned it over for computer data entry. The final level of quality control occurred during the data entry process. If the data manager found any inconsistency or abnormal numbers in the completed questionnaire, he asked the coordinator to rectify the inconsistency. The three levels of quality control system enhanced the reliability of the data.

During the training, all the enumerators, supervisors, coordinators, data manager, and the local counterpart (the director of AME) were required to attend all the sessions. Generally, in each day, the first half of the training session was conducted in English using the questionnaires. The later half of the training was conducted in Hindi, paying attention what would be the correct/equivalent words to translate the major concept in each question. Since English is widely spoken in the area together with Hindi, the local counterpart felt it was unnecessary to translate the whole questionnaire. Instead, in order to maintain the consistency of the translation, once the group agreed on the right words of translation during the training, enumerators were asked to stick with the same words when conducting interviews.

Training session consisted of lectures, individual practice in front of others, mocking interviews by pairing-up enumerators, and finally for actual field practice in a designated neighborhood. For each type of interview practice, the three supervisors worked closely with their enumerators and helped them clarify any mistakes in translation.

During the training, a great deal of attention was given to measuring the volume of water storage spaces and different sizes of utensils commonly used in the area. Actually pouring water into a different size of buckets, each enumerator practiced estimating the capacity of water containers. Likewise, enumerators were also trained how to read water meters (both digital and dial types) by bringing real water meters into the training sessions.

An initial version of a household questionnaire was developed over a four-week period of intensive experimentation in October 1996. The first draft of the questionnaire was developed from over 10 focus group interviews in the field; the focus group households were selected across various areas of the city as well as different income levels of households. Approximately 100 household interviews were conducted as a first pretest in conjunction with the field training of the enumerators. After revision of the questionnaire based on the findings from the first pretest, another 100 household interviews were administered as a second pretest. From the second pretest, there were only a few minor changes.

The two field pretests were utilized as not only for drafting questionnaires, but also for developing the survey management skills of the local contractor (AME). The EHP consultant closely supervised and advised AME in developing a reliable procedure for data quality control/management scheme, for every step of fieldwork. During this period, computer data management capability was assessed, a data analyst with a statistical background was hired for efficient management of the computer database.

APPENDIX A3: ESTIMATION

A3.1 Determinants of WTP Bids for Improved Water Supply

The demand for improved water supply can be represented as an inverse demand function by relating the WTP bids to a set of factors such as:

WTP bids = f (W, I, S, C),

where

W	=	consumers= current water conditions
I	=	household income
S	=	socioeconomic characteristics of respondents
C	=	other control variables

Here, the demand is to estimate for improved water supply, in which the attributes of water are broadly categorized into three: reliability, quantity, and quality. These three characteristics are not mutually exclusive. However, the current water conditions of each respondent would be represented in terms of these three broad attributes. The independent variables to represent each factor are carefully selected according to existing consumer theory and water related behavior. Table A3-1 summarizes the independent variables included in the model, along with the hypothesized effects on the dependent variable.

Table A3-2 reports the result of multivariate analysis using the OLS estimation technique. The explanatory power of the model is 36% (R2), and it is highly significant. This suggests that respondents carefully listened to the various WTP scenarios and responded to reveal their demand for improved water supply truthfully.

Table A3-1
Description of Variables Used for Multivariate Model Analysis

Factors	Variables	Description	Average (S.D.)	Hypothesized Effects
	dependent var.: WTP bids from open-ended question (Rps./mon.)		36 (27)	
Respondents' socioeconomic characteristics				
	Gender	1 if female; 0 otherwise	0.25 (0.52)	?
	ownership of housing	1 if owners of house; 0 otherwise	0.59 (0.59)	+
	Education	years of education completed	11 (6.10)	+
	Knowledge	1 if respondents knew the health risk associated with leaking pipes; 0 otherwise	0.58 (0.60)	+
Current water supply conditions				
- needs for water				
	families sharing the tap	no. of families sharing individual piped connection	0.81 (3.11)	+
	consumption of water	m^3 per month by the household	14.20 (15.47)	+
- source of water				
	public tap	1 if major water source is public tap; 0 otherwise	0.22 (0.50)	+
	Tubewell	1 if major water source is from tubewells provided by big institutions	0.02 (0.18)	-
- private improvement of existing water condition				
	No. of tanks	no. of storage tanks owned	0.94 (1.43)	-
	electric pumps	1 if owned electric pumps; 0 otherwise	0.11 (0.39)	-
	water filters	1 if owned water filters; 0 otherwise	0.27 (0.54)	-
- supply condition from the WWD				
	hours of water flow	Hours of water supply during dry season	5.22 (5.48)	-
	water pressure	Minutes to fill up 20 liter buckets	7.02 (3.33)	+
	satisfaction on quality of water	1 if respondents were satisfied with the quality of water	0.68 (0.57)	-
Other control variables				
	Surcharge	Monthly surcharge proposed to each respondent	89.78 (50.93)	+
	Provider	1 if improved service offered were by a private sector; 0 otherwise	0.38 (0.59)	+
	service level	1 if improved service offered were partial improvement; 0 otherwise	0.39 (0.59)	-

