Willingness to Pay for Water in Rural Punjab, Pakistan

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UNDP-World Bank
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Program

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Executive Summary

During 1988 and 1989 a team from the Applied Economics Research Centre (AERC), University of Karachi, carried out a study of households' willingness to pay for improved water services in rural Punjab. The study was carried out in three groundwater zones: the sweet water zone where good quality water is easily accessible and where the official policy is not to provide public facilities; the brackish water zone where groundwater is freely available but of poor quality and where piped supply systems with household connections are sanctioned for villages with populations exceeding 5000; and the arid zone where the groundwater is of good quality but is difficult to access.

The objectives of the study were to determine:

- The willingness of households to pay for improved service levels;
- The determinants of the willingness to pay for improved service levels;
- The preferences of households regarding the management of water delivery systems; and
- The appropriateness of existing government policy on the provision of water in rural areas.

To determine whether households were actually prepared to pay for the costs of running improved systems, the AERC team used a willingness-to-pay (WTP) or "contingent valuation" methodology. WTP studies are simply household surveys in which a member of the household is asked a series of structured questions designed to determine the maximum amount of money the household is willing to pay for a good or service.

The three groundwater zones differed from each other economically. With reference to the average rural household income in Punjab, the sweet water area (Sheikhupura District) was more affluent, the brackish water area (Faisalabad District) represented the average level, and the arid area (Rawalpindi District) was less affluent. The villages selected were close to the district headquarters because it was felt that such locations would present immediate policy challenges as they evolved into periurban areas. Because of the official policy of providing improved services (piped systems with house connections) only in villages with populations exceeding 5000, the villages selected in the sweet and brackish groundwater areas were large in size. In the arid zone, where the policy is not being enforced, smaller sized villages were selected. The AERC team carried out 261 household interviews in five villages in the sweet water zone, 495 interviews in six villages in the brackish water zone, and 401 interviews in nine villages in the arid zone.

As expected, the percentage of households connected to piped systems at the current tariff was highest in the arid zone (96 percent), lower in the brackish water zone (75 percent), and lowest in the sweet water zone (55 percent). The mean monthly tariffs that households in villages without piped water were willing to pay for piped systems were Rs 50, Rs 40, and Rs 20 in the three zones respectively.

The principal finding of the study is that in Central Punjab (sweet and brackish water zones) there has been a qualitative change in the nature of household demand, from one for water to one for water-based amenities like indoor plumbing, showers, and flush toilets. In the absence of piped systems, households (all of which already have private handpumps) are providing the higher service

level on an individual basis, using electric pumps and overhead tanks. Sixty percent of households in the brackish water zone and 30 percent of those in the sweet water zone have installed such systems. It was estimated that in the brackish water zone in a typical village of 5000 people without piped water, households had already invested one million rupees in capital and were spending approximately Rs 10,000 per month in operation and maintenance costs.

This level of actual expenditure is of the same magnitude as the total cost of a public piped water system serving one hundred percent of the households. The aggregate willingness to pay for piped systems is also of the same magnitude. The survey indicates that cost recovery of piped systems is possible in Central Punjab.

Piped systems are considered a substitute for electric pumps. In villages without such systems in the brackish and sweet water zones, the percentage of households with electric pumps drops to 33 percent and 11 percent respectively. However, a considerable number of households (29 percent and 7 percent in the two zones respectively) continue to invest in multiple systems because of the poor reliability of piped systems. As expected, it is the richer and more educated households that demand and are willing to pay for reliability. However, the demonstration effect of the choices of the elite is a clear indicator of the trend for the future.

In the arid zone, demand is still largely for water for personal use, and households are satisfied with a lower reliability of service, which is still qualitatively superior to the alternatives of public wells and surface water. However, although the willingness to pay is high, the small village sizes mean that the capital costs cannot be recovered because of the absence of economies of scale.

The transition to higher service on an individual basis calls for a review of the policy of not providing piped systems in the sweet water zone. This is necessary because the former option is socially inefficient, the monthly operation and maintenance costs being almost two-and-a-half times those for piped systems.

The level of actual expenditure also indicates that piped systems need not be subsidized in Central Punjab. A collective system is further necessitated by the drainage problem that results directly from increased water consumption following upgraded service. This problem is not amenable to individual solutions. It is suggested that institutional mechanisms be explored to facilitate the private construction and management of collective water supply systems.

Piped systems will not become economically viable or be able to compete effectively with private options unless their reliability is improved. This is not possible without metering because the demand for water at zero marginal cost (namely, unmetered connections) in a dry agricultural area such as the Punjab is immense. Without metering, water must be rationed by reducing reliability; people secure other sources; their willingness to pay for piped systems decreases; and the utility cannot collect sufficient resources to run the system efficiently. A majority of the sampled households were in favor of metering and were willing to pay higher tariffs that those who favored flat rates.

In the small villages of the arid zone, more acceptable and manageable variants of systems with public standpipes need to be explored. Contrary to general opinion, households were willing to pay a reasonable amount of money for such systems. The mean willingness-to-pay bid was Rs 35 per month, and 84 percent of the households indicated that they would subscribe to such a service at a tariff of Rs 15 per month.

The institutional efforts needed to encourage private collective systems are likely to be very difficult and require much motivation and patience. Contrary to the emerging opinion in development circles, village households displayed great initial reluctance to take on any managerial or operational responsibility. In the deeply fractionalized villages of Punjab, it was considered a lesser evil to leave the system in the hands of a neutral government agency uninvolved in local politics, even at the cost of efficiency. Households were also wary of the government to regulate effectively such arrangements.

1. Introduction

1.1 The World Bank has been placing increasing emphasis on rural areas in its lending in the water sector. Considering all World Bank expenditures on water supply, the proportion of funds allocated to rural projects has increased from an average of 8 percent between 1974 and 1980 to an average of 14 percent from 1981 to 1985. However, a Bank review of projects in this sector concluded that overall performance was disappointing. The review suggested that technology per se did not appear to be a major problem. It was concluded that the design of rural water supply projects had been overly supply oriented and that crucial demand aspects had been neglected. In particular, it recommended an emphasis on understanding (a) what people want and (b) what they are willing to pay for.[1]

1.2 In light of the above conclusions a research study was approved to find ways to improve the financial and economic performance of water sector projects by developing improved information on households' willingness to pay for upgraded services in rural areas. This research project, titled "Willingness to Pay for Water in Rural Areas," involved field studies in six countries: Brazil, Nigeria, Tanzania, Zimbabwe, India, and Pakistan. This document reports on the results obtained from the field study carried out in Pakistan.

Objectives

1.3 The objectives of the study were to determine the following:

- The willingness of households to pay for improved service levels;
- The determinants of the willingness to pay for improved service levels;
- The preferences of households regarding the management of water delivery systems; and
- The appropriateness of the existing government policy on the provision of water in rural areas.

1.4 An additional objective was to test and validate a rapid appraisal method (the contingent valuation method to be described later) as a potential tool for planners in designing rural water supply systems. It was hoped that the use of this method and the information derived from it would help the water authorities improve their decision-making on appropriate levels of service, cost-recovery policies, and water pricing in rural areas.

Policy Overview

1.5 *Coverage, Targets, and Allocations.* At the start of the Sixth Five Year Plan (1983) 22 percent of the rural population of Pakistan was considered to have access to water of acceptable

[1]World Bank: *Water for Rural Communities: Helping People to Help Themselves*, Policy and Research Division, Water and Urban Development Department, 25 pages, May 1987.

quality. Identifying rural water supply as a neglected sector, the plan announced a doubling of rural coverage to 44 percent by the end of 1988. By the mid-point of the Sixth Plan, however, progress was well below target, with only 28 percent deemed to be covered.

1.6 Under the 5-Point Programme announced on December 31, 1985 rural water supply was again identified as a priority sector, and a target was set of increasing coverage from 28 percent to 66 percent by 1989. While the administration associated with the 5-Point Programme is no longer in office, recent policy pronouncements have indicated an even greater commitment to rural water supply. The tentative target being set for the end of the Seventh Plan in 1993 is 75 percent.

Institutional Responsibilities

1.7 Virtually all resources for the rural water supply sector flow from the federal to the provincial governments. Accordingly, the federal government is the critical policy-making level of government, with the provincial agencies having responsibility for implementing the policies set at the federal level.

1.8 At the federal level the Ministry for Planning and Development (Planning and Development Division, Physical Planning and Housing Section) is the key policy-making body with major responsibility for incorporating rural water supply into overall development plans.

1.9 The Ministry of Housing and Works (Environment and Urban Affairs Division) has the major responsibility for the technical aspects of rural water supply. The technical agencies at the provincial level must report to this ministry.

1.10 At the provincial level the Public Health Engineering Department (PHED) is the technical agency which has responsibility for the construction and initial operation of most rural piped water supply systems. The local authorities (District and Union Councils), under the Department of Local Government and Rural Development, are supposed to be responsible for the operation and maintenance of public water supply systems. In fact, because neither of these bodies discharges this responsibility, in most instances, it is assumed by the PHED.

1.11 The major consequence of the dominance of the rural water supply sector by the PHED is the over-emphasis of the engineering aspects and the relative neglect of the social and economic aspects of sectoral issues.

Levels of Service and System Costs

1.12 Decisions on the level of service to be provided by government rural water supply programs are made entirely on technical/administrative grounds. The efficiency of these policies from a strictly economic perspective has yet to be established. In Punjab, for instance, the current policy regarding service levels is as follows:

Sweet water areas:

- Public supplies are no longer built.

Brackish areas (with canal irrigation and arid areas):

- Standpipes for villages with population below 5000.
- House connections for villages with population above 5000.

1.13 With rare exceptions, the government bears 100 percent of the capital costs of public water supply projects. In Punjab and Sind typical capital costs for piped systems providing house connections are as follows:

Areas with sweet water (supplied by tubewell): Rs 450 per capita in Punjab and Rs 620 in Sind.

Irrigated areas with brackish water (supplied with filtered canal water): Rs 600[2] per capita in Punjab and in Sind Rs 900 (where perennial canal water is available) to Rs 1300 (where canal supply is nonperennial).

Arid areas: Rs 1200-1800 per capita in Punjab.

1.14 Based on experience in Punjab, standpipe systems generally cost the PHED only 10 percent to 20 percent less per capita. In parts of Sind, where settlements are more scattered, the unit cost differences between house connections and standpipes are greater. The costs to the household for a domestic connection are typically Rs 80 to the PHED as fee and about Rs 500 for the materials and labor to effect the connection from the distribution line.

1.15 The cost to the PHED of operating and maintaining piped water systems (based on an average household size of 6.5) is estimated to be between Rs 20 to Rs 30 per household per month in Punjab and about Rs 35 per household per month in Sind.[3]

1.16 In principle, after a two-year "demonstration period," District or Union Councils should take over the running of piped systems. In fact this does not happen, and the PHED continues to bear the responsibility and the expenses.

Tariffs

1.17 Public tap users are supposed to pay Rs 5 per family per month. However, partially because the users are dissatisfied with such systems (they desire house connections) and partially

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[2]These cost figures of Rs 450 and Rs 600 for Punjab are reported by Briscoe (1987). The figures reported to us were Rs 300 and Rs 500, respectively. These are also the figures used by the PHED in preparing cost estimates.
(US$1 = approximately Rs 20 during 1987-1989.)

[3]Again, the figures for Punjab reported by Briscoe seem to be on the high side. The PHED uses a figure of between 3% and 5% of capital costs as the annual operation and maintenance (O&M) estimate. These generally work out to be lower than the figures mentioned above.

because of the difficulties inherent in collecting for standpipe systems, essentially no attempt is made to collect the user fee.

1.18 For systems providing house connections, the monthly tariff is between Rs 10 and Rs 25 per connection. This is a flat tariff, since household water supplies in Pakistan are not metered. Collection is uneven; in some areas most who are connected pay, in other areas compliance is less. In Punjab the PHED has no data on overall compliance but believes that about 60 percent of those connected pay. Those who do not pay are threatened with disconnection, but in fact the threat is rarely carried out.

Future Plans

1.19 Cost recovery is beginning to emerge as an important issue in the financing of rural water supply projects. One proposed solution is the proposal for the establishment of village development committees. This is seen by planners as a necessary step in the assumption of local responsibility for the efficient operation and maintenance of village water supplies.

2. Study Design, Methodology, and Site Selection

Study Design

2.1 To achieve the objectives of the study, the proposed research design undertook fieldwork in three different regions chosen to cover a range of economic and environmental conditions. In each region two types of sites (Type "A" and Type "B") were to be chosen. Type A sites were to be located in an area where a functioning improved water supply system was being used by between 30 percent and 70 percent of the population. Type B sites were similar ones nearby at which an improved water supply system was not yet available. It was hoped to conduct 200 household interviews at each site yielding an overall sample size of 1200 households.[4]

Methodology

2.2 Since Type A sites would include both types of households (connected and voluntarily unconnected to an available improved water source) it would be possible to use an indirect approach (one based on observation of actual choices) to understand household behavior. Thus, it would be possible to assess the effects of different characteristics of improved and alternative sources (price, distance to source, quality, level of service, reliability, time since installation, etc.) and users (economic, social and demographic factors) on the likelihood of a household's using an improved source.

2.3 Since no observations on actual choice would be available in type B sites, a direct approach (the willingness to pay [WTP], or contingent valuation method) would be used to elicit household preference for improved service.

2.4 WTP studies are simply household surveys in which a member of the household is asked a structured series of questions that are designed to determine the maximum amount of money the household is willing to pay for a good or service. When WTP studies are conducted to assist with water sector policy or planning, the specified good or service could be a house connection to a piped distribution system, access to a handpump or standpost, or provision of household sanitation facilities. WTP studies are also termed "contingent valuation" studies because the respondent is asked about what he or she would do in a hypothetical (or contingent) situation.[5]

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[4]World Bank, "Willingness to Pay for Water in Rural Areas," Research Proposal, Water and Urban Development Department, March 1987.

[5]For details of the methodology, see Ronald G. Cummings, David S. Brookshire, and William D. Schulze (editors), *Valuing Environmental Goods: An Assessment of the Contingent Valuation Method.* Totowa, New Jersey: Rowman and Allanheld, 1986.

2.5 Comparisons between the results obtained from Type A and B sites (e.g., connection frequency at given tariff rates) should help to validate the reliability of the WTP method as a tool for rapid appraisal of planning choices and alternatives.

Site Selection

2.6 The overall research framework proposed for the multi-country study was tailored to the needs of the specific conditions in Pakistan. Deliberations by the Pakistan team followed by consultations with the counterpart staff at the World Bank led to the following decisions:

a. Restriction of the study area to Punjab. Since the WTP surveys involved techniques that were unfamiliar to the enumerators and that involved extensive interviewing, it would be advisable for team leaders and interview supervisors to be familiar with the language of the respondents. This effectively restricted the sample area to Punjab. In terms of population, Punjab is the largest province in Pakistan with 57 percent of the rural population.

b. Within Punjab, three environmental zones were identified based on groundwater characteristics: the sweet water zone where good quality water is easily accessible; the brackish water zone where water is easily accessible but of poor quality; and the arid zone where water is not easily accessible though of good quality.

c. Restriction of improved source to piped distribution systems with household connections. The research design deemed it important that households be paying a money price for the improved water supply. This limited the choice to piped distribution systems with household connections since tariff collection for handpumps or public standposts was virtually nonexistent.

d. Selection of large villages. Partly as a result of the restriction mentioned in paragraph 1.12 (in Punjab household connections are supposed to be provided only to villages with populations exceeding 5000) the sample villages had to be large in size. It was also felt that from a planning perspective the many large villages close to major cities would present challenging and immediate policy problems as they would evolve into periurban towns within the next five to ten years. Analysis of such locations would be particularly useful for the planning authorities. However, where possible, as in the arid zone, smaller villages were included in the sample.

e. Disaggregation of Type B villages. It was decided to include two kinds of Type B villages - B1 where an improved supply was scheduled to be installed in the near future, and B2 where no such supply was scheduled. This was considered to be helpful in testing whether any strategic bias was incorporated in the WTP bids. Such a bias would occur if households in B1 villages, already assured of a water supply, systematically under-reported their bids in order to convey the impression that they would not connect if the tariff were raised. Households in B2 villages, with no prospects of access to a piped supply in the foreseeable future, on the other hand,

might systematically over-state their bids in the hope of influencing policy-makers to include their village in those marked for the installation of piped water supplies.

2.7 Based on the above considerations villages were selected and surveyed in the following areas:

Sweet water zone	-	Sheikhupura District
Brackish water zone	-	Faisalabad District
Arid zone	-	Rawalpindi District

2.8 The locations are depicted in maps at the back of the book. According to information obtained from the PHED (1986), approximately half the rural population of Punjab resides in the sweet water zone and a quarter each in the brackish and arid zones.

Sampling within Villages

2.9 Since no household lists were available, the following procedure was adopted for sampling within the selected villages. Rough maps of the selected villages were available from visits prior to the main survey. Villages were divided into four approximately equal quadrants, each quadrant comprising a known number of lanes. Two enumerators were assigned to each quadrant, one responsible for houses on the left side of a lane and the other for houses on the right. The total number of houses in the village could be estimated from census records. Since the sample size had been broadly specified in the research design, for any particular village the number of houses to be sampled was known. The first house on each side of a lane, for every lane, was chosen randomly and then every nth house was sampled based on the sampling ratio. Households where the appropriate respondent was absent were not replaced by nearby households. Large villages, which required more than one visit, were surveyed both in the mornings and in the evenings. Smaller villages, which were visited only once, were surveyed in the evenings. This was meant to ensure that no occupational category (e.g., farmers or wage employees) were systematically missed in the survey.

General Description of the Study Areas

2.10 *Punjab.* Punjab, the largest province in Pakistan, contains 57 percent of the total rural population and 56 percent of the total number of rural localities in the country according to the 1981 census. The size distribution of rural localities in Punjab is virtually identical to that characterizing the country as a whole (see Table J-1). In 1981, about 3 percent of the villages exceeded a population size of 5000, 22 percent exceeded a size of 2000, and 46 percent exceeded a size of 1000.[6] However, in terms of the proportion of total rural population, 17 percent resided in villages exceeding a size of 5000, 57 percent resided in villages exceeding a size of 2000, and 83 percent resided in villages exceeding a size of 1000 inhabitants.

[6]At the 3% population growth rate per annum used by the PHED, the proportion of larger villages would have increased considerably since 1981.

2.11 The level of economic affluence in rural Punjab is also very similar to that of rural Pakistan. In 1984-1985 the monthly rural household income per capita[7] was Rs 243 in Punjab and Rs 234 in Pakistan as a whole.

2.12 In Punjab Province, 21 percent of rural localities (15 percent of rural households) had access to electricity in 1981. By 1986-1987 the percentage of rural localities with access to electricity had increased to 49 percent.[8] This is important since connection to the electric grid facilitates the economic provision of piped water.

2.13 According to the 1980 Housing Census, 45 percent of rural households had access to water inside their homes. Of these, 3 percent relied on piped water, 37 percent on handpumps, and 5 percent on wells. The remaining 55 percent of households obtained water from outside their homes. Of these, 3 percent relied on piped sources, 15 percent on handpumps, 16 percent on wells, 4 percent on ponds, and 17 percent on springs, rivers, streams, etc. (see Table J-2). Thus by 1980 6 percent of rural households had access to piped water, 3 percent to domestic connections, and 3 percent to public taps. Access to piped water is stated to have doubled by 1986.

Sheikhupura, Faisalabad, and Rawalpindi Districts

2.14 Within Punjab, Sheikhupura District (sweet water area) and Faisalabad District (brackish water area) lie in the central canal-irrigated plain while Rawalpindi District (arid area) lies in the northern rain-irrigated region.

2.15 The size distribution of rural localities is shown in Table J-1. It can be seen that the proportion of larger-sized villages is much higher in Sheikhupura and Faisalabad Districts than in Rawalpindi District. Thus 26 percent of the rural localities of Sheikhupura District and 60 percent of Faisalabad District exceed a population size of 2000 inhabitants. The comparative figure for Rawalpindi District is 11 percent. This is probably due to the fact that the available water resources in the arid zone cannot support large-sized settlements.

2.16 Data for Sheikhupura, Faisalabad, and Rawalpindi Sub-districts are also provided in Table J-1, since the sample villages are located mostly within the sub-districts. The data show that the first two sub-districts have a higher proportion of larger sized villages than the districts as a whole.