Table A3-2
Determinants of WTP Bids for Improved Water Supply

Variable Names	Parameter	Standard	T Statistics	
Dependent Variable = WTP: open-ended (Rps./m)				
INTERCEPT	14.17	4.00	3.54	***
gender	3.19	1.36	2.35	**
ownership of housing	2.75	1.28	2.14	**
education	0.85	0.17	4.92	***
household income	0.14	0.03	4.25	***
families sharing the tap	-0.19	0.23	-0.82	
public tap	-1.04	2.32	-0.45	
tubewell	-25.89	4.18	-6.19	***
No. of tanks	2.25	0.71	3.16	***
electric pumps	1.34	2.19	0.61	
water filters	3.72	1.44	2.59	***
hours of water flow	-0.65	0.14	-4.50	***
water pressure	0.19	0.22	0.86	
satisfaction on quality of water	-2.36	1.26	-1.88	*
consumption of water	-0.05	0.06	-0.89	
knowledge	8.46	1.30	6.50	***
surcharge	0.01	0.01	0.58	
provider	1.28	1.28	1.00	
service level	-2.84	1.29	-2.21	**

Note: ***, **, * indicates the significant level of t-statistics at 1, 5, and 10% level, respectively.

Most of the coefficient estimates for explanatory variables resulted in the signs as hypothesized except six variables. Only two of those six variables indicated significance in explaining variances of WTP bids; number of water storage tanks, and water filter. For a review of the major findings from the results, see Chapter 6, Section 6.3.

A3.2 Demand and Elasticity Estimates

Table A3.3 (below) shows the results of the estimation of the demand equation using coping costs as a proxy for willingness to pay.

Table A3.3
Price Elasticity Estimation from OLS model, using Full Sample and Coping Costs

Variables		Parameter	t-stat.		Sample values from the users of: pub. tap	indiv.conn	Total
Dependent variable							
water consumption (m3/mo/hh)					4.87	18.45	14.84
Independent variables							
	Intercept	-0.765899	-2.468	**	1	1	1
LnP	avg.total price paid/m3	-0.303981	-8.713	***	33.9	6.14	13.51
W_1*LnP	avg.price/m3 (for shared)	-0.072973	-0.891		-	-	-
W_2*LnP	avg.price/m3 (for public tap)	0.249891	5.931	***	-	-	-
LnY	income (Rp/month)	0.409265	11.303	***	1969	5908	4862
S	family size	0.044764	5.875	***	5.28	5.24	5.25
T	homeowner	0.130224	3.101	***	0.6	0.81	0.7
W_1	shared indv. connection	0.054483	0.366		0	0.24	0.17
W_2	use public tap	-1.109176	-10.273	***	1	0	0.27
U	hours of water flow/day	0.017605	4.544	***	8.46	6.92	7.32
V	water pressure (liters/min.)	0.015605	1.602		3.33	3.21	3.24
Total number of observations		743			46	697	743
F-values		147.812					
R-square		0.6691					
Price elasticity					-0.05409	-0.303981	

***,**, and * indicates 1%, 5%, and 10% significance level.

Specification and Variables:

$$LnQ = a + (b + c_1*W_1+c_2*W_2)*LnP + d*LnY + e_1*W_1 + e_2*W_2 + f_1*S + f_2*T + g_1*U + g_2*V + u$$

where
Q = monthly water consumption (m3/month/hh)
W_1 = sharing individual water connection
W_2 = public tap users
P = average total coping cost paid per m3
Y = Monthly household income (Rps.)
S = size of family
T = home ownership
U = number of hours water flows per day through taps
V = water pressure measured by discharge rate (liters/minute)

APPENDIX A4:
WILLINGNESS TO PAY AND SERVICE OPTIONS: QUESTIONNAIRE

I. Willingness-to-pay for an improved water supply

FULL SERVICE SECTION

WTP Section A:
1. Full service water supply --from the government --existing connection

---

Now, I would like to ask you how much your family is willing to pay for FULL SERVICE WATER SUPPLY system, PROVIDED BY THE GOVERNMENT.