2.17 The monthly rural household incomes per capita for Pakistan and Punjab in 1984-1985 were Rs 234 and Rs 243, respectively. The comparative incomes for Sheikhupura, Faisalabad, and Rawalpindi Districts are Rs 307, Rs 247 and Rs 217, respectively. The range in Punjab is from Rs 175 to Rs 320. Thus Sheikhupura is among the more affluent districts, Faisalabad represents the average level of affluence, and Rawalpindi is among the less affluent districts in Punjab.

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[7]The monthly rural household income is obtained from the Household Income and Expenditure Survey, 1984-1985. The average rural household size is obtained from the Population Census, 1981.

[8]Punjab Development Statistics, Bureau of Statistics, Government of the Punjab, Lahore, 1988.

2.18 The occupational structure in the three districts is shown in Table J-3. Sheikhupura and Faisalabad Districts have very similar profiles while Rawalpindi District has a much lower proportion of the working population engaged in industry and a higher proportion engaged in services. The proportion of the working population engaged in agriculture is virtually the same in all three districts and accounts for just over half of the total working population.

2.19 The comparative situation with respect to access to water is shown in Table J-2. In Sheikhupura and Faisalabad Districts, handpumps inside the house are the primary source of water: 72 percent and 64 percent of total households, respectively, rely on such sources. The second main source is handpumps outside the house. In Rawalpindi District, on the other hand, 62 percent of households rely on wells outside the house and another 25 percent on springs, rivers, and streams. The modeling of households' water source choices is thus much more complex in the arid zone especially because many sources dry up during the summer months and are not accessible.

2.20 Zones with accessible groundwater have a lower proportion of households supplied with piped water than the average for the province as a whole. This situation is the result of current government policy, which is based on need and not on demand.

3. Analytical Overview

Principal Lines of Inquiry

3.1 The analysis shall be directed towards the investigation of the following broad issues in each environmental zone:

- Actual choice behavior;
- Hypothetical choice behavior; and
- The economic viability of investments in rural water supplies.

The details of the issues to be investigated and the techniques to be used for that purpose are discussed in the following sections.

Actual Choice Behavior

3.2 In each environmental zone households have a number of choices in deciding upon the type of water source to use. The study would identify the set of choices and infer from the observations the effects of different variables on the likelihood of a household's making a particular choice.

Hypothetical Choice Behavior

3.3 In many villages a particular service option, e.g., house connections to a piped system, may not exist. Such an option is not part of the choice set of households. The valuation of such a choice is obtained by offering the households a well-described hypothetical choice in a bidding game format. The responses, in terms of willingness-to-pay bids, are then used to estimate the value placed on the particular option offered.

3.4 The description of the hypothetical choice includes presentation of all the relevant characteristics of a specific piped service option. These include hours of supply, quality of water, expected pressure and reliability, and the prices under which service would be available. In Punjab, the price structure for piped service includes a one-time charge (an official connection fee payable to the PHED plus the cost of connecting the house to the distribution line, which is borne by the household) and a flat monthly tariff. In this study, the amount of the one-time costs are included as part of the description (in villages where the distribution lines have not yet been laid, the households are given an average cost figure based on the costs in villages with piped water systems). The households are then asked whether they would connect to the system described at a given monthly tariff. Depending upon the response, the tariff is raised or lowered and the household is asked to respond again. This pattern is followed consistently in the study: the one-time costs are always indicated to the household and the bidding is on the level of the monthly tariff.

3.5 The willingness-to-pay bids are used for three different purposes:

- To determine the proportion of households that would accept a particular service option at any given tariff, which allows calculation of the possible revenue yield;
- To study the determinants of the willingness-to-pay bids and thereby to identify possible trends as social and economic conditions change in the future; and
- To compare, where possible, the pattern indicated by the hypothetical choices (e.g., connection ratio at a given tariff level) with the pattern reflecting actual choice behavior. Such a comparison would serve as one test of the validity of the contingent valuation methodology.

Economic Viability of Investment in Rural Water Supplies

3.6 The willingness-to-pay bids for any particular option would yield an estimate of the number of households that would choose the option at a given price. In the case of water sources these responses would be interpreted in terms of the choice to connect given a particular connection cost and tariff level.

3.7 The above information on the percentage of households connecting to a service level at varying tariff rates is sufficient to estimate the monthly revenues that could be generated if that service were actually offered. This estimate could then be compared with actual data on maintenance and capital costs to determine the degree to which cost recovery is possible in any specific situation.

Description of Variables Used in the Analysis

3.8 In explaining household behavior, either in terms of actual choices or willingness to pay for hypothetical choices, responses would need to be related to a set of independent variables representing both source and household characteristics. The following is a complete listing, description, and rationale of the independent variables used in the multivariate analyses. (Not all variables may be present in any specific analysis.)

3.9 We identify a set of broad factors that are relevant to an analysis of water-related behavior. To capture particular aspects of these factors, a number of variables are specified within each one. The factors, variables, and their indicators are given below.

Factor	Variable	Specification
Need for water	- Household size	Number of household members
	- Consumption of water	Liters per capita per day
	- Ownership of animals	Number of cattle owned and kept inside or just outside the house

Factor	Variable	Specification
Available labor for collecting water	- Adult women	Percent in household
	- Children*	Percent in household
	* defined as a household member 15 years old or younger	
Ability to pay	- Household expenditure	Rupees per capita per month
	- Construction value of house	Rupees
	- Ownership of land or property	Dummy variable: 1 if household owns land or other property, 0 otherwise
Existing arrangements for water	- Private source	Dummy variable: 1 if household has a private source, 0 otherwise
	- Vendors	Dummy variable: 1 if household uses vendors, 0 otherwise
	- Time	Minutes of household time (one way) spent per week in obtaining water from outside the house
Quality of water currently used	- Quality	Dummy variable: 1 if respondent considers water safe for health, 0 otherwise
Personal characteristics of household members	- Age	Age of household head
	- Education	Number of years of education of most educated household member
	- Occupation	Dummy variable: 1 if occupation of household head is related to farming, 0 otherwise
	- Sex	Dummy variable: 1 if male respondent, 0 otherwise
Household attitudes	- External exposure	Dummy variable: 1 if any male member has had exposure to life outside village for a period exceeding six months, 0 otherwise
	- Awareness of piped systems	Dummy variable: 1 if respondent has visited a village with a piped water system, 0 otherwise

Factor	Variable	Specification
	- Metering of water supplies	Dummy variable: 1 if respondent feels domestic house connection ought to be metered, 0 otherwise
	- Responsibility for provision of water	Dummy variable: 1 if respondent believes water ought to be provided free by the state, 0 otherwise
	- Satisfaction with existing water system	Dummy variable: 1 if respondent in village with a piped system is satisfied with its management, 0 otherwise
Other factors	- Distance of house from distribution line	Yards
	- Distance of village from provincial headquarters	Kilometers
	- Proximity of village to perennial source of water	Dummy variable: 1 if village is close to perennial source of water, 0 otherwise
Control variables	- Village dummies	Identification of specific villages
	- Household type dummies	Identification of household types A1, A2, B1, or B2
	- Starting point dummy	Identifies whether the bidding game was started with a low or high value

Explanation and Rationale of Independent Variables

3.10 *Need for Water.* The preference for an improved source ought to be directly related to the need for water. The most obvious determinant of need is household size. The water needs of animals, especially cattle, are also significant. In the hot summers of the Punjab, cattle have to be kept cool by being allowed to wallow in pools of water or by being hosed down. Because this entails considerable expenditure of household time, the convenience of having running water available within the house ought to be an attractive proposition. (Information on the ownership of animals was not obtained in the sweet water zone.)

3.11 The total household need for water is also related to the level of consumption of water per capita per day. In households where the primary source of water supply is either handpumps inside the house or taps, it is very difficult to estimate the total quantity of water consumed. The task is somewhat more manageable in villages (as in the arid zone) where most of the water is either fetched

from outside the house or delivered by vendors. We have experimented with estimating the minimum amount of water a household would normally need for its essential use. This estimate is determined by posing the respondent with a hypothetical situation in which the household's primary source was out of order or under repair (a situation with which all households were familiar). The respondent was asked to indicate the vessel in which water would be fetched from outside the house in such a situation and to give the number of vessels that would be required to meet the essential needs of the house (it is reasonable to assume that households would curtail nonessential usage in such situations). The capacity of the vessel was estimated by asking the respondents how much milk it could hold, a judgment which rural respondents made with great ease. In the arid zone, where households are familiar with the vending of water, respondents were simply asked to state how much water they would acquire from a vendor for meeting essential household needs on a representative day.

3.12 Of course, the variation in essential consumption would be much less than the variation in total consumption. However, under the circumstances this was the only quantitative measure of water consumption that it was possible to estimate with any degree of accuracy.

3.13 In households with access to improved water sources, the consumption of water per capita per day, even for essential usage, might be higher than that of comparable households without improved sources. Such endogeneity would make it difficult to interpret the variable.

3.14 *Available Labor Supply.* Wherever water is primarily fetched from outside the house, as in the arid zone, the available labor supply (which, in the context of fetching water in the Punjab, is predominantly women and children) assumes critical significance. Households with scarce labor ought to be more desirous of improved water sources.

3.15 The choice of the proportion of women and children as independent variables means that the excluded category is the proportion of men. If an increase in the proportion of women at the expense of men makes only a marginal difference to the need for water, the preference for an improved source would be lessened because of the increase in the available labor supply. However, if a woman needs more water than a man (inability to bathe at natural sources could be one reason), the overall impact could be ambiguous. An increase in children at the expense of men, on the other hand, could be expected to both decrease the need for water and increase the available labor supply. Therefore, an increase in the proportion of children should have an unambiguous negative impact on the preference for expensive improved sources of water.

3.16 *Ability to Pay.* A greater ability to pay could normally be expected to be directly related to a greater preference for an improved source of water. However, if more affluent households have already made significant investments in expensive private water supply arrangements (e.g., installation of an electric motor on a handpump), the impact could be ambiguous.

3.17 The estimation of rural household income is generally very difficult because of seasonal variations and noncash components (e.g., own production). The effort required for accurate estimation is not feasible in surveys where the primary objective is not the estimation of income, as, for example, in willingness-to-pay studies. We have used monthly cash household expenditure per capita as a proxy for household income per capita. This variable is subject to limitations since it is

unable to correct for the possible lower cash expenditures of farming households. (Information on this variable was not obtained in the sweet water zone.)

3.18 The estimation of household wealth is also a difficult proposition. We have used two proxy variables. The ownership of land or other property is fairly straightforward. The construction value of the house in which the family resides could be more controversial. It has been frequently documented that the highest priority in the use of discretionary funds is given to housing. This is especially true for rural households in Pakistan where housing is a very visible indicator of social status and achievement. The pattern of utilization of remittances from the Middle East by rural recipients has established this beyond doubt. Thus, housing quality could be a reasonable indicator of household wealth. We have measured it by asking the amount of money that would be required to construct a house similar to the one occupied by the household if the construction were to be carried out at the time of the survey. The latter condition takes care of the problems inherent in the possible valuation at different points in time.

3.19 One frequently used alternative is to enquire about the ownership of household assets (usually durable goods like TVs, motorcycles, etc.) and to construct an index of asset value. We feel that the valuation problems associated with this procedure (when were the goods purchased? at what price? new or used? are they in working order? do they really exist? etc.) result in an estimate whose reliability is not likely to be any better than that of the indicator we used. This is especially true since the residence can be considered to be the primary and most valuable asset of the household, dominating assets like TVs, radios, etc., and is also visible to the enumerator. The benefits of relying on a single indicator are savings in terms of time and less apprehension on the part of respondents who are generally suspicious of enquiries into ownership of assets (TVs, radios, and motorcycles require licenses) and reluctant to admit to social deprivation.

3.20 *Existing Arrangements for Water.* The impact of the ownership of a private source of water on the preference for a piped supply can be quite complex. If the source involved high recent capital expenditure and is an acceptable substitute for piped water the impact could be negative. However, if it is not considered a substitute (e.g., does not provide the same quality of water, as is the case in the brackish zone) the impact could well be positive, being an indicator of the desire for improved service. At the same time, if the running costs are higher than the tariff for piped water and the capital costs are recoverable (e.g., by the sale of used equipment) the impact could again be positive.

3.21 Households using vendors could be expected to express a clear preference for piped water, since vended water is much more expensive than the flat monthly rates at which piped water is supplied in the Punjab. However, since existing piped water systems are generally unreliable and require initial connection costs, the choice between using vendors and obtaining a private connection may be less clear cut than it would first appear. Also, purchasing water from vendors allows households to have greater control over their cash flow.

3.22 The excluded households, according to the dummy variable, are those which exclusively use their own labor supply to fetch water from outside the house. Such households exist only in the arid zone, since in the other two zones virtually every household has at least a private

handpump inside the house. The important implication is that in the arid zone the amount of time spent fetching water is highly correlated with the ownership of a private source of water or the use of water vendors.

3.23 In the sweet and brackish water zones, households can be distinguished from each other by whether or not they own an improved private source of water which consists of an electric motor installed on the handpump. However, since the quality of the groundwater in the brackish zone is generally poor most households spend some time in fetching water for drinking and cooking from outside the house. It can be hypothesized that households having to expend more time would express a greater preference for a connection to a piped water supply.

3.24 *Quality of Water Being Used.* Households that consider the water currently being used to be unsafe for health could be expected to demonstrate a greater preference for a piped water supply. This is not an objective assessment of water quality, rather it depends on a certain degree of health consciousness and a judgment about the quality of the available water source.

3.25 *Personal Characteristics.* It is generally believed that younger and more educated households would express a greater preference for modern conveniences like piped water supplies.

3.26 Households involved in farming (landlords, tenants, and owner-cum-tenants) are likely to express less interest in piped water supplies for a number of possible reasons: flexible work schedules, the location of work close to water sources, and the ability to combine water-related activities with work (e.g., bathing and watering of animals). The generally presumed conservatism of farming households could be a contributing factor.

3.27 It is generally assumed that women would express a greater preference for piped water sources than men since the former are primarily responsible for the arduous task of fetching water. Responses from both sexes are available in the arid zone to enable this assumption to be tested.

3.28 *Attitudes of Respondents.* Households which include members who have had exposure to life outside the village might express a lower or higher preference for the service being offered depending upon how it compares with what they have seen elsewhere. Thus, the reaction to public taps or limited service hours could well be negative.

3.29 Respondents who have seen operational piped water systems themselves could be expected to have a positive attitude towards the provision of a similar facility in their own village. The attitude of respondents in villages with piped water could be affected by their level of satisfaction with the management of the system.

3.30 Respondents in favor of the metering of water supplies could be taken to represent those who are comfortable with the notion that a commodity like water should be charged for. They are, therefore, likely to be willing to pay more for piped water than those who consider the provision of water to be an obligation of the state.

3.31 *Other Factors.* Households have to bear the costs of connecting their houses to the distribution line. It is thus reasonable to expect that households further away from the line would be less likely to connect to a piped system. Probably the cost would be higher and because beyond some critical distance the alternative of installing a private improved source might become economically more attractive.

3.32 Village-level characteristics could be expected to have some impact on the level of preference expressed for piped systems. For example, the distance of a village from the district headquarters could be a proxy for the general level of affluence and awareness in the village.

3.33 Similarly, in the arid zone, the proximity of a village to a perennial source of water could be expected to lower the felt need for improved sources compared to other villages. Such village-level influences are tested for in the arid zone.

3.34 *Control Variables.* Wherever it is felt that specific village characteristics could be affecting the results, the supposition is tested by using a village identification dummy. Similarly, differences in the responses of various types of households (A1, A2, B1, B2) are tested by the use of household identification dummies.

3.35 Some bidding games are used to test for the presence of a starting point bias. Such a bias will be manifested if there are systematic differences between the willingness-to-pay bids of respondents who were randomly assigned a high or a low starting point. A starting point dummy is used to test for the presence of such a bias.

Estimation Techniques

3.36 *Analysis of Actual Choice Behavior.* The analysis of actual choice behavior is based on the estimation of a logit model. The dependent variable is binary, indicating the choice or otherwise of a particular service level. The model is used to assess the impact of different factors on the likelihood of a household's making the particular choice.

3.37 *Analysis of Hypothetical Choice Behavior.* The analysis of hypothetical choice behavior is based on the estimation of an Ordinary Least Squares regression model. Since a bidding game is used to obtain the willingness-to-pay estimates, the observed dependent variable is not the maximum amount the household would be willing to pay, but rather an interval within which the "true" willingness to pay falls. Linear regression is actually not an appropriate technique for dealing with such an ordinal dependent variable; in this situation the correct approach is to use an ordered probit model.[9] However, the use of the mid-points of the intervals as a dependent variable in an ordinary

[9]Whittington, Dale, John Briscoe, Xinming Mu, and William Barron. "Estimating the Willingness to Pay for Water Services in Developing Countries: A Case Study of the Use of Contingent Valuation Surveys in Southern Haiti." *Economic Development and Cultural Change* 38:2 (January 1990): 293-312.

least squares model seems to yield results which are consistent with those obtained from an ordered probit model, and the parameters are much easier to interpret.[10]

3.38 In this study the intervals are quite small (e.g., Rs 10-20, 20-30, 30-40, 40-50, 50-60, 60-70, 70-100 in the arid zone). In addition, zero bids are clearly identified, and bids beyond the end-points of the range (Rs 10 and Rs 100) are elicited and recorded as actual values (the sweet water zone is an exception. See Appendix B-1). The use of actual values beyond the end-points and mid-points within the range should yield close enough approximations to the "true" bids to make ordinary least squares estimation an acceptable first level of analysis.

3.39 *Presentation of the Results of the Multivariate Analyses.* The results are presented by reporting two models. The first model includes all the relevant variables from the list presented in Section 3.9. In the analysis of hypothetical choice behavior step-wise deletion of variables is used to identify the estimation with the highest adjusted R-squared. This is the second model reported. Such a presentation helps to ascertain the stability of the estimated parameters as insignificant variables are deleted from the model.

3.40 Mean values of all the variables used in individual regressions are reported. Variables which are statistically significant at the 90 percent and 95 percent levels are identified by one and two asterisks, respectively.

[10]Whittington, Dale, Mark Mujwahuzi, Gerard McMahon, and Kyeongae Choe. *Willingness to Pay for Water in Newala District, Tanzania: Strategies for Cost Recovery.* USAID Water and Sanitation for Health Project, Field Report No. 246, Washington, DC. June 1989, pp. 205.

4. Sweet Water Zone: Overview and Field Procedures

4.1 Sheikhupura District is located in the central canal-irrigated part of the Punjab. The district capital is Sheikhupura City with a population of 141,168 according to the 1981 census. It is situated 35 kilometers from Lahore, the provincial capital, and 105 kilometers from Faisalabad, the center of the textile industry and the third largest city in Pakistan. Agriculture is mechanized, and industry is located along both the principal axes, the Lahore-Sheikhupura road and the Sheikhupura-Faisalabad road.

4.2 Three fourths of the area in Sheikhupura District lies in the sweet groundwater zone, and water can be tapped at an average depth of 25 to 30 feet. Water quality is almost universally perceived to be good.

Policy Issues

4.3 The current policy of the Punjab Public Health Engineering Department is that public piped distribution systems are not to be built in the sweet water areas. This policy is the result not of a demand-based but of a need-based rationale. The PHED has been entrusted with the responsibility of providing acceptable quality water to the largest number of people possible. Given that there are many areas without such access, the scarce resources of the PHED are deployed accordingly. Within such a framework the low priority accorded to the sweet water areas is understandable.

4.4 The above policy has also been supported because the private sector is rightly considered to be more efficient than the public sector. In his recommendations to the World Bank, Briscoe (1987) states that "[I]n those areas where government-funded water supply programs are not undertaken (such as the large areas of the Punjab in which good quality groundwater is available), the private sector has a major role. Individual families contract private drillers for sinking a well, and purchase a handpump on the open market. . . . While there are probably some improvements which could be made in handpump design, government policy in this area -- namely to leave it to families and the private sector to resolve -- is appropriate."

4.5 Thus, one of the major objectives in including a sweet water zone was to investigate the extent to which the above policy was justified. The other objectives included those that form the core of the research effort, i.e., to determine the willingness of people to pay for improved services.

Water in the Sweet Water Zone

4.6 Historically, wells were the primary source of drinking water in the villages falling in the sweet water zone. Indeed, the center point of a village was identified by a well, and more were located at other convenient points, especially as the village grew in size.

4.7 However, as households became more affluent, wells were replaced by handpumps inside the house. Now virtually every household has installed a private handpump. Almost all the wells, except those in some mosques, have been bricked over. This process of improvement in the level of service took place between 15 and 20 years ago. The excess of the privately borne costs of operation and maintenance of the handpumps over whatever contribution must have been required to keep the wells operational provides a baseline estimate of the value placed on the convenience of having a water source inside the house. This convenience was almost entirely in the form of time and effort saved in fetching water from an outside source. Given the high summer temperatures on the Punjab plains, the value of the convenience is easily understood.