Suppose that it is proposed to upgrade the existing piped water supply system in your neighborhood. In order to provide a WHOLE DAY CONTINUOUS reliable water supply FOR EVERYDAY, the major capital investment for the system AND ASSOCIATED POTENTIAL BENEFITS ARE as follows;

1. MORE TUBEWELLS
2. installing a separate electricity generator for continuous water pumping
3. UPGRADING water treatment plant TO improve water quality and to REDUCE CALCIUM CONTENTS
4. increasing the holding capacity of overhead tanks
5. staging up the height of the overhead tanks
6. having more number of overhead tanks
7. blocking the leakage in the pipe lines
8. if it is necessary, mainpipe lines would be extended to your neighborhood

After the upgrading, the system would have the following benefits:
1. Water would be available day and night, continuously everyday.
2. The system would be reliable, and you don't need to worry about opening and closing the tap to store water in the containers everyday.
3. The pressure in the line would be such that no electric motor, water storage tanks would be necessary.
4. The quality of water would be cleaner and less calcium contents, and your family would not need any treatment before drinking.
5. Since water would be running all the time in the pipelines, it will maintain enough pressure to prevent any contamination of the water inside the pipelines or infiltration of sewage into the pipelines. As a result, your family may have less chance of getting water-borne diseases (such as dysentery, cholera, diarrhea).

KNOW1. Have you known about this--a continuous full water pressure in the pipe line can prevent infiltration of sewage, and my rerduce the chance of getting water-borne diseases?

1 = Yes 0 = No

C Please think about your willingness-to-pay amount for this service, and keep that amount in your mind until I ask you how much is yours. But, before I ask your maximum willingness-to-pay for this improvement . . .

C I will first suggest a specific price; if your maximum is higher than the suggested one, you can only say AYES@; or, if your maximum is lower than the suggested one, you can only say ANO@ to that price. This process is like a referendum vote.

C **This suggested price is not a government enforcement**. By counting the number of AYES@ votes at the suggested price, the government would estimate the financial feasibility of the improvement plan.

C if you answer artificially high price, then you might actually have to pay for it; or if you answer artificially low price, the government would not get enough revenue to provide the full service water supply. So, please answer truthfully.

If there are more than one families sharing this individual connection............. (such as owners, neighbors, or renters), each family is expected to pay for the following monthly surcharge. The government would collect this surcharge from every family using the service, and the revenue would be used to payback the loan for this capital improvement project.

WTPA1.

Suppose the municipal government is going to have polls to find out how many families would support this full service improvement plan, *if monthly surcharge is < > Rps*. Would you vote for AYES@ to this full service water supply plan at this monthly surcharge?

1 = Yes, support the plan at this monthly charge
0 = No, do not support the plan at this monthly charge

WTPA2.

What is **YOUR MAXIMUM** willingness-to-pay for the monthly surcharge of this full service water supply system?
.... Rps. _______________ per month

WTPA2a.

If the respondents is not willing to pay any, ask why, and record the reason here.
reason ____

WTPA3.

Since the municipal government does not have enough capital sources, the government proposed to turn over this project to a commercial enterprise. The enterprise will build, operate and manage this full service water supply system. Since the private enterprise can directly control their accountings without being intervened by a central government, the private enterprise may provide you a more efficient management of the service. *You can deposit this monthly water bill to any of the commercial bank nearby your house. Would you prefer this private sector participation?*

2 = Yes, prefer private sector participation ....**[continue, ask WTPA4.]**
1 = No, prefer government management..........**[stop]**
0 = No preference.......... **[stop]**

WTPA4.
If you prefer private sector participation, how much is your total maximum willingness-to-pay amount for private sector's efficient delivery service ?
Rps. _______________ per month .... **[stop]**

VI. Willingness-to-pay for an improved water supply

IMPROVED WATER SUPPLY

WTP Section A:
3. Double increase of no. of hours supply --from the government --existing connection
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Now, I would like to ask you how much your family is willing to pay for IMPROVED WATER SUPPLY, PROVIDED BY THE GOVERNMENT.