4.8 Our survey revealed that a process of further improvement in the level of service was under way. Perhaps as a result of increased affluence, almost 20 percent of the households in the villages surveyed had installed small electric motors onto the handpumps. These motors could pump water into an elevated tank for distribution to various parts of the house through indoor plumbing and also could help to operate a flush toilet. Thus the complete system associated with a piped supply was being replicated privately at the individual level. This was an important finding because it revealed that households were willing to spend on improved service levels. Numerous economic implications resulted from the spread of this process. These shall be discussed later.

Selection of the Study Villages

4.9 Since it is government policy not to install piped supplies in sweet water areas, there are very few villages with public supplies. The choice of Type A villages (villages with operational piped water systems) was thus very restricted. We selected the only two villages that lay within the maximum distance from the district headquarters that we wanted to consider. Public supplies had been installed in these villages as an exception to the general policy, most probably due to the influence of local politics.

4.10 Similarly it was not possible to locate a Type B1 village (village where a public system was due to be installed in the near future). We selected a village in which a piped household supply had been operational, but which, for various reasons, had fallen into disuse over five years ago. Currently an effort was under way to restore the system. The selection of such a village offered the opportunity to see how poor performance in the past had affected the willingness to pay in the future of those households which had been connected to the system.

4.11 The location of Type B2 villages (villages with no plan to install a public water system) posed no problem, and we selected two convenient villages close to the district headquarters.

4.12 The following are the particulars of the five selected villages:

- Jandiala Sher Khan : Type A
  Mirza Virkan :
- Kharianwala : Type B1
- Ghazi Minara : Type B2
  Bhaddroo Minara :

While the populations of the types A and B1 villages exceeded 5000 by necessity, the two B2 villages were selected from the size category 2000 to 4000. The populations of Ghazi Minara and Bhaddroo Minara were 4514 and 2173, respectively, in 1981. A more detailed profile of the selected villages is provided in Table A-1 in Appendix A.[11]

The Questionnaire and Bidding Games

4.13 The core questionnaire consisted of five broad modules. The first dealt with the socio-demographic nature of the household. The second dealt with the household's water use practices. The third consisted of bidding games designed to elicit the household's willingness to pay for improved service levels. The fourth obtained information on the household's attitude towards issues connected with the provision of drinking water. The fifth module aimed to obtain information on household assets.

4.14 To capture information specific to different types of households, five questionnaire schedules were used. All the schedules contained the core questionnaire in addition to the supplementary questions required. The key details of the various schedules are as follows:

Type A village	Schedule A1	•	For households connected to an operational water supply system;
	Schedule A2	•	For households voluntarily not connected to an operational water supply system;
Type B1 village	Schedule B11	•	For households previously connected to an operational system (system currently in-operational; restoration under consid-eration);
	Schedule B12	•	For households not connected to the above system when it was operational;
Type B2 village	Schedule B2	•	For households in a village without a piped water system and not expecting one to be installed in the near future.

4.15 Some bidding games included a built-in test to determine whether the starting point of the bidding game affected the willingness-to-pay bids. This was achieved by varying the starting point. For selected bidding games, half the questionnaires contained high starting points while the other half contained low starting points.

[11]Statistical tables and analyses generated by the survey, grouped by subject, appear in the Appendixes.

4.16 The following bidding games were included in the questionnaires:

Questionnaire Schedule	Bidding Games		Starting Point
	No.	Description	
A1	1.	WTP for an improved system (4 hours of additional supply).	High, Low
A2	2.	WTP for a standard system with a more attractive financing option (all connection charges to be borne by the water authority).[12]	High, Low
	3.	Same as bidding game number 1.	High
B11	4.	WTP for a standard system.	High
B12	5.	Same as bidding game number 4.	High, Low
	6.	Same as bidding game number 2.	High
B2	7.	Same as bidding game number 4.	High
	8.	Same as bidding game number 2.	High

4.17 The bidding games were designed to evaluate three options:

- The standard PHED system.
- The standard system with a more attractive financing option (all connection costs borne by the water authorities).
- The standard system with an additional 4 hours of water supply.

4.18 For analysis, the WTP bids from the following games could be pooled:

Bidding game numbers 4,5,7	Standard system	Households (B11+B12+B2)
Bidding game numbers 2,6,8	Standard system with financing option	Households (A2+B12+B2)
Bidding game numbers 1,3	Improved standard system	Households (A1+A2)

[12]Existing policy requires the household to bear all the cost of connection from the distribution line into the house.

4.19 In addition to the above bidding games, every respondent was asked to describe the characteristics of his preferred water supply system. He was then asked via a direct question to indicate the maximum monthly tariff he would be willing to pay for such a system.

Conducting the Survey

4.20 The survey was carried out in the five villages over a one-week period (March 6-13, 1988), and 261 interviews were completed in the five study villages:

Jandiala Sher Khan	: 99	:	Type A : 144
Mirza Virkan	: 45	:	
Kharian Wala	: 58	:	Type B1 : 58
Ghazi Minara	: 28	:	Type B2 : 59
Bhaddroo Minara	: 31	:	

4.21 The number of interviews by schedule type was as follows:

A1	:	79
A2	:	65
B11	:	40
B12	:	18
B2	:	59

Three visits were made to Jandiala Sher Khan, two to Ghazi Minara, and one each to Bhaddroo Minara, Mirza Virkan, and Kharianwala. The interviews were conducted in Punjabi and the questionnaires were administered to an adult male, usually the head of the household. Some basic socio-economic characteristics of sample households and their attitudes towards water- related issues are presented in Tables A-2 and A-3.

5. Findings in the Sweet Water Zone: Analysis of Actual Choice Behavior

5.1 Water is freely available in the sweet water zone. The quality of water from traditional sources (wells, handpumps) is considered to be satisfactory and as good as water from piped water systems. These two facts are important: water is not a scarce good and there is little quality differential between water obtained from traditional sources and that obtained from improved sources. Therefore, if households are spending money on higher service levels it is either for considerations of convenience, status, or some indirect benefits not related to needs of water for human consumption.

Upgrading Service Levels

5.2 The transition from wells as the primary source of water to handpumps inside the house has long been complete. Households have incurred the capital cost of between Rs 600 and Rs 1,000 in current value for the convenience of not having to go outside the house to fetch water. This is so even though in the sweet water zone public wells were conveniently located and never very far from any household. Indeed, the village center was marked by a well in a majority of villages.

5.3 A second transition is now in progress. Our survey shows that 20 percent of the households in the study area have installed electric motors onto the handpumps. This capital expenditure of between Rs 1,000 and Rs 2,000 in current prices, depending on the quality of the motor, obviates the need for manual pumping. This is being followed by the installation of overhead tanks (cost: Rs 400 to Rs 500), indoor plumbing (cost: approximately Rs 400 for a 20 foot network, usually enough to operate a bathroom with shower), and flush toilets in some cases.

5.4 At considerable expense, households are putting in place modern indoor plumbing systems with their own private source of water. The monthly maintenance cost alone according to the survey is Rs 6 for the handpump and Rs 16 for the motor. To this one must add the electricity charges incurred to operate the motor. The total monthly expenses are far in excess of the flat monthly tariff of Rs 10 for a house connection to a public piped water supply system where it is available. However, even in villages where the latter option is available, 11 percent of the households have installed electric motors. This could signal a demand for more reliable service. (Table A-4 shows the pattern of household choice over available service options along with their approximate costs.)

Who Installs Electric Motors?

5.5 The statistical analysis (for details see Table B-1) shows that the better educated, the propertied, and the more economically affluent households have a significantly higher probability of installing electric motors. These results accord well with the theoretical expectation that better off households would be more willing to invest in improved and/or more reliable levels of service.

5.6 Since handpumps require manual effort for drawing water it could be hypothesized that overcoming this inconvenience might be a consideration in installing an electric motor. However, the statistical analysis shows that neither the variables related to the need for water (household size and per capita consumption) nor those related to available labor supply (proportion of women and children in the household) are significant. This suggests that upgraded service levels are the main motivation for the installation of electric motors (indoor plumbing and flush toilets are possible with motor-operated handpumps but not with manual handpumps).

5.7 This conclusion is important because village elites have historically exerted a very strong demonstration effect on the rest of the rural population. Their choices can therefore be taken as a pointer to the potential demand for reliable, modern piped water systems in rural areas.

5.8 In this context the analysis highlights another important fact: in the subset of villages where a public piped water scheme exists, households are significantly less likely to install an electric motor. Indeed, in such villages only 11 percent of the households have electric motors, whereas in villages without piped water systems the corresponding figure is 30 percent. This indicates that house connections to a piped water system are considered to be, and have the potential of being, an attractive alternative for consumers.

5.9 However, it was also a fact that 7 percent of households that had domestic connections also had electric motors. This is a strong signal that public piped water systems have to be of comparable reliability to compete effectively with private alternatives.

Who Connects to Piped Water Systems?

5.10 In two of the sample villages, Jandiala Sher Khan and Mirza Virkan, households have had the alternative of connecting to a public piped water supply system with household connections. In the sample 55 percent of the households had availed themselves of this alternative.

5.11 The statistical analysis (Table B-2) indicates that households that need more water (larger household size and higher daily per capita consumption[13]) are more likely to connect to a piped system. At the household level there is no real limit to the amount of water that can be drawn up with a handpump. However, the physical effort required increases in proportion. Therefore, one could conclude that for households with a need for substantial amounts of water the convenience of access associated with a piped connection is a factor in opting for that choice.

5.12 It is also quite probable that in areas with good quality groundwater households with handpumps have not invested in storage devices. Everyone draws up water for his or her own use and without water storage it is not possible for women and children to substitute their labor for that of the adult males in the house. Perhaps this is the reason that households with a higher proportion of women and children are not less likely to connect to piped water systems (note that the respondents

[13]The data suggest that essential daily per capita consumption of water is not an endogenous variable, i.e., it is not higher for households because they have connected to piped systems. Table A-3 indicates that the value of the variable is actually higher in villages without piped water supplies.

were all adult males). On the contrary, households with a higher proportion of children in the household are more likely to connect to a piped system.

5.13 The other important conclusion suggested by the statistical analysis is that wealth is not quite as significant a determinant of the decision to connect to a piped system as it is for the installation of electric motors. This is, perhaps, because the former is a much less expensive choice (the capital and monthly operation and maintenance costs are Rs 500 and Rs 10 as against Rs 3,500 and Rs 22 for an electric motor - see Table A-4) and therefore generally affordable in an area where the monthly household income was of the order of Rs 2,000 in 1984-1985.

5.14 However, cost considerations do enter into the decision to connect. The variable representing distance of the house from the distribution line is negative and significant. The costs of connection that have to be borne by the household are directly related to this distance (approximately Rs 10 per running foot). The increase in cost with distance is likely to act as a deterrent to connection not only because of the expense but also, perhaps, because beyond a certain point the cost becomes comparable to that of an electric motor. The latter is likely to be a preferred alternative in such situations because of its greater reliability. The issue of reliability is important and shall be discussed again later.

5.15 The analysis also shows that households engaged in farming are less likely to connect to piped systems while households with better education are more likely to do so. Households which have electric motors are not significantly less likely to connect to the piped supply system.

5.16 The reasons mentioned by the respondents for either connecting or not connecting to the piped water supply system are listed in Tables A-5 and A-6. These were obtained as responses to open-ended questions.

Electric Motor and Household Connection as Alternative Choices

5.17 The fact that households are significantly less likely to have electric motors in villages where a piped water supply is available clearly suggests that the two are considered to be alternative improvements in service level.

5.18 At the existing, subsidized, rates, a domestic connection to a piped supply system is a much cheaper option. Both the average privately borne capital costs and the monthly operation and maintenance costs are less than half for a domestic connection compared to a motor-operated pump. As a result, many more households can afford to upgrade to a higher service level in villages where piped water supplies are available (59 percent as against 30 percent in villages without piped supplies - see Table A-4).

5.19 It is also of interest to note the relationship between the choice of service level and the economic status of the household in villages where a piped supply option is available (Table A-7). Motors are installed by households at the upper end of the economic scale. On the other hand, domestic connections are affordable to households only slightly above the average value of the economic indicator used. The most affluent households have both electric motors and piped

connections. Given the poor performance of public water supply systems, this probably reflects the willingness to pay for reliable back-up service by households that can afford the expense.

5.20 If the existing subsidy on the capital costs of piped systems (approximately Rs 300 per capita with a household size between 7 and 10) is removed, the capital costs of the two options become comparable while the operation and maintenance costs of the piped system remain lower. However, in such a situation the much greater reliability of the private option would make it a dominant choice, and connection rates to public piped systems would be likely to fall very steeply.

6. Findings in the Sweet Water Zone: Analysis of Willingness-to-Pay Bids

Hypothetical Choice Behavior

6.1 In the previous chapter the analysis was based on the actual, observable choices made by respondents. In this chapter the analysis is based on the responses proffered to hypothetical options presented to the respondents. These responses yield the maximum monthly tariff that a household is willing to pay for the particular option described.

6.2 To the extent that households understand all the changes that will result from the acquisition of the option presented, the amount they say they will pay, their bid, can serve as a measure of its benefit to them. WTP bids may include valuation of aesthetic, health, and other difficult-to-measure benefits of water. If WTP bids are an accurate measure of individuals' preferences, the summation of the WTP bids for all households served by a project could serve as an estimate of the total benefits of the project. It can be compared with the cost of the project to decide whether the investment is justified.

Service Options Offered

6.3 The following service options were presented to different groups of respondents:

- A household connection to a standard piped water system of the type existing in type A villages;
- The same, with a more affordable financing arrangement; and
- A household connection to an improved piped water system.

6.4 In the Punjab the standard system is designed to provide a maximum of 15 gallons of water per capita per day with the service available for eight hours a day at the most. However, actual performance is very uneven (40 percent of the connected households expressed dissatisfaction with the system) with problems of reliability, insufficient pressure, and service for less than the specified period (See Tables A-8, A-9, A-10). For this reason, all households familiar with existing systems do not perceive the same product when evaluating the 'standard' system, especially because pressure variations occur almost from lane to lane.

6.5 The option with an alternative financing arrangement was offered to determine if the low connection rate (55 percent of households) to piped water systems was related to the structure of the costs involved. Obtaining a connection requires two types of payments: a one-time payment made up of an official connection fee and the costs of connecting the house to the distribution line, which have to be borne by the household; and a flat monthly tariff. The dominant component is the cost of connecting the house to the distribution line. The connection fee is of the order of Rs 100, the connection costs are of the order of Rs 500, and the monthly tariff is Rs 10.

6.6 Cash flow problems (i.e., the inability to bear the one-time costs) may be acting as a deterrent to connection for some households. To test this hypothesis, an option was offered in which the water authorities would bear the connection costs in exchange for a higher monthly tariff. The objective was to test if connection ratios would go up with the availability of such a financing arrangement and the extent to which tariffs could be raised.

6.7 The improved system was offered to households in villages where a system was already operational. The improvement offered was an increase of four hours in the daily supply period and the willingness to pay for the improved system was elicited.

Response of Households in Villages without an Operational Water System

6.8 *Willingness to Pay for Connection to a Standard System.* At present no household in either Type B1 or B2 village has the option of connecting to a standard piped water system. The difference between B1 and B2 villages is that there are no plans to install a system in the latter category. The B1 village had a system in the past which has been out of operation for over five years and for whose restoration efforts are now under way. Within the B1 village we can distinguish those households that had obtained a connection when the system was operational (B11) and those that had chosen to remain unconnected (B12). When the standard system option was offered in the B1 village the WTP bids were conditional on the designed performance level being guaranteed. This was made necessary by the extent of dissatisfaction with the performance of the standard piped system when it was operational.

6.9 The distribution of the WTP bids is shown in Table C-1. In calculating the connection ratio we can assume that all households whose WTP bids are less than Rs 10 would not connect since the existing tariff rate of Rs 10 per month is not likely to be reduced. We also treat the "No Responses" as protest bids and add them to the group of households not likely to connect to the service offered.

6.10 At the existing tariff of Rs 10 per month, the percentage of connection frequencies for the B11, B12, and B2 households would be 70, 83.3, and 74.6, respectively. The mean bids (computed over the valid responses) for the same groups are Rs 17, Rs 17, and Rs 21, respectively. The mean bids of the subset of households likely to connect are Rs 21, Rs 19, and Rs 25, respectively.

6.11 A number of observations can be made based on the above estimates:

- Thirty percent of the B11 households (all of which were connected when the piped system was operational) would not reconnect even if the performance of the system were guaranteed. This reflects a loss of credibility in the system.
- Connection ratios resulting at the existing tariff rate are quite high (74 percent in B1 and 75 percent in B2). These compare favorably with the actual connection frequency of 69 percent, which obtained in the B1 village when its piped system was operational. This correspondence supports the validity of the WTP methodology.

- The mean bid of the households likely to connect in the B1 village is approximately Rs 20 per month. Only 4 out of the 57 responses were for bids over Rs 25 per month. This is reassuring. The monthly maintenance cost of a motor-operated pump is Rs 25, and because of its greater reliability, it should provide an upper bound on the monthly tariff of a piped water supply. (The one-time costs of the motor-driven pump are, however, higher. See Table A-4.)
- The mean bids are approximately Rs 4 per month higher in the B2 village. This could be due to overbidding in B2, underbidding in B1, or both. However, overbidding seems the more likely explanation since nearly 19 percent of respondents bid Rs 50 or more in B2 compared to 5 percent in B1. Such high bids could be interpreted as evidence of strategic behavior.

6.12 *Type of Household Likely to Connect to a Standard System.* A multivariate analysis of the WTP bids presented in Table B-3 indicates that younger, more educated and propertied households are more likely to connect. Farming households are less likely to connect compared with nonfarming households. Households that have a motor-operated handpump system are willing to pay Rs 7 more than others. This could be because, compared to their expenses on the motor system, a piped connection would be a cheaper alternative even at the higher end of the feasible tariff range. Households that favor the metering of domestic connections are also willing to pay more, perhaps a reflection of their appreciation of water as a valuable resource. (The complete results of the multivariate analysis are presented in Table B-3.)

6.13 *Willingness to Pay for a Connection to a Standard System with a More Affordable Financing Arrangement.* Types B12 and B2 households that had never previously connected to a piped system were offered a more attractive financing option (one-time connection costs to be borne by the water authorities) to test if affordability was a factor in the decision to remain unconnected. The distribution of the WTP bids is shown in Table C-2. These can be compared to the WTP bids for the standard option presented in Table C-1.

6.14 Table C-1 indicates that 17 out of 76 households (B12+B2) would not connect when offered the standard option (WTP bids less than Rs 10 per month). The comparable numbers from Table C-2 are 17 out of 74. It is clear that the more affordable financial arrangement does not result in increasing the connection ratio. However, the mean bid over the B12 and B2 households increases by approximately Rs 3 per month. This suggests some preference for the more affordable arrangement among even the households that would otherwise connect to the standard system.

Response of Households in Villages with an Operational Piped Water System

6.15 *Willingness to Pay for Connection to an Improved System.* Type A villages are characterized by the existence of an operational piped water supply system which is working below its design specifications. Type A villages include two types of households: A1, which have domestic connections; and A2, which have voluntarily remained unconnected to the system.

6.16 All households in the Type A villages were offered the choice of connecting to an improved system, the improvement being an additional daily supply of 4 hours of water from the

existing system. The distribution of the WTP bids is shown in Table C-3. A number of observations can be made based on the figures:

- The number of "No Responses" or protest bids is much higher than in Types B1 and B2 villages (over 10 percent as compared to a maximum of 2.5 percent). This may be a reflection of the lack of credibility that households familiar with the performance of piped systems place in any promises of improvement in the existing system.
- The proportion of households bidding more than the existing tariff of Rs 10 per month is about 50 percent (51 percent for A1 and 45 percent for A2 households). Thus, only half the households that are currently connected to the system are willing to pay more for an improved system, while half the households that are currently unconnected would connect to an improved system.
- The mean WTP bids are low, Rs 14 for A1 households and Rs 12 for A2 households. If it is assumed that none of the A1 households connected to the standard system would disconnect if the service is improved (i.e., the protest bids are ignored) and will continue paying the existing tariff of Rs 10 per month, their mean WTP bid would rise to Rs 15 per month.
- The mean WTP bids computed over the subset of households likely to connect are Rs 20 and Rs 19 for the A1 and A2 households, respectively.

6.17 *Type of Households Likely to Connect to an Improved System.* The multivariate statistical analysis of the WTP bids (for details see Table B-4) indicates that wealthier households are willing to pay more for an improved system. Households that favor metered connections are willing to pay Rs 6 more than others. Households with motors again bid Rs 5 per month more than those without motors.

6.18 Households with a higher proportion of women and children are willing to pay more for an increased supply of water. This suggests that labor supply considerations are not relevant in areas where water does not have to be fetched from outside the house.

6.19 A very interesting aspect revealed by the multivariate analysis is the comparative behavior of farming and nonfarming households. In villages without piped water the former bid Rs 4 per month less for a connection to a piped water system. However, in villages where a piped system has been in operation, farming households bid Rs 4 per month more than nonfarming households for an increased supply of water. This could be attributed to learned behavior whereby farming households have come to recognize some previously (prior to the installation of a piped system) unforeseen advantages of domestic connections. Our field observations revealed that households with animals were very keen on a domestic connection because it made the task of washing them much more convenient. Buffaloes, which need to be kept cool, could be hosed down at home, rather than be taken to the canal or the village pond, thus saving on time and supervision costs. Further, water for drinking by animals could also be provided through the domestic connection. Although this hypothesis was not tested statistically, as we did not collect information on animal ownership, if farming households own more animals than nonfarming households the explanation would be quite plausible.

6.20 If the explanation is true, it would also have significant implications for the design of rural water supply systems. The PHED design criteria at present take into account human needs only and use a consumption figure of 15 gallons per capita per day. However, if households are actually using the water to cater to animal needs also, including water-intensive ones like washing, the design estimate could be easily exceeded. Perhaps this suggests one explanation for the ubiquitous problem of low pressure which plagues rural water supply systems in Pakistan.

6.21 *Willingness to Pay for a Connection to a Standard System with a More Affordable Financing Option.* To explore the reasons for the nonconnection of A2 households to the existing system, they were offered the same financing option mentioned earlier in the case of type B villages. The distribution of WTP bids is included in Table C-3. The data suggest that the availability of the flexible financing option in the type A villages would raise the connection ratio from 55 percent (79/144) to 79 percent (113/144) if the existing tariff continues to be charged. Approximately half the previously unconnected A2 households would connect. Their mean bid for the monthly tariff is Rs 21.

6.22 However, Table C-3 also shows that if the standard system is improved (an extra 4 hours water supply per day over the existing supply period) the same results could be obtained. Slightly less than half the A2 households would connect at the existing tariff. Their mean bid for the monthly tariff is Rs 19.

6.23 While it is possible that there may be very little overlap between the households that decide to connect in the two cases (poorer households might be the ones that connect under the flexible financing option while households dissatisfied with system performance might be the ones to connect to the improved system) the net result from the point of view of connection rates is quite similar. Therefore, if the objective was solely to achieve high connection rates at minimum cost any choice between the two options would need to be based on comparative costs.

7. Estimated Revenues and Cost Recovery Potential

7.1 The willingness-to-pay bids can be used to estimate the likelihood of connection to and the revenues generated from the provision of various upgraded services. Such a computation helps determine whether the provision of such services would be economically sustainable.

Provision of a Standard Piped Water System in Villages Familiar with Such Systems

7.2 The Type B1 village is particularly attractive from the analytical point of view. Type B1 households have had first-hand experience with a piped water system but do not have access to the same at present. Therefore, their willingness-to-pay bids are for a commodity with which they are quite familiar and for that reason could be expected to be more reliable than if the commodity had been a hypothetical one.

7.3 *Connection Frequencies.* The connection frequencies and revenue estimates are shown in Table C-4 and are plotted in Figure 7.1. At the existing monthly tariff of Rs 10 the connection frequency would be 84 percent, if the service level was guaranteed. This is to be compared with the actual connection frequency of 69 percent (at Rs 10 per month), which prevailed when the piped water system was operational over five years ago. There are numerous indications that the system was poorly managed and it eventually fell into disuse. The impact of that history is demonstrated by the fact that, even with a performance guarantee, only 83 percent of the households that had previously been connected indicated a willingness to restore their connections at the previous tariff rate of Rs 10 per month.

7.4 The plot of connection frequency against monthly tariff rates lends credibility to the bids elicited through the willingness-to-pay method. Three reference markers could be used to interpret the plot. Below Rs 7.5 per month the connection frequency is very high (95 percent and above). This is as it should be since Rs 7.5 is the approximate monthly expenditure at the minimum acceptable service level, the manually operated private handpump. At Rs 10 per month the connection frequency is approximately 84 percent which compares favorably with the actual frequency (69 percent) which prevailed at that rate. As mentioned earlier, the increase in connection frequency could be attributed to the fact that a performance guarantee was part of the package offered to respondents. Increased economic growth during the past five years could also be a contributing factor. At Rs 22.5 per month the connection frequency drops to 21 percent. This corresponds well with the response of the 26 percent households that have installed electric motors in the Type B1 village; monthly expenditure on electric motor-operated systems is around Rs 25 per month. At Rs 27.5 the connection frequency becomes negligible at 7 percent, indicating that the electric motor is the preferred option at this tariff rate.

7.5 *Monthly Revenues.* The plot of revenue against monthly tariff (Figure 7.1) indicates that revenues would be maximized at a tariff rate of Rs 17.5 per month. Revenue yield would be Rs 1026

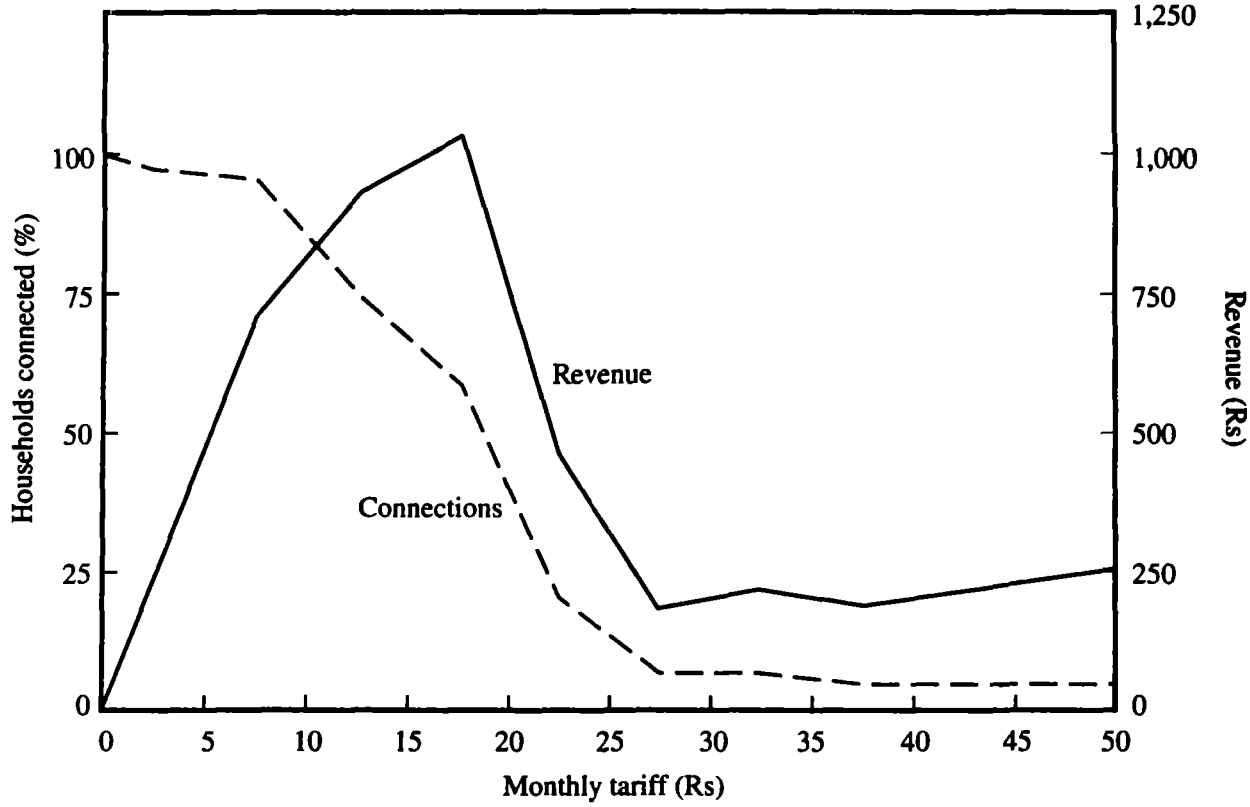

Figure 7.1 Connection frequencies and monthly revenue (per 100 households): Provision of a standard piped water supply system in a type B1 village

per 100 households of which 59 percent would be connected. At a tariff rate of Rs 12.5 per month the corresponding figures would be Rs 926 and 74 percent. (These figures are to be compared to the situation which existed when the piped system was operational when the connection frequency was 69 percent and the revenue Rs 690 per 100 households at a tariff rate of Rs 10 per month). Therefore, any tariff in the range of Rs 12.5 to Rs 17.5 per month should achieve the dual objectives of a reasonably high connection frequency and high cost recovery.

7.6 *Operation and Maintenance Costs.* To what extent can the range of revenues mentioned above pay for the operation and maintenance costs of a piped water system in the sweet water zone? An examination of the actual cost data used by the PHED for the scheme installed in the Type B1 village would be useful in this context.

7.7 The scheme was initiated during 1973-1974 and completed in 1976. The system was designed for a population of 6800 at 15 gallons per capita per day and cost Rs 333,080 at approximately Rs 50 per capita. The annual operation and maintenance costs were computed to be Rs 10,516 as follows (annual O&M costs work out to be 3.2 percent of capital costs, at the lower end of the 3-5 percent range used by the PHED):

Personnel (Operator, Plumber/Valveman, Watchman)	Rs 4930	(47 percent)
Operation Cost (Electrical & Mechanical)	Rs 2717	(26 percent)
Annual Repair	Rs 351	(3 percent)
Contingencies (at 5 percent of b+c)	Rs 153	(1 percent)
Depreciation	Rs 2365	(23 percent)
Total:	Rs 10,516	(100 percent)

7.8 Using the figure for household size mentioned in the 1981 Census (6.7), the O&M cost (including depreciation) works out to Rs 1 per household per month at the 100 percent connection rate assumed by the PHED. Even if a connection frequency of 50 percent is assumed, a tariff rate of Rs 2 per month would meet O&M costs. The tariff rate was set at Rs 6 per household per month in 1976.

7.9 Since 1976, costs have escalated rapidly. The capital costs per capita currently used for the design of tubewell systems are Rs 300. Calculating O&M costs at the upper-end rate of 5 percent of capital costs for a population of 10,000 (the approximate population of the Type B1 village at present) would yield a figure of Rs 12.5 per household per month (the household size at present is 10), assuming universal coverage. If the connection frequency is 75 percent, the tariff rate that would ensure full recovery of O&M costs would rise to Rs 16.7 per household per month.

7.10 The estimates obtained above are upper bounds. A look at the breakdown of O&M costs enumerated above shows that only 26 percent of the costs are due to the actual running of the system. The rest are fixed costs of which the largest proportion is due to personnel costs (47 percent). Therefore, with increasing population the O&M costs per household should decrease. If we compute annual O&M costs at the lower value of 3 percent of capital costs, the corresponding tariff rate for full recovery of O&M costs at a 75 percent connection frequency would be Rs 10 per household per month.

7.11 Rs 10 per household per month is the existing tariff rate in the sweet water zone. In general, it seems that the tariff rates imposed by the PHED, which range from Rs 10 to Rs 25 per month in the Punjab, are calculated on the basis of recovery of O&M costs. In the light of the above, the tariff rates, connection frequencies, and revenue estimates revealed by the WTP analysis for the Type B1 village suggest that full recovery of operation and maintenance costs is possible.

Provision of a Standard Piped Water System in Villages Unfamiliar with Such Systems

7.12 Results from the Type B2 villages, where the bidding game could be considered hypothetical, are reasonably similar. Table C-5 and Figure 7.2 show the connection frequencies and estimated revenues at various possible tariff rates. The one significant difference in comparison to the Type B1 village is the high connection frequencies (around 20 percent) at tariff rates beyond Rs 27.5 per month. This is due to the disproportionate number of high bids indicated in Type B2 villages as compared to both the Type B1 and the Type A villages. These could be due to the presence of strategic bias in the bidding, either overbidding in the type B2 villages or, less likely, underbidding in the other two types of villages.

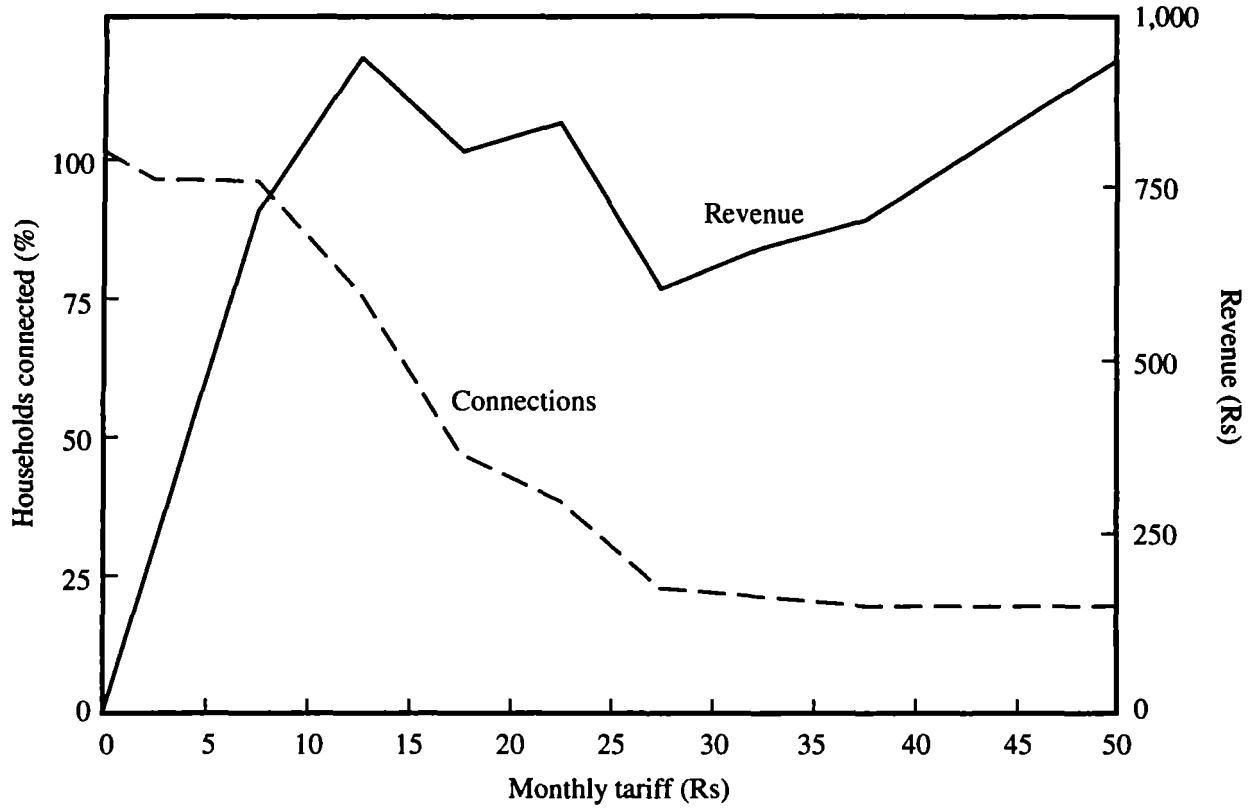

Figure 7.2 Connection frequencies and monthly revenue (per 100 households): Provision of a standard piped water supply system in a type B2 village

7.13 Revenues would be maximized at a tariff of Rs 12.5 per household per month yielding a revenue of Rs 933 per 100 households of which 75 percent would be connected to the system (Figure 7.2). This figure compares favorably with the tariff required for full recovery of O&M costs. Assuming a village population of 5000, a household size of 9, Rs 300 per capita capital costs, 3 percent of capital costs as O&M costs per annum and a connection frequency of 75 percent, the tariff required for full recovery of O&M costs works out to be Rs 9 per household per month.

Provision of an Improved System in Villages with an Existing Piped Water System

7.14 Type A villages, where a piped water supply was in operation, were offered the choice of an additional 4 hours of water per day from the existing system. Table C-6 and Figure 7.3 show the connection frequencies and revenues from various tariff rates, as revealed by the WTP bids.

7.15 The revenues would be maximized at a tariff of Rs 17.5 per month with a yield of Rs 693 per 100 households of which 40 percent would be connected. At a tariff of Rs 12.5 the corresponding figures would be Rs 599 and 48 percent (the existing revenue potential is Rs 550 per 100 households, the connection frequency being 55 percent at a tariff of Rs 10 per month).

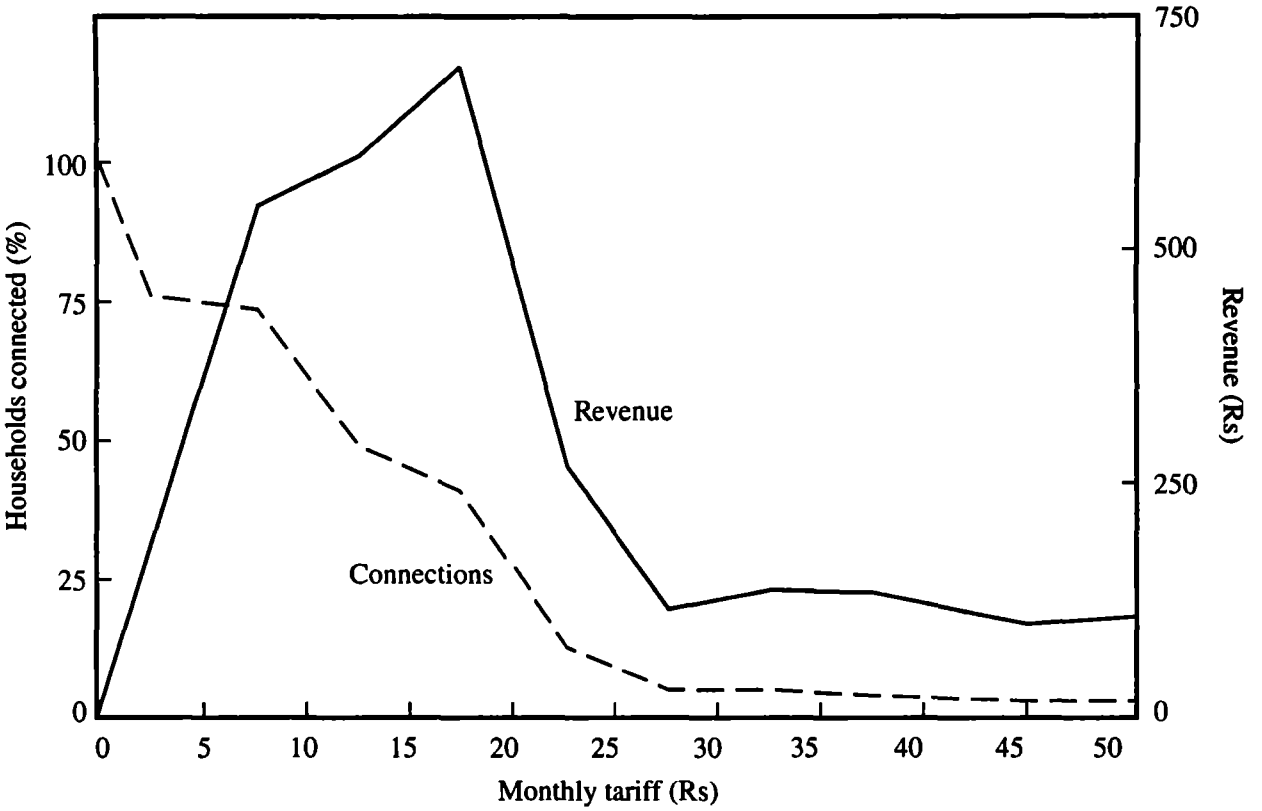

Figure 7.3 Connection Frequencies and monthly revenue (per 100 households): Provision of an improved piped water supply system in a type A village

7.16 The connection frequencies, and therefore the revenue yields, are lower than at equivalent tariffs in the Types B1 and B2 villages. This probably reflects dissatisfaction with the performance of the existing system and the fact that an extra 4 hours of water from a poorly run system suffering from low pressure in the pipes is not very attractive to the respondents. This suggests that the emphasis ought to be on improving system performance.

Experiments with Alternative Financing for Household Connections

7.17 The alternative financing option was described earlier. Table C-5 presents the comparative connection frequencies and revenue estimates if either the standard option or the flexible option alone are offered to respondents in a Type B2 village.