Suppose that it is proposed to upgrade the existing piped water supply system in your neighborhood. In order TO INCREASE THE NUMBER OF HOURS OF WATER SUPPLY TWICE LONGER THAN NOW, the major capital investment for the system are as follows;

1. MORE TUBEWELLS
2. installing a separate electricity generator for continuous water pumping
3. UPGRADING water treatment plant TO improve water qualiry and to REDUCE CALCIUM CONTENTS
4. increasing the holding capacity of overhead tanks
5. staging up the height of the overhead tanks
6. having more number of overhead tanks
7. blocking the leakages in the pipe lines
8. if it is necessary, mainpipe lines would be extended to your neighborhood

After the upgrading, the system would have the following BENEFITS AND WEAKNESSES COMPARED TO A WHOLE DAY CONTINUOUS WATER SUPPLY:

- Water would be available TWICE LONGER HOURS THAN THE CURRENT SUPPLY, *and will provide you enough time to store water for your daily needs.*
- *The quality of water would be the same as now since no water treatment improvement is included in this plan*.
- Since water would be stop running sometimes everyday, the water pipelines will not maintain enough pressure to prevent any contamination of the water or infiltration of sewage into the pipelines. As a result, your family may still have the same chance of getting water-borne diseases (such as dysentry, cholera, diarrhoea).
- Please think about your willingness-to-pay amount for this service, and keep that amount in your mind until I ask you how much is yours. But, before I ask your maximum willingness-to-pay for this improvement................
- I will first suggest a specific price; if your maximum is higher than the suggested one, you can only say AYES@; or, if your maximum is lower than the suggested one, you can only say ANO@ to that price. This process is like a **referendum vote**.
- **This suggeted price is not a government enforcement**. By counting the number of AYES@ votes at the suggestsed price, the government would estimate the financial feasibility of the improvement plan.
- if you answer artifically high price, then you might actually have to pay for it; or if you answer artifically low price, the government would not get enough revenue to provide the full service water supply. So, please answer truthfully.

If there are more than one famillies sharing this individual connection..............
(such as owners, neighbors, or renters), each family is expected to pay for the following monthly surcharge. The government would collect this surcharge from every family using the service, and the revenue would be used to payback the loan for this capital improvement project.

WTPA1.
Suppose the municipal government is going to have polls to find out how many families would support this *twice longer hours of water supply improvement plan, if monthly surcharge is <   > Rps.* Would you vote for AYES@ to this *twice longer hours of water supply plan* at this monthly surcharge?

1 = Yes, support the plan at this monthly charge
0 = No, do not support the plan at this monthly charge

WTPA2.
What is **YOUR MAXIMUM** willingness-to-pay for the monthly surcharge *for the increase of supply hours*?
.... Rps. _______________ per month

WTPA2a.
If the respondents is not willing to pay any, ask why, and record the reason here.
reason ____

Suppose, instead of this partial improvement, a WHOLE DAY CONTINUOUS reliable water supply FOR EVERYDAY has been proposed. The ADDITIONAL capital investment for the system AND ASSOCIATED POTENTIAL BENEFITS ARE as follows;

1. MORE TUBEWELLS
2. installing a separate electricity generator for continuous water pumping
3. UPGRADING water treatment plant TO improve water qualiry and to REDUCE CALCIUM CONTENTS
4. increasing the holding capacity of overhead tanks
5. staging up the height of the overhead tanks
6. having more number of overhead tanks
7. blocking the leakages in the pipe lines
8. if it is necessary, mainpipe lines would be extended to your neighborhood

THE WHOLE DAY CONTINUOUS WATER SUPPLY system would have the following ADDITIONAL benefits:

C Water would be available day and night, continuously everyday.
C The quality of water would be cleaner and less calcium contents, and your family would not need any treatment before drinking.
C Since water would be running all the time in the pipelines, it will maintain enough pressure to prevent any contamination of the water inside the pipelines or infiltration of sewage into the pipelines. As a result, your family may have less chance of getting water-borne diseases (such as dysentry, cholera, diarrhoea).

KNOW1. **Have you known about this--a continuous full water pressure in the pipe line can prevent infiltration of sewage, and my rerduce the chance of getting water-borne diseases?**
1 = Yes   0 = No

WTPA3.
Would you prefer this WHOLEDAY CONTINUOUS WATER SUPPLY?
2 = Yes, prefer CONTINUOUS EVERYDAY WATER SUPPLY.**[continue, ask WTPA4.]**
1 = No, prefer THE INCREMENT OF THE SUPPLY HOURS ONLY..........**[stop]**
0 = No preference.......... **[stop]**

WTPA4.
If you prefer WHOLEDAY CONTINOUS WATER SUPPLY, how much is your total maximum willingness-to-pay amount for THIS FULL service ?   Rps. ___________ per month ...... **[stop]**