7.18 Suppose the PHED seeks to recover the extra capital expenditure of Rs 500 per household incurred under the flexible financing option over a period of 5 years at an interest rate of 10 percent. The additional monthly payment would amount to Rs 10.5. Thus the effective tariff would be approximately Rs 21 per month.

7.19 The two options can now be compared. At the existing tariff of Rs 10, 85 percent of the households would connect to the standard system yielding a monthly revenue of Rs 850 per 1000 households. At a tariff of Rs 21 per month under the flexible option, 54 percent of the households would connect yielding a monthly revenue of Rs 1134 per 100 households. Thus, the revenue yield would improve but the connection frequency would decline. The objective of the policy would not be served.

7.20 A variant of the policy would be to offer the flexible financing option only to the households that have not connected to the system at the existing tariff rate. The connection frequencies and revenue estimates resulting from such an offer to A2 households in a Type A village are shown in Table C-7. At a tariff of Rs 21 per month, 24 percent of the households would connect to the system raising the overall connection rate to 66 percent (55 percent households connected at the existing tariff plus 24 percent of unconnected households connecting under the flexible financing arrangement). Thus, under the cost recovery conditions stipulated, the policy of offering both the standard and the flexible option in the same village would succeed in raising the connection rate to some extent.

7.21 The monthly revenue yield per 100 households under the above scenario would amount to Rs 781 (Rs 10 x 55 + Rs 21 x 11). This can be compared to the revenue yield if the existing system is improved in the Type A village. Table C-6 shows the connection frequencies and the revenue estimates. While the exact costs of providing an additional 4 hours of water per day are not known, suppose that the tariff would have to be raised to Rs 17.5 per month. At this tariff the connection frequency would be 40 percent and the monthly revenue yield per 100 households would be Rs 700. Thus, the connection rate would be considerably lower and the monthly revenue would be only marginally less compared to the flexible financing option.

8. Brackish Water Zone: Overview and Field Procedures

8.1 Faisalabad District is also located in the central canal-irrigated part of the Punjab. The district capital, Faisalabad City, had a population of 1,104,209 according to the 1981 census. It is situated 145 kilometers from Lahore, the capital of the Punjab, and is the third largest city in Pakistan. Faisalabad is an internationally recognized center of the textile industry.

8.2 Almost half the area in Faisalabad District lies in the brackish groundwater zone. Water is available at accessible depths but its quality is generally perceived to be poor, although there are variations, often within villages.

8.3 Villages in what is now the brackish water zone formerly relied on wells as their primary source of water. In keeping with the transition in the sweet water zone almost every household has now replaced that source with a private handpump inside the house.

8.4 However, because of developments attributed to water-logging and salinity, the quality of groundwater has deteriorated over time so that by now dissatisfaction with its taste and its impact on health is fairly widespread. Of the households without access to piped connections, 54 percent rely on sources other than their private handpumps for water used for drinking and cooking. Among these alternative sources are canals and public handpumps alongside water-courses channeling water from canals to agricultural lands where the seepage water is of better quality. Water from such sources is either fetched by household members who devote approximately 35 minutes per day to this task or delivered for a charge by water carriers.

8.5 In such a situation piped supply systems provide the only convenient source of good quality water. Neither private handpumps nor motorized pumps can provide water of similar quality. Therefore, it is not surprising that connection frequencies to piped water supply systems are on the high side, around 75 percent.

8.6 What is surprising is the high percentage of sample households (50 percent) that have nonetheless installed motorized handpumps. This is partly attributable to the fact that the motorized pump can yield somewhat better quality water than the handpump by going deeper into the subsoil. It also underscores the demand for water-related conveniences like indoor plumbing, flush toilets, and showers, which are not accessible with handpumps.

8.7 The above facts suggest that domestic connections to a reliable piped water supply system should be preferred to motorized pumps because they can provide a better quality of water fit for drinking and cooking in addition to the water-related conveniences mentioned earlier. Besides, domestic connections are a less expensive choice for the consumer.

Selection of Study Villages

8.8 The selection of Type A villages was rendered difficult by the need to ensure a reasonable proportion of households that had remained unconnected to a piped supply system by choice; the connection frequencies were generally on the high side. Two villages, Manawala and Sudhar, were selected where the connection frequencies were around 75 percent. Manawala, a large village now incorporated within the limits of the Faisalabad municipality, has a piped supply system more than 10 years old. Sudhar, on the other hand, has a piped supply system which was only commissioned in January 1988.

8.9 Selection of Types B1 and B2 villages was straightforward. There are many villages where piped supplies are scheduled to be installed. The selected villages of the B1 type, Bhaiwala and Akalgarh, are at the stage where the distribution mains have been laid but domestic connections have yet to be sanctioned. The system in Bhaiwala is based on a tubewell, while that in Akalgarh is based on filtered canal water. The two Type B2 villages are both located close to the district headquarters.

8.10 The following are the particulars of the six selected villages:

• Manawala	:	Type A
Sudhar	:	
• Bhaiwala	:	Type B1
Akalgarh	:	
• Santpura	:	Type B2
Gatwala	:	

All the selected villages exceeded a population size of 5000. A more detailed profile of the selected villages is provided in Table D-1.[14]

Description of the Questionnaire and Bidding Games

8.11 The questionnaires are the same as used in the sweet water zone with only minor modifications due to site-specific considerations and the experience gained in the first round of interviewing. The one major difference is that there is only a single schedule pertaining to the Type B1 village since, unlike the sweet water zone, there was no need to distinguish among households in the B1 village.

[14]Statistical tables and analyses generated by the survey, grouped by subject, appear in Appendixes D, E, and F.

8.12 The bidding games were designed to evaluate the following options:

- The standard PHED piped water supply system of the kind existing in Type A villages. This option was offered to all households. The WTP of already connected households (A1) was elicited by bidding up from the existing tariff. The WTP of the voluntarily unconnected households (A2) was elicited by bidding up from a tariff rate of Rs 0 per month.
- An improved piped water supply system which would supply clean and safe water continuously with adequate pressure and reliability. This option was offered to every household.
- The standard PHED system with alternative financing arrangements. Only A2 households were offered the following two alternatives:
  (a) 50 percent of the connection costs to be borne by the water authorities; and
  (b) 100 percent of the connection costs to be borne by the water authorities.

8.13 The design of the bidding games ensured that protest bids and genuine zero bids would be clearly identified. When a respondent indicated that he would not be willing to connect to the piped water system at the lowest monthly tariff included in the bidding game, he was asked whether he would connect if the monthly tariff was zero (i.e., the water was free). If the respondent indicated that he would still choose not to connect, the enumerator asked him to explain the reason(s) why. The low and high starting points used were Rs 20 and Rs 40 per month as compared to Rs 15 (or Rs 5 in some cases) and Rs 50 in the sweet water zone. In the randomization of the starting points households either had low starting points or high starting points for both the games offered to them (for existing and improved systems).

Conducting the Survey

8.14 The survey was carried out in the 6 villages over a 10-day period (August 18-28, 1988). Some basic socioeconomic characteristics of sample households and their attitudes towards water-related issues are presented in Tables D-2 and D-3. A total of 495 interviews were completed, as follows:

Manawala	:	106	:	Type A : 202
Sudhar	:	96	:	
Akalgarh	:	106	:	Type B1: 200
Bhaiwala	:	94	:	
Santpura	:	52	:	Type B2: 93
Gatwala	:	41	:	

The number of interviews by schedule type was as follows:

A1 :	151
A2 :	51
B1 :	200
B2 :	93

Two visits each were made to Manawala, Sudhar, Akalgarh, and Bhaiwala and one each to Santpura and Gatwala.

9. Findings in the Brackish Water Zone: Analysis of Actual Choice Behavior

9.1 Water is freely available in the brackish water zone. The quality of water from traditional sources (wells, handpumps) is generally considered to be poor for drinking and cooking except from handpumps alongside water channels which pick up seepage water from canals.

9.2 The transition from wells to handpumps as the primary source of water is complete. Most households have private handpumps inside the house to cater to their water needs. However, for drinking and cooking many households fetch water from outside (public handpumps along water channels at the village periphery or canals) or have water delivered to their homes.

9.3 About 50 percent of the households in the sampled area have installed electric motors on their private handpumps. The motorized pump, because it can lift water from a greater depth than the manual pump, yields somewhat better quality water that households not willing to expend the time or effort required to fetch water from outside use for drinking and cooking as well. The electric motors also provide the same upgraded services that were mentioned in the case of the sweet water zone. However, the quality of piped water is clearly considered superior, and, wherever the option of connecting to such a system is available, the connection frequencies are high. Table D-4 shows the pattern of household choice over available service options along with their approximate costs.

Who Installs Electric Motors?

9.4 Once again, the statistical analysis (for details see Table E-1) confirms expectations based on economic theory. Better educated, economically affluent and propertied households are more likely to install electric motors. Households with more animals kept inside or just outside the house are less likely to install motors. This suggests that animal needs are not a factor in the decision to install electric motors. Perhaps water obtained from this source is considered too expensive for such a purpose.

9.5 One important difference from the pattern in the sweet water zone is that variables related to household size and time spent in fetching water are quite unambiguously positive. This would make sense in the brackish zone where motors are also used to improve upon the quality of water available from handpumps. Thus, motors would serve both the objective of making water-related services available and of providing better quality water for drinking and cooking inside the house. This is one reason for the greater incidence of motor-operated pumps in the brackish zone (62 percent of households in Type B villages against 30 percent in the sweet water zone).

9.6 As in the sweet water zone, households with access to piped water systems are significantly less likely to install electric motors (33 percent of households in Type A villages against 62 percent in Type B villages). This is because, ideally, piped connections provide better quality water as well.

9.7 However, 33 percent of households in Type A villages continue to have motor-operated pumps (29 percent have a piped connection as well as a motor). The corresponding numbers in the sweet water zone are 11 percent and 7 percent. Part of the explanation could lie in the fact that one of the sample villages, Sudhar, has had a water supply for less than six months. Households that had installed motors prior to the provision of piped water might continue to retain them till such time as major repairs are required (44 percent of households in Sudhar have motors against 23 percent in Manawala). The other reason could be the greater reliability of electric motors in providing water for general household needs besides drinking and cooking.

9.8 Households that consider water from their primary source (handpumps) to be satisfactory for health are less likely to install motors, but the variable is not statistically significant. This would suggest that the quality of water is not the primary motivation in installing electric motors.

Who Connects to Piped Water Systems?

9.9 In two of the sample villages, Manawala and Sudhar, households have had the alternative of connecting to a public piped supply system with domestic connections. Of the sampled households 75 percent had availed themselves of this alternative.

9.10 The statistical analysis (Table E-2) shows that better educated and economically affluent households are more likely to connect to piped water systems. Households located further away from the distribution line are less likely to connect because of the increase in connection costs.

9.11 Households that consider water from their handpumps to be unsafe for health are more likely to connect to piped systems. The coefficient is statistically significant suggesting that the improvement in water quality is an important factor in the decision to connect.

9.12 Farming households and those with a higher proportion of children are less likely to connect. This could be, as argued earlier, both because of reduced needs and the availability of labor to fetch water for drinking and cooking from outside the house. This reinforces the conclusion that piped water serves much more as a substitute for water fetched from outside the house than motor-operated pumps.

9.13 Contrary to the pattern in the sweet water zone, households with motors are more likely to connect to piped systems (the coefficient is positive but not significant). This suggests that the two options are not considered to be complete substitutes in the brackish water zone.

9.14 Households that favor the metering of water supplies have a greater likelihood of connecting to piped water systems.

9.15 One variable which needs explanation is per capita household expenditure. Both the linear and quadratic terms are close to significance with the former having a negative and the latter a positive coefficient. One explanation could be the poor correlation between income and expenditure at low values; an increase in expenditure unrelated to incomes (e.g., increase in family size) would

strain the budget which might be adjusted by giving up items for which cheaper alternatives are available. Water, which can be fetched at zero out-of-pocket costs, is one such item. On the other hand, at higher levels, increases in per capita expenditure could be expected to reflect increases in income.

9.16 The reasons mentioned by the respondents for either connecting or not connecting to the piped water supply system are listed in Tables D-5 and D-6. These were obtained as responses to open-ended questions.

Electric Motors and Household Connections

9.17 Ideally, household connections to piped systems should be a dominant choice because they are not only less expensive than electric motors but also provide better quality water. However, in reality, piped systems have not proved to be reliable enough to be acceptable as a dependable source for water-related services like indoor plumbing, showers and flush toilets. Therefore, even in a village like Manawala where the piped supply is over 10 years old, 21 percent of households continue to have electric motors along with domestic connections.

9.18 This lack of reliability has restricted the utility of piped systems to providing limited water of good quality for drinking and cooking. In villages without piped supplies 38 percent of households rely on the base service level of handpumps; in villages with a piped supply the percentage falls to 21 percent. However, households that desire a reliable upgraded service level cannot do so without investing in a private electric motor.

9.19 For comparison with the sweet water zone, Table D-7 shows the relationship between choice of service level and the economic status of the household in villages where a piped supply option is available. Once again, it is the most affluent households that have both a domestic connection and an electric motor.

10. Findings in the Brackish Water Zone: Analysis of Willingness-to-Pay Bids

10.1 The following options were evaluated through bidding games:

- A household connection to a standard piped water system of the type existing in Type A villages;
- The same, with more affordable financing arrangements. This option was offered only to the unconnected households in Type A villages; and
- A household connection to an improved piped water system.

10.2 The perceptions of households with experience of piped water systems are presented in Tables D-8 and D-9. It can be noted that 66 percent of the connected households expressed dissatisfaction with the operation of the system, with the primary complaint relating to its reliability.

10.3 To determine the acceptance of a well-functioning system, willingness-to-pay bids were elicited for an improved system. The improved system was stipulated to provide clean and safe water on a continuous basis with an acceptable level of reliability and pressure.

10.4 Households that had remained unconnected to available piped water supply systems were offered two alternative financing packages to determine if the one-time connection costs were a factor in their remaining unconnected. In the packages offered the water authorities were to bear 50 percent or 100 percent of the connection costs in return for a higher monthly tariff.

Willingness to Pay for Connection to a Standard System

10.5 The distribution of WTP bids for connection to a standard piped water system is presented in Table F-1. In the brackish water zone bids for such a system were obtained from Type A households as well as from Types B1 and B2 households.

10.6 A number of observations can be made based on the data presented in the table:

- There is little difference between the bids obtained from Type B1 and Type B2 households. The mean bids are Rs 41 and Rs 37, respectively; the percentages of households bidding more than Rs 12 per month (and therefore likely to connect at the prevailing tariff) are 97 percent and 90 percent, respectively; and the mean bids of the latter households are Rs 43 and Rs 40, respectively.
- The bids and connection ratios are slightly higher in the Type B1 village in comparison to the Type B2 village. Given that distribution lines have already been laid in the former and there are no plans for the installation of a system in the latter, one would have expected strategic bias to lead to a converse pattern. One obvious explanation would emerge if, despite the advanced stage of installation, Type B1 households have no more information about system parameters (connection fee, monthly tariff) than Type B2 households. This would also constitute concrete evidence of the lack of community participation in the preparation and implementation of village-level projects. The relevant data are presented in Table

D-10, which reveals a very high level of nonawareness regarding basic information about the parameters of the piped water system. This nonawareness is just as prevalent in Type B1 villages as in Type B2 villages.

- The pattern in the Type A village is quite different. The mean bid (Rs 16) and the connection ratio (75 percent) are much lower than in either of the villages without operational systems. Even the mean bid of the connected households (Rs 21) is about half the mean bid of similar households in the other villages.

There can be two possible reasons for the above pattern. First, the experience of Type A households with the piped supply in their village could be negatively affecting their bids; Types B1 and B2 households, not aware of the actual performance of such systems, are not only bidding higher but more households are indicating an intention to connect than in the Type A village. Second, there could be an anchoring or strategic bias effect because the existing tariff is known to the respondents. In this, the design of the bidding game for already connected households, which involves bidding up from the existing tariff to a value at which they would disconnect, could be a contributing factor.

10.7 *Types of Households with Higher Willingness to Pay for a Standard System.* A multivariate analysis (see Table E-3) shows that the WTP bids are systematically related to a number of explanatory variables. Households that require more water (greater household size and per capita consumption of water) and those that need to spend more time fetching it from outside the house bid higher than others.

10.8 The bids are positively and significantly related to household expenditure per capita; an increase of Rs 100 in the variable would raise the bid by approximately Rs 2. Younger households, those which include members who have lived outside the village, and those favoring the metering of water connections bid more than others.

10.9 Households that consider the water from existing sources to be satisfactory for health bid Rs 3.5 per month less than others but the variable is not statistically significant. The nonsignificance of the existence of electric motors (50 percent of sampled households possessed motors) indicates that they are not considered as substitutes for piped water.

10.10 As mentioned earlier, households in Type A villages bid significantly less compared to Type B1 households. There was no significant difference between the bids of Types B1 and B2 households.

Willingness to Pay for Connection to an Improved System

10.11 The distribution of WTP bids for connection to an improved piped water system is presented in Table F-2. It should be kept in mind that Types A2, B1 and B2 households were asked to assume that, for the improved system, connection costs were zero. This was to maintain compatibility with Type A1 households that already had a domestic connection and would not have to incur connection expenses again for access to an improved system.

10.12 The following observations can be made based on the data presented in the table:

- The connection ratios are very high and similar for all three types of villages: 95 percent, 99 percent and 97 percent for village Types A, B1, and B2, respectively.

- The mean bids are again similar for the Types B1 and B2 villages (Rs 58 and 51 respectively), which, in turn, are higher than the mean bid in the Type A village (Rs 33).
- The fact that Types B1 and B2 households were offered connections to improved systems at zero connection cost (compared to connections to the standard system for which they had to bear the connection costs) does not seem to have affected their bidding to any significant extent. Thus, the increases in the mean WTP bids over the standard system for the Types A, B1, and B2 households are 98.5 percent, 40.9 percent, and 37.6 percent, respectively. The corresponding figures computed only over those households likely to connect (those bidding more than Rs 12) are 64.9 percent, 37.7 percent, and 29.5 percent, respectively. In both cases the increase is much more for the Type A households. This could be due to the fact that, having had experience with the standard system, the Type A households could appreciate the improvements much better than the Types B1 and B2 households for whom the standard system itself would be a great improvement.

10.13 *Types of Households with Higher Willingness to Pay for an Improved System.* The multivariate analysis (see Table E-4) shows virtually the same pattern as for the standard system; households that are willing to pay more for the standard system are also willing to pay more for the improved system. Wealth, education and health considerations emerge as additional significant variables in the case of the improved system.

Response of Households in Villages with and without Operational Piped Water Systems

10.14 To develop an understanding of the factors that affect the willingness-to-pay bids for various service levels it is useful to focus on the Type A and Type B villages separately. Since Type A households have had actual experience of existing piped water systems, their evaluation of such a system would reflect concrete considerations. It would be of interest to see the overlap with the considerations that affect the evaluation of an hypothetical improved system. A similar analysis could be performed by comparing the evaluation of the standard system by Type A and Type B households since for the latter the standard system represents a hypothetical choice.

10.15 *Response of Type A Households.* The results of the multivariate analyses of WTP bids offered by Type A households for existing and improved systems are presented in Tables E-5 and E-6. It can be noted that the only significant considerations in the case of the existing system are income (expenditure) and ownership of livestock which is kept inside or just outside the house. Households with such animals are willing to pay Rs 2 per animal per month more than others. The typical livestock owning household possesses two animals. The premium of Rs 4 per month constitutes 25 percent of the mean value of the dependent variable.

10.16 This last consideration is important and it confirms the hypothesis that was developed during the analysis of the sweet water zone. Piped water from the existing system is used for washing livestock and this suggests that the consumption figures used by the PHED in the design criteria ought to take this factor into account.

10.17 In the case of the improved system the significant considerations are income, wealth, household size, age, concerns about health, and attitudes towards metering of domestic connections. While ability to pay and animal needs dominated in the case of the existing system, modern attitudes and quality of life considerations emerge as significant in the evaluation of the improved system.

Younger, more affluent and more discriminating households bid higher for a "modern" system regardless of whether they owned animals or not.

10.18 *Response of Type B Households.* The response of Type B households to the existing system (Table E-7) shows that household size and per capita consumption of water are significant determinants of WTP bids indicating that the need for drinking water plays a part in the evaluation. In addition, age and preference for the metering of domestic connections are other significant determinants indicating the influence of attitudes.

10.19 The variables for wealth or income are not significant, suggesting either that the bids are not anchored by the ability to pay or that the tariff rates are a very low proportion of monthly incomes and so considered generally affordable by most households bidding in an hypothetical market. The latter hypothesis is supported by the fact that wealth does emerge as a significant variable in the bidding for the improved system.

10.20 Moreover, the coefficient for the ownership of animals is negative and not significant. This is a strong suggestion that learning has taken place in the Type A villages resulting in the significantly higher bids by the owners of livestock.

Response of Unconnected Households in Type A Villages

10.21 To explore the reasons for nonconnection, Type A2 households they were offered two alternative financing arrangements for sharing the costs of connection to the existing system. Under the first arrangement the water authorities would contribute 50 percent of the costs while under the second they would contribute 100 percent of the costs; in exchange the tariff would be raised.

10.22 Table F-3 shows the distribution of the WTP bids. It can be seen that while no households are at present connected at the prevailing tariff (Rs 12 per month) the connection ratios (at the same tariff) under the two arrangements would be 47 percent and 63 percent, respectively. The mean WTP bids of the connecting households are Rs 16 and Rs 21 per month, respectively.

10.23 Table F-4 shows the distribution of the WTP bids offered by A2 households for an improved system. At the existing tariff, 82 percent of A2 households would connect to the improved system. Their mean WTP bid is Rs 27 per month as tariff.

11. Estimated Revenues and Cost Recovery Potential

Costs of Piped Water Systems

11.1 Two types of piped water distribution systems are used in the brackish water zone: systems based on tubewells alongside canals (as in Bhaiwala) and systems based on filtration of canal water itself (as in Akalgarh). Capital and O&M costs of the two systems under various conditions are shown in Table D-11. The capital cost per capita of a tubewell-based system is Rs 300, while that of a canal water system is Rs 500. Based on these figures the total capital costs of the systems can be computed for the type of large villages studies (approximate population 10,000).

11.2 The PHED estimates annual O&M costs to range from 3-5 percent of capital costs. In the case of the sweet water zone, the lower bound is more appropriate for large villages because of economies of scale; a large component of O&M costs being fixed in nature. Using the average household size in the sampled area (8.9) the monthly charges required to recover the O&M costs fully at various connection frequencies have been computed. For tubewell-based systems, even the upper bound estimates (at 5 percent of capital costs) of Rs 14.83 per household per month (assuming the prevalent 75 percent connection frequency) are well within the achievable region. For canal water systems the corresponding value is Rs 24.71. However, at the more appropriate value of 3 percent of capital costs the latter figure drops to Rs 14.83, again a target that should be quite achievable given the existing tariff of Rs 12.

Provision of a Standard Piped Water System

11.3 The connection frequencies and revenue estimates pertaining to the provision of a standard piped water system at different monthly tariff rates are shown in Table F-5. The connection frequencies for the Types A, B1, and B2 villages are plotted in Figure 11.1. It can be seen that the frequencies for the Types B1 and B2 villages are very similar and much higher than those for the Type A village. The reason for the possible bias in the responses of Type A households has been mentioned earlier. The plot suggests that there is no further need to distinguish between the Type B1 and B2 villages. The corresponding plot of estimated revenues is shown in Figure 11.2.

11.4 If the target of 75 percent connections is to be maintained, the monthly tariff cannot be increased beyond the existing rate of Rs 12. At this tariff a tubewell-based system is economically viable at the lower bound of O&M costs (Rs 8.9 per household per month) but not at the upper bound of Rs 14.83. A canal water system is not economically viable even at the lower bound (Rs 14.83).

Provision of an Improved Piped Water System

11.5 The connection frequencies and revenue estimates pertaining to the provision of an improved piped water system at different monthly tariff rates are shown in Table F-6. The connection frequencies are plotted in Figure 11.3. Again it can be noted that there is no need to distinguish between the Type B1 and B2 villages. The corresponding plot of estimated revenues is shown in Figure 11.4.

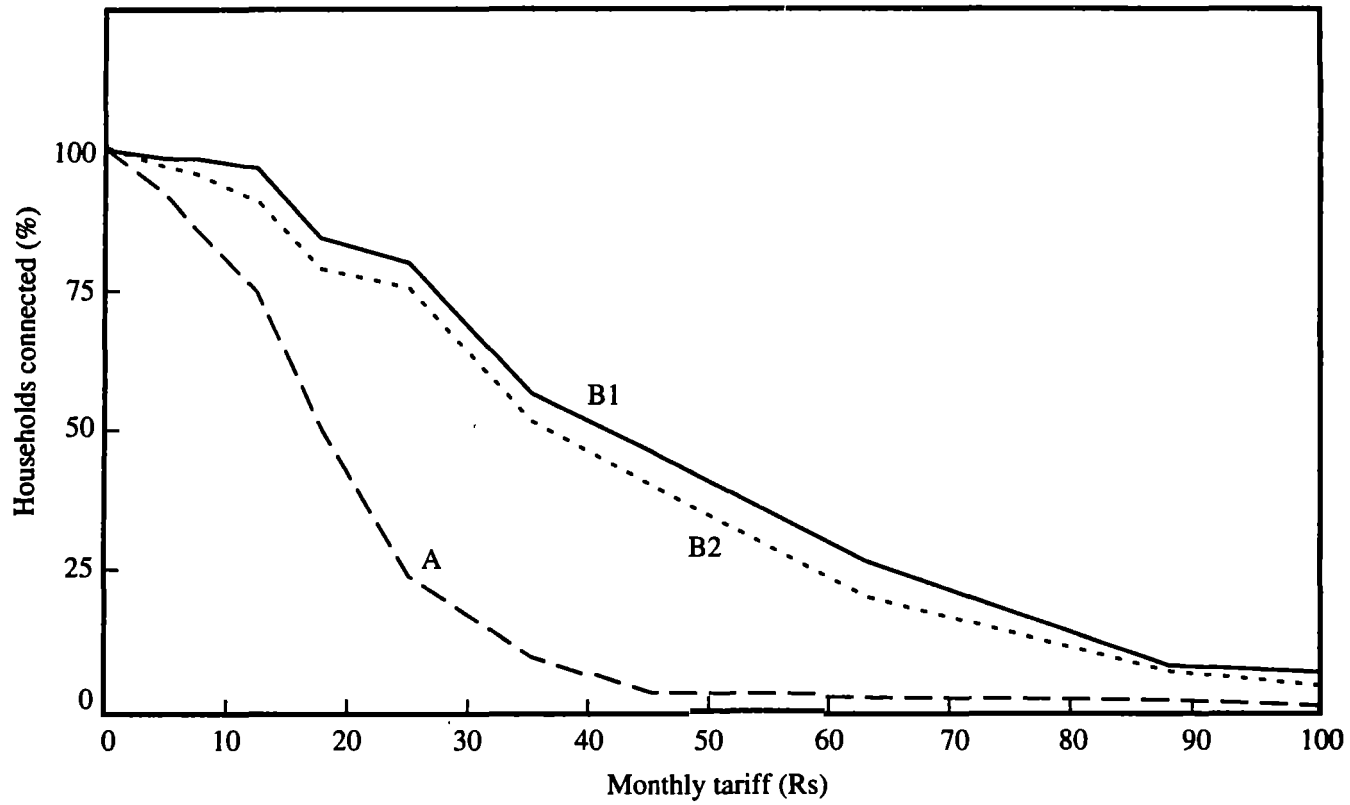

Figure 11.1 Connection frequencies: Provision of standard piped water system in village types A, B1, and B2

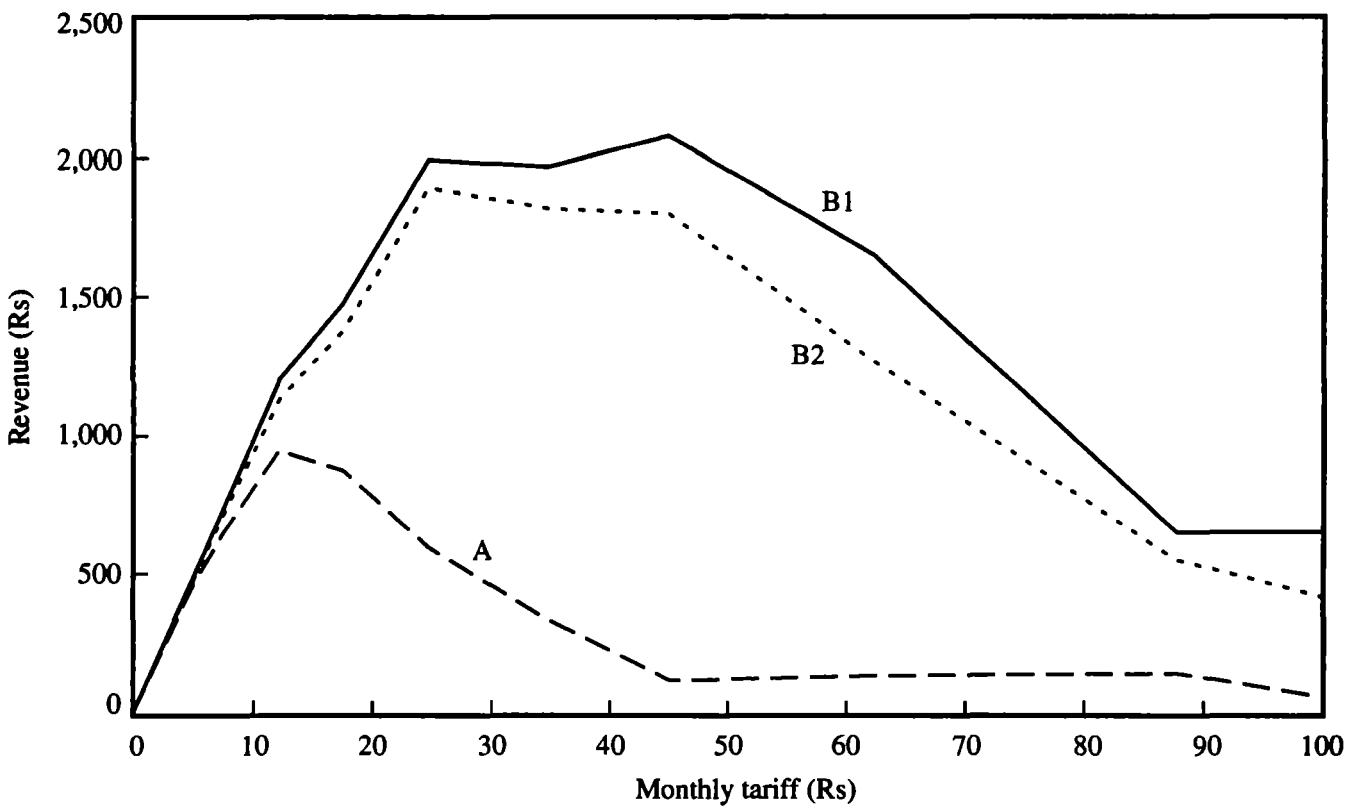

Figure 11.2 Monthly revenue (per 100 households): Provision of a standard piped water system in village types A, B1, and B2

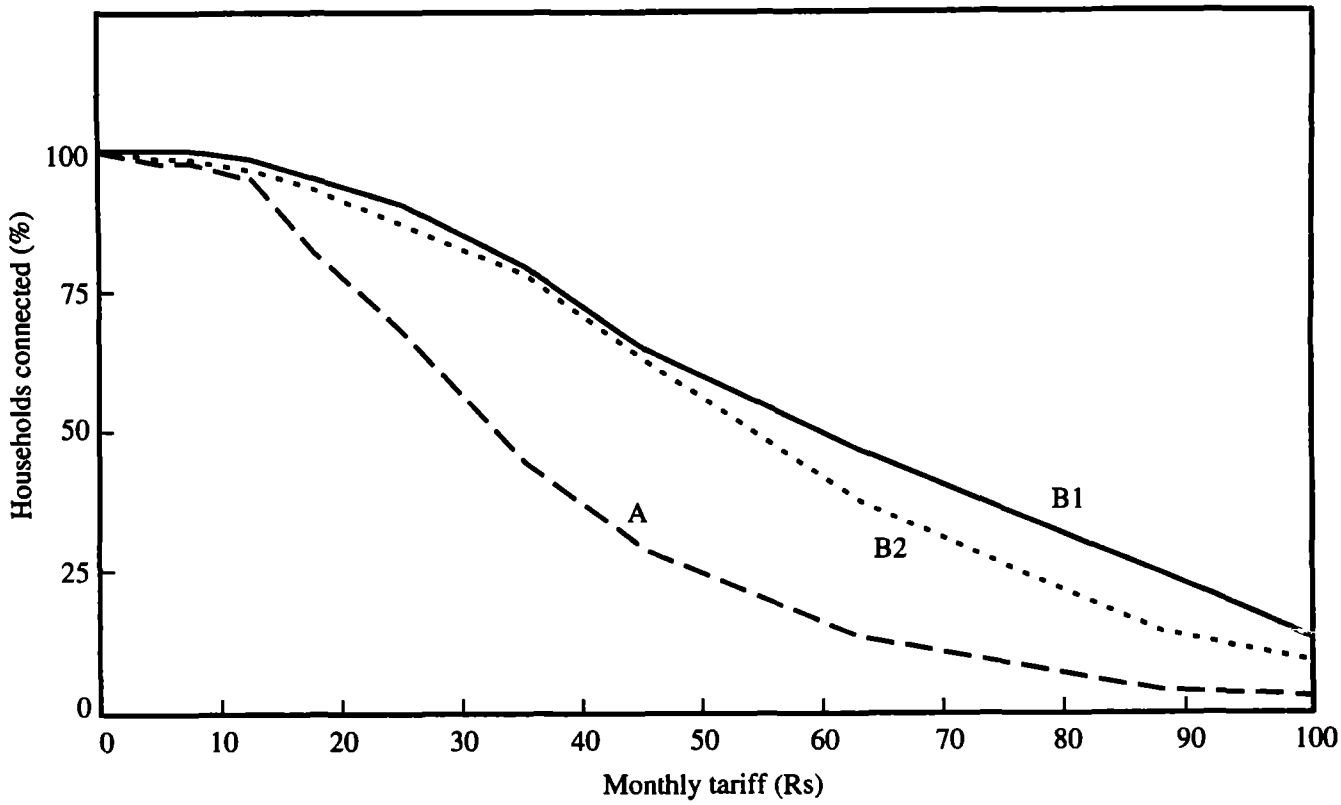

Figure 11.3 Connection frequencies: Provision of an improved piped water system in village types A, B1, and B2

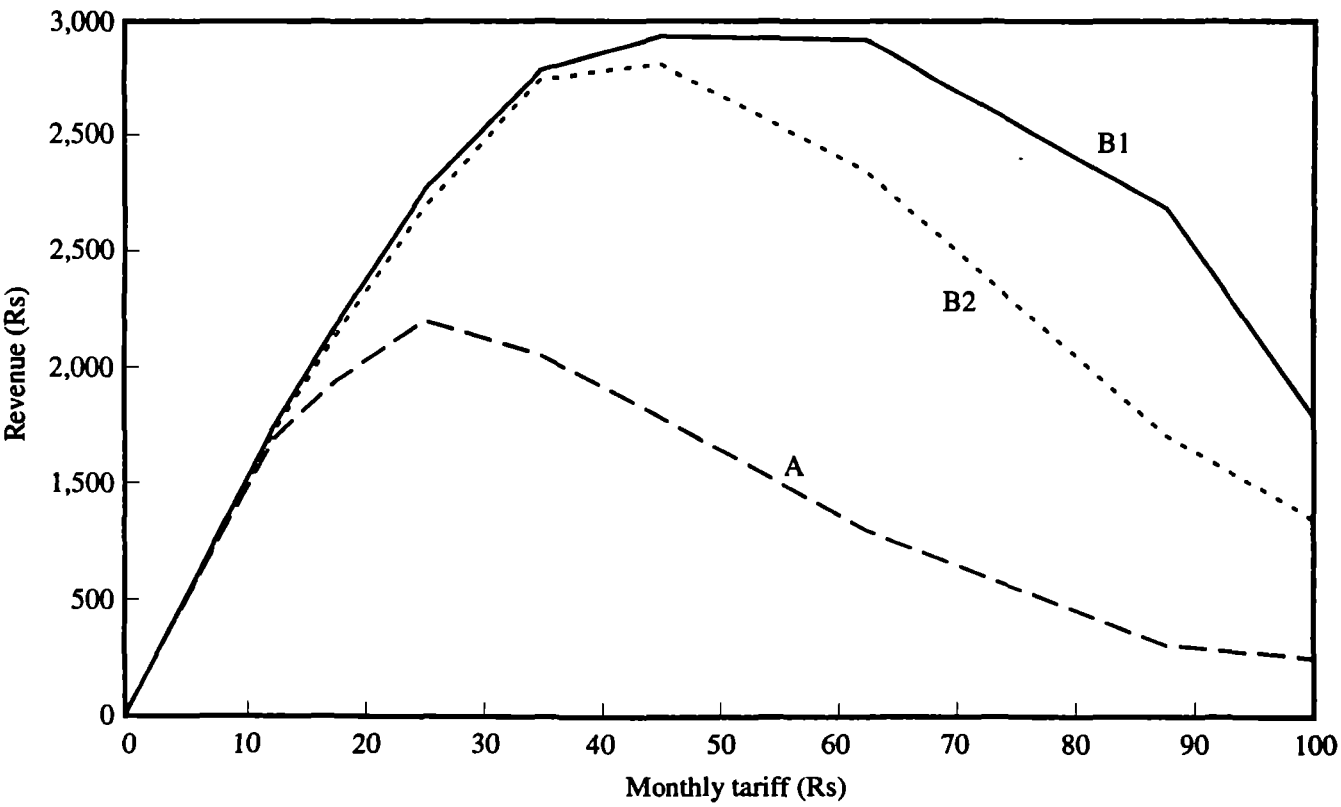

Figure 11.4 Monthly revenue (per 100 households): Provision of an improved piped water system in village types A, B1, and B2

11.6 Again, if a lower bound of 75 percent connections is to be maintained, it can be seen that the tariff can be set in the range of Rs 17.5 to Rs 25.0 per month in a Type A village. Figure 11.4 shows that revenues would be maximized at Rs 25 per month. Thus, a tariff of, for example, Rs 20 per month would achieve both high connection frequencies and high revenue collections. If a Type B village is used as a reference, the feasible range for the monthly tariff could extend to Rs 35. While the exact costs of improving the piped water system are not known, it seems that at least the O&M costs could be fully recovered without causing households to disconnect from the system because of an unwillingness to pay an increased tariff.

Comparison of Standard and Improved Piped Water Systems

11.7 Since the Type A villages provide the lower bounds on connection frequencies and estimated revenues we can use the responses of Type A households to compare the gains resulting from improving the existing piped water systems. Figures 11.5 and 11.6 show the connection frequencies and estimated revenues in a Type A village resulting from the provision of standard and improved systems.

11.8 The improved system completely dominates the standard system. The monthly tariff can be raised from Rs 12 to Rs 20 without the connection frequency dropping below 75 percent. The maximum estimated monthly revenues go up from Rs 935 per 100 households to Rs 1693 per 100 households.

11.9 *The Response of Unconnected Households in Villages with an Operational Piped Water System.* Table F-7 shows the response of Type A2 households to the four options offered to them: the standard system, the standard system with two financing arrangements, and the improved system. The connection frequencies and the estimated revenues are plotted in Figures 11.7 and 11.8.

11.10 The improved system dominates the other alternatives. Thus there should be little doubt that improvements in the existing system have a greater payoff than offering special incentives to households that have not connected to existing systems in the brackish water zone.

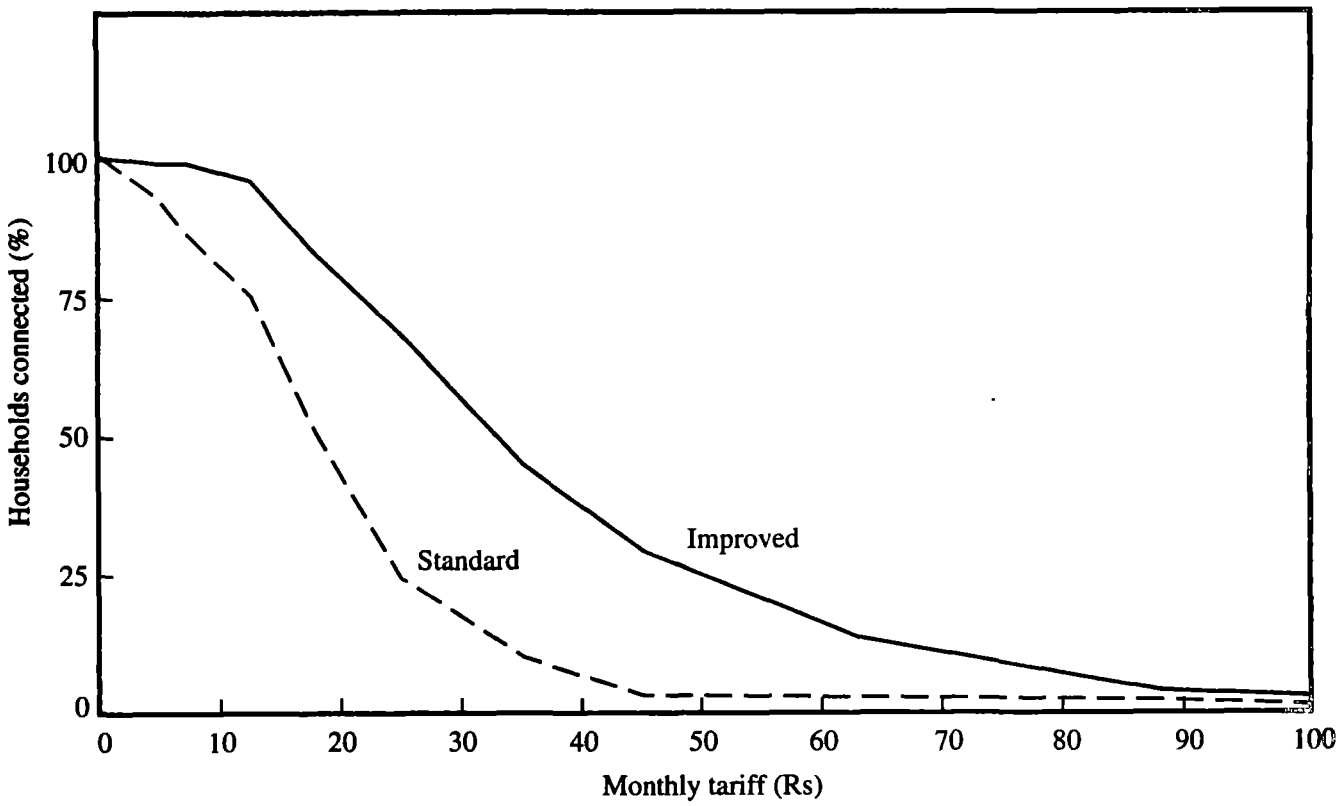

Figure 11.5 Connection frequencies in a type A village: Standard versus improved piped water systems

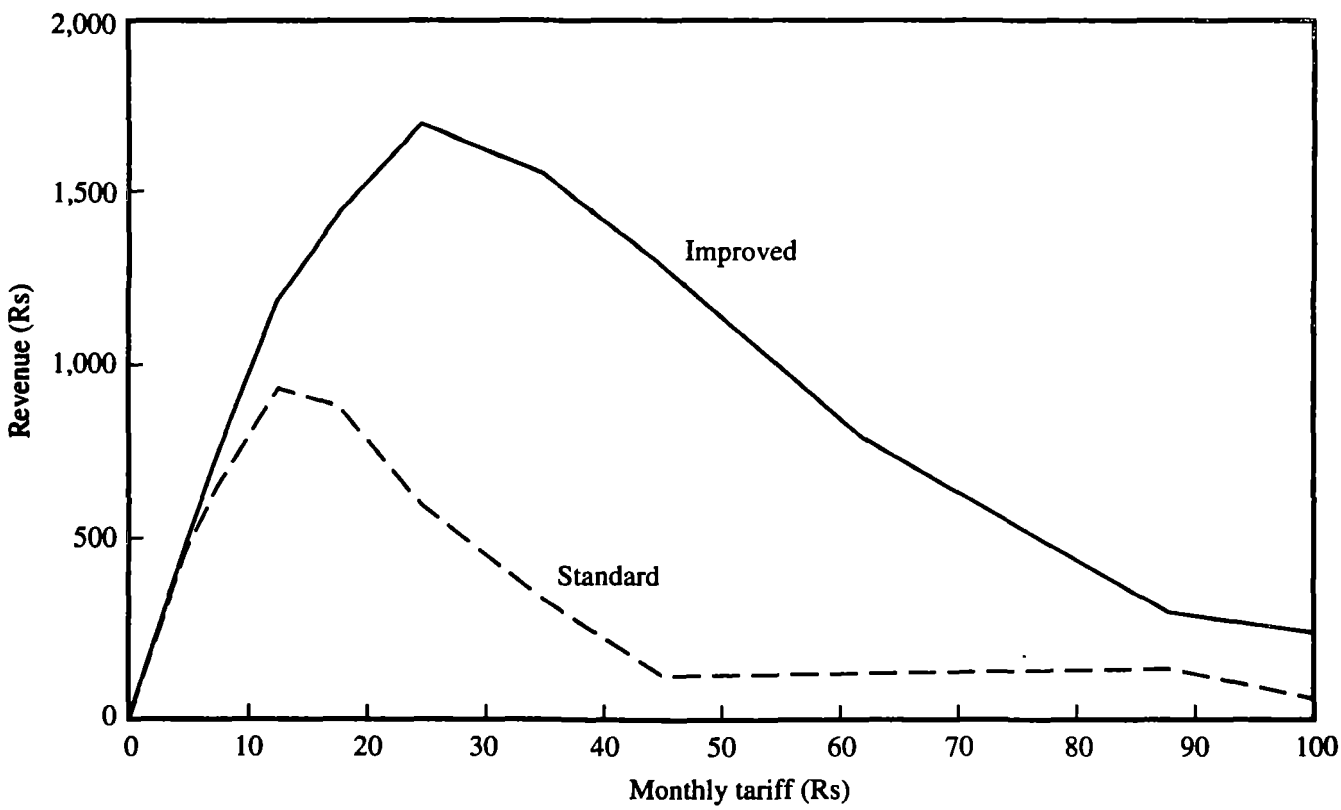

Figure 11.6 Monthly revenue (per 100 households) in a type A village: Standard versus improved systems

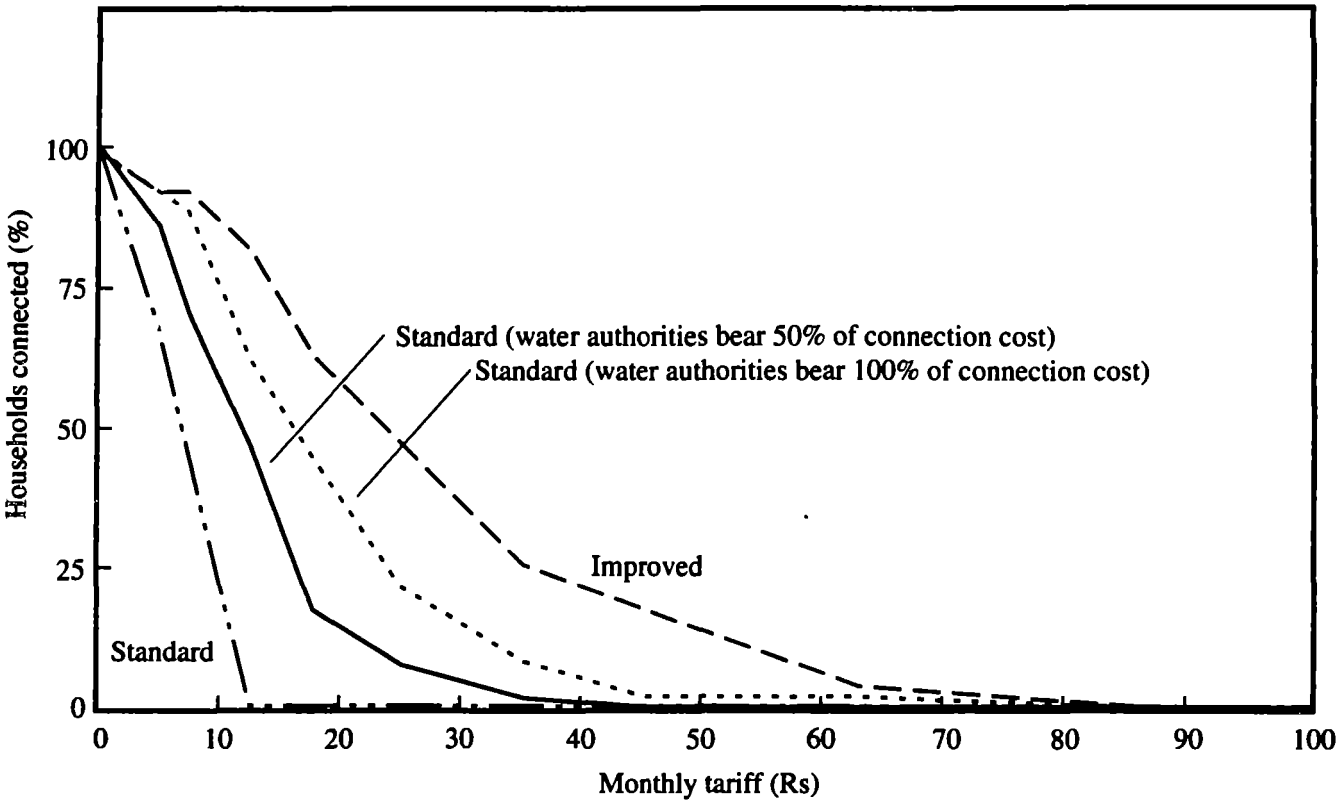

Figure 11.7 Connection frequencies under different options presented to type A2 households

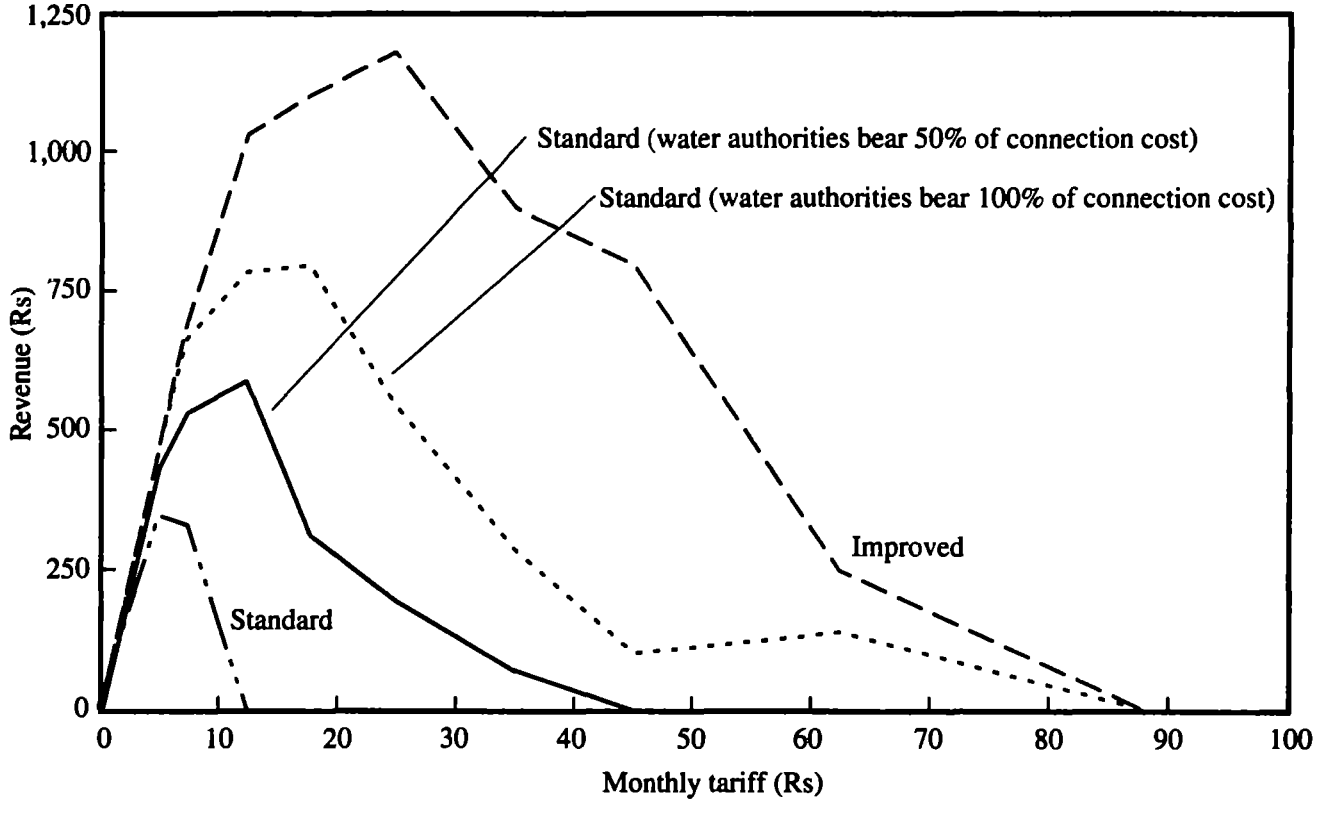

Figure 11.8 Monthly revenue (per 100 households) under different options presented to type A2 households

12. Arid Zone: Overview and Field Procedures

12.1 Rawalpindi District is located in the northern, rain-irrigated part of Punjab. The district capital, Rawalpindi, has a population of 794,843 according to the 1981 census. It is situated 16 kilometers from the federal capital, Islamabad, and 272 kilometers from Lahore, the capital of Punjab. Rawalpindi is the fourth largest city in the country and is the headquarters of the armed forces. Not much industry is located in the district, which has traditionally been an area of high recruitment in the army.

12.2 Almost the entire area in Rawalpindi District lies in the arid zone. Groundwater is available at much greater depths than in the other districts studied and even this dries up during the peak summer period from April to July. Perhaps because of the lack of water, the villages in the arid zone are much smaller, the typical village population lying between 1000 to 2000 inhabitants.

12.3 Villages in the arid zone rely on wells as their primary source of drinking water. However, unlike the other two zones studied, these wells are generally not within easy reach of the households. Because of the scarcity of agricultural land most villages are located on rocky formations, usually at an elevation above that of the agricultural land. The groundwater is often at a more accessible depth near such land because of seepage from some water source (the Soan River in three of the study villages) or the lower elevation. Thus, many wells, private as well as public, are located at a distance from the village. In addition, the natural sources of water (river, ravine, etc.) are also at a distance and often involve a steep climb on the way back.

12.4 Because of the distance and the elevation, water is fetched only for the most essential uses. Many water-related activities take place at the sources, e.g., bathing, laundry, and watering of animals. During the summer, households spend approximately 6.5 person-hours per day in travelling to and from water sources (compared to 4 hours per week in the brackish water zone).[15] Most of this time is spent by women and children except for that involved in the watering of animals, which is generally a task handled by men.

12.5 The summer months from April to July are particularly difficult because of the lowering of the water table. Water in wells becomes almost inaccessible and waiting time becomes exceedingly long. The need for water becomes an overwhelming concern during this period before the groundwater is recharged by the monsoon rains.

12.6 Vendors are present in villages without piped water but only a minority of households (5.7 percent) use them on any sort of regular basis. This is perhaps due to the cost which can reach between Rs 100 to Rs 150 per month if a vendor is used to deliver 30 liters of water daily. However, vendors are routinely used on social occasions like marriages and deaths. On such occasions a vendor may be paid between Rs 300 to Rs 500 to fetch as much water as may be needed over two or three days.

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[15]The computations exclude queuing because information is only available for maximum queuing time.

12.7 Because of the desperate need for water, quite a few households have developed a private source (24.4 percent) or have attempted (5.4 percent) to do so. While some have experimented with wells, others have tried a simple bore down which a three inch diameter metal sleeve can be lowered and drawn up filled with water. The costs are quite high. Digging a well costs Rs 200 per yard through soft earth and Rs 400 to Rs 500 per yard through hard, stony, or rocky formations. A bore costs Rs 75 per yard and often has to be between 20 to 25 yards deep. Even so, it yields little water and invariably dries up during the summer months.[16]. Consequently, efforts have increased, beginning with the 5-Point Programme, to provide public water supplies to villages in this region. Many villages have received, or are in the process of receiving, public water supplies. Villages smaller than 5000 inhabitants have been selected to receive piped water systems with house connections, contrary to the stated policy of the Punjab PHED. No schemes based on public taps are under consideration.

12.8 Connection rates were very high, and even in villages supplied for less than six months, almost all the households had connected. This was so despite the fact that the monthly tariff of Rs 20 was much higher than in the other two zones studied. This underscores the great need for water in the arid zone.

Selection of Study Villages

12.9 Villages with public water supplies in Rawalpindi District showed two important features. Most of these supplies were relatively new (two years old or less) and the connection rates were very high (close to 100 percent). These characteristics are reflected in the Type A villages selected.

12.10 Because of the high connection rates there is no meaningful distinction between houses with (A1) and without (A2) connections. Therefore, a comparable analysis of actual choice behavior based on connection to the water system is not possible in the arid zone. The selection of B1 and B2 villages was straightforward. All the selected B1 villages had public water systems at an advanced stage of construction.

12.11 The small population of the villages in the arid zone made it necessary to select three villages of each type. The following are the particulars of the nine selected villages:

Jawa	:	
Banda	:	Type A
Dhalla	:	
Papin	:	
Payal	:	Type B1
Gorakhpur	:	
Dhuddian	:	
Mohra	:	Type B2
Bodhial	:	

[16]The average capital cost of a successful private source is Rs 7960 and the monthly maintenance expenses are approximately Rs 40. The unsuccessful attempts have cost Rs 5730 on the average.

12.12 Three villages, one of each type, (Dhalla, Gorakhpur, and Bodhial) were located by the Soan River, the main perennial river in the area. The others were located by nonperennial ravines. The following villages were located at a considerable height above ground level: Dhalla, Gorakhpur, Bodhial, Papin, and Banda. A detailed profile of the selected villages is provided in Table G-1.[17]

Description of the Questionnaire and Bidding Games

12.13 The questionnaires are essentially the same as those used in the brackish water zone. The one major addition pertains to sections added to obtain more detailed information on all the water sources available and on the pattern of water usage. This addition was made because, unlike the other two zones (where handpumps inside the house were the primary source of water), many more sources were used and different sources were used for different purposes. It was felt that more information ought to be collected if a source choice model was to be constructed at a later stage and also to obtain estimates of the quantity of water fetched and time spent on water-related activities.

12.14 The specification of a source choice model requires the precise identification of sources. In the situation where multiple facilities of a given type existed (e.g., more than one public handpump in the village) the facilities were recorded in the questionnaires by their local names (e.g., mosque handpump or village center handpump, etc.). At the time of data entry each facility was given a unique two digit code. Thus source 43 would indicate a public handpump (source type = 4) located by the mosque (handpump number = 3). Each code would denote the same facility for all households. These identification codes would also be used to cross-reference the data on source characteristics and water usage.

12.15 Information on water usage patterns during summer were obtained from all households. However, information for the winter months was collected only from a sub-sample of households. This was primarily to reduce interview time and also because the limited objective was to obtain an average scaling factor to estimate the consumption of water during the winter months.

12.16 There was one additional bidding game in the arid zone. The details of the bidding games and the options they were designed to evaluate are as follows:

- A scheme based on public taps in which a public tap would be located at most 20 yards from any house. Water of satisfactory quality would be available for approximately 4 hours per day. This option was offered to households in B2 villages.
- The standard PHED piped water scheme with house connections of the kind existing in Type A villages. This option was offered to all households in the sample. The WTP of already connected households (Type A1) was elicited by bidding up from the existing tariff. The WTP of unconnected households (Type A2) was elicited by bidding up from a tariff rate of Rs 0 per month.
- An improved piped water supply system with house connections which would supply clean and safe water continuously with adequate pressure and reliability. This option was offered to every household in Types A and B1 villages.

[17]Statistical tables and analyses generated by the survey, grouped by subject, appear in Appendixes G, H, and I.

12.17 As noted in the case of the brackish water zone, the design of the bidding games ensured that protest bids and genuine zero bids would be clearly identified. In addition, the low and high starting points to test for starting point bias were Rs 30 and Rs 50 respectively. These were higher than in the brackish water zone because the existing tariff was already Rs 20 per month compared to Rs 12 in the brackish water zone and Rs 10 in the sweet water zone. In the randomization of the starting points, households either had low starting points or high starting points for both the games offered to them (existing and improved systems).

Conducting the Survey

12.18 The survey was carried out in the 9 villages over a 10-day period (June 13-22, 1989). A total of 401 interviews were completed in the 9 study villages, as follows:

Jawa	:	44	:	
Banda	:	48	:	Type A : 140
Dhalla	:	48	:	(A1 : 134, A2 : 6)
Papin	:	42	:	
Payal	:	48	:	Type B1 : 140
Gorakhpur	:	50	:	
Dhuddian	:	30	:	
Mohra	:	43	:	Type B2 : 121
Bodhial	:	48	:	

12.19 The interviews were conducted during the peak summer season during which water needs are critical.

12.20 A major difference from the other two zones was the inclusion of female respondents where available; 11.4 percent of the respondents were women.

12.21 One visit was made to each of the 9 villages. Some basic socioeconomic characteristics of sample households and their attitudes towards water-related issues are presented in Tables G-2 and G-3.

13. Findings in the Arid Zone: Analysis of Willingness-to-Pay Bids

Service Options Evaluated

13.1 The following options were evaluated through bidding games:

- A scheme based on public taps (this option was offered to households in Type B2 villages);
- A household connection to a standard piped water system of the kind existing in Type A villages (this option was offered to all households in the sample); and
- A household connection to an improved piped water system (this option was offered to households in Types A and B1 villages).

13.2 The public tap option was offered since, under PHED guidelines, this is the service level that ought to be provided in the arid zone where the majority of villages are below the critical population size of 5000, which makes a village eligible for house connections. The bidding games would enable an assessment of the willingness to pay for public taps as well as yield an estimate of the premium that households place on domestic connections.

13.3 The perceptions of households with experience of piped water systems are presented in Tables G-4 and G-5. It can be seen that households are reasonably satisfied with the service primarily because the systems are relatively recent and, despite their shortcomings, are a major improvement over the past situation. Nevertheless, willingness-to-pay bids were elicited for an improved system. The improved system was stipulated to provide clean and safe water on a continuous basis with an acceptable level of reliability and pressure.

Response of Households in Villages without Plans for Installation of Public Water Systems

13.4 Households in villages which are not under consideration for the installation of public water systems were offered two supply options: A system based on public taps and an alternative based on house connections to a standard PHED system (the details of these systems were described earlier).

13.5 The distributions of WTP bids for the two service options are presented in Table I-1. A number of observations can be made based on the data presented in the table:

- The mean WTP bid for a system based on public taps was quite high (Rs 35 per month).
- However, a sizeable minority (13 percent) of the households were not willing to pay anything for a system based on public taps. The stated tariff for such a system is Rs 5 per month, but if a more reasonable rate of Rs 10 per month is considered for the arid zone, approximately 16 percent of the households would not be willing to join the system.
- The mean WTP bid for the standard PHED system with house connections was Rs 55 per month, a premium of Rs 20 over the public tap system. It should be

kept in mind that the former also involves additional fixed costs due to connection and installation.

- Only 2.5 percent of the households were not willing to pay anything for the standard PHED system. If the existing tariff in the arid zone (Rs 20 per month) is used as a cutoff, the data indicate that 9 percent of the households would not connect if such an option were offered.

Willingness to Pay for Connection to a Standard PHED System with House Connections

13.6 The distributions of WTP bids for a connection to a standard piped water system with house connections in the three types of villages are presented in Table I-2.

13.7 The following observations can be made based on the data presented in the table:

- There is very little difference between the mean bids obtained from Type A and B1 villages. The mean bids are Rs 39 and Rs 42, respectively. The mean bid in Type B2 villages, however, is significantly higher at Rs 55.
- There appears to be a significant difference between the connection rates in Types A and B1 villages, 95.7 percent and 78.6 percent, respectively. However, the connection ratio in Type A village is based on actual observation while that in B1 villages is derived from the WTP bids. Households biding below Rs 20 per month are assumed not to connect if the system were installed. The comparable rate in Type B2 villages is 90.9 percent.
- The above information suggests the following interpretations:

  (a) The piped water supplies in Type A villages are of very recent origin (less than 1 year in Jawa and Dhalla and less than 2 years in Banda at the time of the survey). Type B1 villages have piped water systems under construction. Thus the two types of villages are quite similar in one respect. Unlike the sweet and brackish water zones, Type A households have not had sufficient negative experience with the systems to lead to lower bids in comparison with villages without such experience.

  (b) If a strategic bias exists, both Type A and Type B1 households are likely to manifest the bias in the same direction, i.e. by underbidding.

  (c) In the light of the above two arguments, the closeness of the mean bids is understandable. However, the underbidding in Type B1 villages is manifested in a low connection ratio (bids less than Rs 20 per month being considered as not likely to connect to the standard system). Such a manifestation is not possible in Type A villages where the connection choice has already been made.

  (d) An upward strategic bias might be expected in Type B2 villages where there are no plans for the installation of piped systems but where the felt need for such systems is equally acute. Both the mean bid (Rs 55) and the connection rate (90.9 percent) are higher than in Type B1 villages.

Willingness to Pay for an Improved Piped Water System with House Connections

13.8 The distributions of WTP bids for a connection to an improved piped water system with house connections in Types A and B1 villages are presented in Table I-3.

13.9 The following observations can be made based on the data presented in the table:

- Once again the mean bids in Types A and B1 villages are fairly close, being Rs 51 and Rs 59, respectively. Also the connection rates are fairly similar, being 95.0 percent and 99.9 percent, respectively. Of the 6 households unconnected to the standard system in Type A villages, 2 indicated that they would connect to the improved system, bidding Rs 35 and Rs 45, respectively. Incidentally, they had indicated the unreliability of the standard system as their primary reason for not connecting. Of the other 4, 2 were single person households and 1 was occupying a rented premise. The fourth household indicated no need for piped water because of access to a private handpump inside the house.
- The mean bids are significantly higher compared to the standard system. The premium is 31 percent in Type A villages and 40 percent in Type B1 villages.

Multivariate Analysis of Willingness-to-Pay Bids for Piped Water Systems

13.10 *Results in Type B2 Villages: Comparison of Systems with Public Taps and House Connections.* The results of a multivariate analysis of WTP bids for a piped water system based on public taps in Type B2 villages are presented in Table H-1.

13.11 Larger households are willing to pay more (Rs 3 per month for each additional member) as are households with higher monthly expenditure per capita. Households dissatisfied with the quality of alternative sources of water bid much higher than households that were satisfied. Households that favored metering of water supplies also bid higher.

13.12 Most other variables had the expected sign but were not significant. The variables representing household labor supply are interesting. Households in which labor is scarce did bid more than households with more labor available to fetch water, but the difference was not statistically significant. This suggests that public taps have a limited attraction for households with few labor supplies, possibly because public taps do not obviate the need for fetching water from outside the house. One would expect the difference between the two types of households to be much more marked in the case of piped connections inside the house. Only 3 percent of the sample respondents indicated that they are dissatisfied with the quality of water available from other sources, and, as one would expect, these respondents bid significantly more for public taps.

13.13 The negative sign of the coefficient for external exposure reinforces the interpretation that a system based on public taps is considered an inferior good by those with experience of systems based on house connections.

13.14 The results of the multivariate analysis of WTP bids for a standard system based on house connections for the same households are presented in Table H-2. Once again household size and monthly per capita expenditure are a significant positive determinant of WTP bids. In addition, for this option, water consumption per capita is positively related to WTP bids although it is not statistically significant.

13.15 As expected, both labor supply variables are significant and negatively related to WTP bids. This negative relationship and the positive association with water consumption per capita clearly captures the differences between systems based on public taps and house connections.

13.16 Households dissatisfied with the quality of alternative sources of water are still willing to pay more for piped water but the coefficient is not significant. This indicates that other advantages are associated with house connections. This is in contrast to the attitude towards public taps where health considerations had more weight.

13.17 None of the variables reflecting personal characteristics or attitudes is significant, perhaps indicating the fact that piped water is not considered a discretionary or luxury good but a basic necessity in the arid zone.

13.18 In both options the village-level variables are significant. WTP bids decrease systematically with distance from the district headquarters and with proximity to a perennial water source (village dummy = 1 for the one village with access to the Soan River).

13.19 *Results in Type B1 Villages.* The results of a multivariate analysis of WTP bids for a standard piped water system in Type B1 villages are presented in Table H-3. These results presented a puzzle. The most obvious manifestation is the behavior of households that could be expected to value piped water. Thus households with more animals bid significantly less than households with fewer animals. Similarly, households satisfied with the quality of alternative sources of water bid higher (Rs 17 per month more) than households that consider the sources unsafe for health.

13.20 Further, households with more labor supply did not bid lower than households with less labor supply. The signs of the coefficients of the proportion of women and children are the opposite of what one would expect and are insignificant as well.

13.21 However, the bids are positively correlated with household size, value of house and the ownership of land or property (and significantly for the first two). The value of the coefficient for household size (Rs 1.5) is much smaller than in Type B2 villages (Rs 4).

13.22 One explanation for these results is that respondents bid strategically. The water supplies in Type B1 villages had already been sanctioned and it could be possible that the respondents considered the bidding games to be an attempt to set the monthly tariff. This would explain the systematic underbidding by households that could be expected to bid (and that do so, based on evidence from B2 villages in the arid zone and most other experiments in the other zones) higher for piped water.[18]

13.23 The general affluence of the households seems to have determined a base for the WTP bids with the more affluent starting from a higher level. However, beyond that, bids seem to have been quite systematically suppressed by the respondents.

13.24 If this interpretation is correct, it would suggest that the mean bid received for a standard piped system with house connections (Rs 41 per month) is an underestimate. However, even with this possible downward bias, the WTP bids are quite high. Perhaps the mean bid in Type B2 villages (Rs 56 per month) can be considered an upper bound yielding a range of Rs 40 to Rs 55 per month as the one within which the "true" average would lie.

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[18]Unlike the surveys in the sweet water and brackish water zones, the surveys in the arid zone were carried out after the 1988 general elections in Pakistan. During the election campaign, many promises were made that water schemes would be provided as a "gift" to the people. This could explain the apparent strategic responses of households in the arid zone.

13.25 The results of the multivariate analysis pertaining to an improved system with house connections are presented in Table H-4. No major modification needs to be made to the conclusions derived from the response to the standard system. However, as in the other environmental zones studied, for an hypothetical improved system, attitudinal variables become somewhat more significant. Thus, households aware of piped systems bid significantly higher while households that consider the provision of water to be a government obligation bid significantly lower (Rs 15 per month).

13.26 *Results in Type A Villages.* The results of multivariate analyses of WTP bids for standard and improved piped water systems with house connections in Type A villages are presented in Tables H-5 and H-6.

13.27 The explanatory power of the models is poor in comparison with the models for the other types of villages. However, there is no distortion of responses as witnessed in Type B1 villages, most of the coefficients having the correct sign without being significant. This is probably because the system is already in operation in Type A villages so that the respondents might not have interpreted the bidding games as an attempt to set the tariff.

13.28 The labor supply variables are both highly significant as expected, and in contrast to Type B1 villages. The only other variable which is significant is monthly household expenditure per capita. The village-level variable, distance from district headquarters, is insignificant, perhaps because two of the villages are at the same distance although along different directions. The village dummy for Jawa, a village with a new water supply having operational problems, is insignificant.

13.29 The WTP estimations were based on the responses of connected households (Type A1) only because of the very small number of unconnected households in the sample (6 out of 140). When the latter are added to the regression, the variable representing connection to the system emerges as highly significant. Not much change results in the coefficients or significance of the other variables but the overall significance of the regression improves considerably. As expected, the bids of the unconnected households are significantly less than those of the connected households.

14. Estimated Revenues and Cost Recovery Potential

Costs of Piped Water Systems

14.1 The estimation of capital costs of piped water systems in the arid zone based on a notional value of capital cost per capita did not prove very useful. This was so because the parameter is very sensitive to population size; thus, whether the population is 1000 or 2000 (the typical range in the arid zone) makes a tremendous difference to the capital cost per capita.

14.2 To overcome this limitation, the actual project costs for the six villages included in the sample (three each of Type A and Type B1) were obtained from the PHED. Actual O&M allocations for the three Type A villages were also obtained. Using these figures, averages were computed for a typical village in the arid zone. The average capital cost was Rs 1,440,000 for Type A villages and Rs 1,309,000 for the six villages. The average annual O&M costs were Rs 68,937 for Type A villages. Thus annual O&M costs as a percentage of capital costs work out to 4.8 percent in Type A villages and 5.3 percent in the six villages. This is in conformity with the 5 percent benchmark used by the PHED.

14.3 To obtain per capita costs and the tariff required for full recovery of O&M costs, the populations of the six villages were averaged to obtain an estimate for a typical village. The 1981 census yields an estimate of 1230. The 1989 population was obtained by assuming a 3 percent annual growth rate. A similar averaging procedure yielded a typical household size of 6.3 in 1981 (this is lower than the estimate (7.5) obtained from the sample data). The above two estimates together yield the number of houses in a typical village of the arid zone. For the three Type A villages this estimate is 222 while for the entire six villages the number is 208.

14.4 The connection rate in Type A villages determined from the survey information is 95.7 percent (only 6 out of 140 houses surveyed were not connected by choice). Thus, one could expect 212 or 200 houses to be connected in a typical arid zone village, depending on whether the averaging is based on Type A villages or Types A and B1 villages.

14.5 Using the above data, the average capital cost per capita in the arid zone works out to be Rs 838. The monthly O&M costs total Rs 5745. Thus, the monthly tariff required for full recovery of O&M costs varies between Rs 27 (Type A villages) to Rs 29 (Types A and B1 villages). All the above data and computations are presented in Table G-6.

14.6 The existing monthly tariff for a standard PHED system with house connections in the arid zone is Rs 20.

Provision of a Standard Piped Water System

14.7 The connection frequencies and revenue estimates pertaining to the provision of a standard piped water system at different monthly tariff rates are shown in Table I-4. The plots of connections frequencies and estimated revenues against monthly tariff are shown separately for Types A, B1, and B2 villages in Figures 14.1

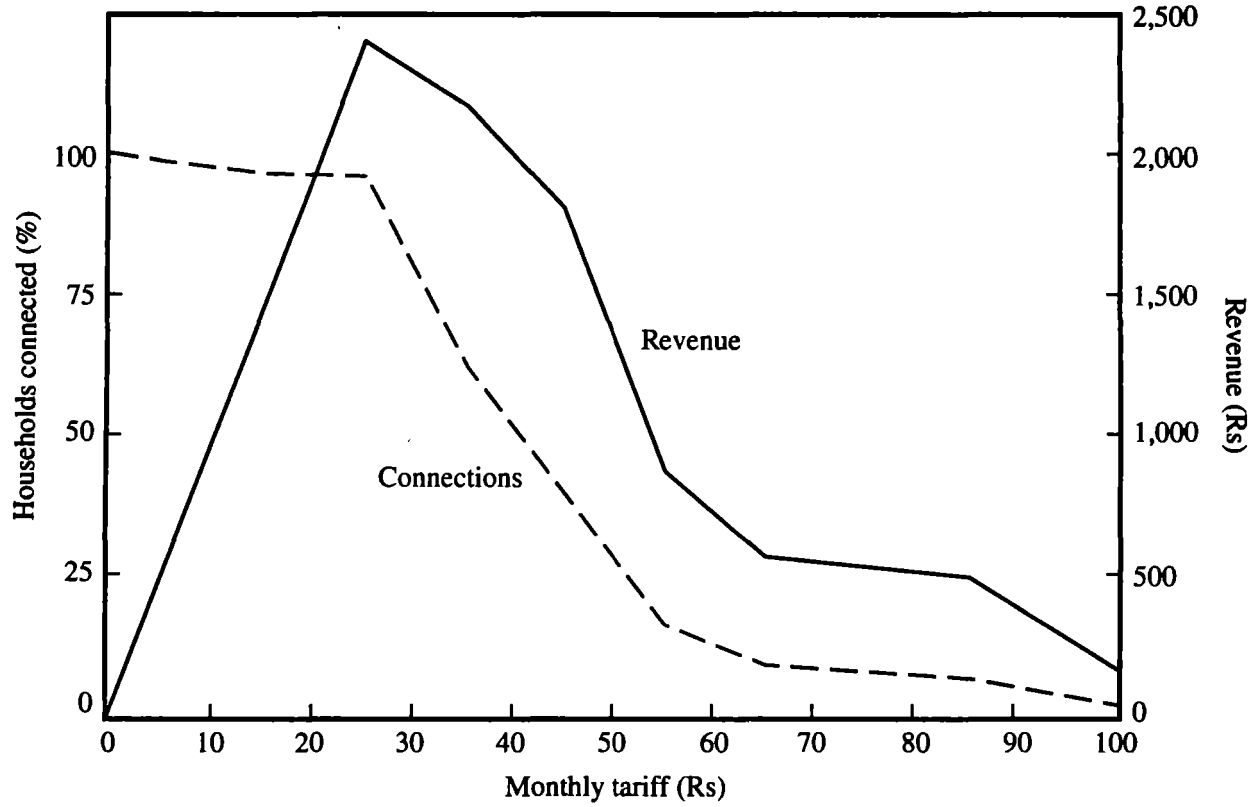

Figure 14.1 Connection frequencies and monthly revenue (per 100 households): Provision of a standard piped water system in a type A village

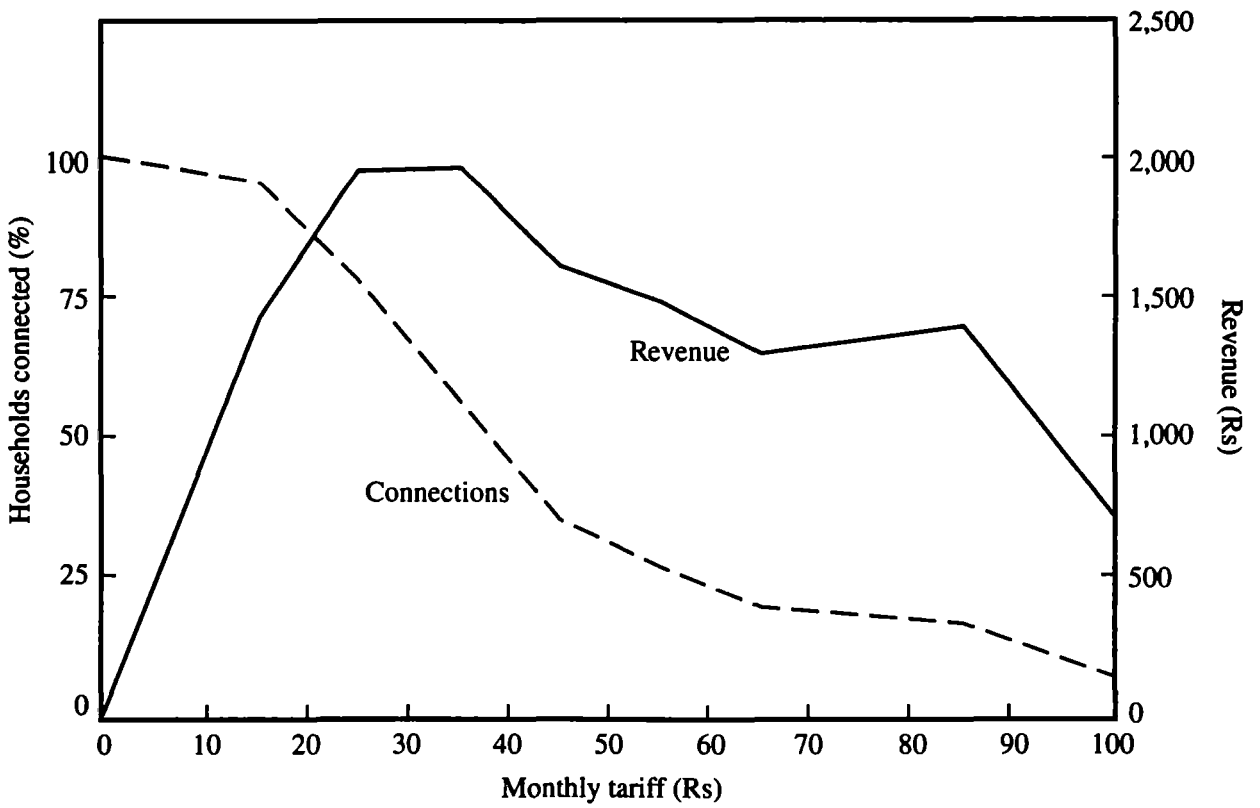

Figure 14.2 Connection frequencies and monthly revenue (per 100 households): Provision of a standard piped water system in a type B1 village

14.8 Beyond a certain threshold connection frequency is very sensitive to changes in the monthly tariff. This threshold occurs at Rs 25 per month in Type A villages, Rs 15 per month in Type B1 villages, and Rs 35 per month in Type B2 villages.

14.9 As remarked earlier in comparing Type A and Type B1 villages, the connection frequency in Type A villages is a better guide to actual behavior. Therefore, we can expect that a rise in tariff from Rs 20 to Rs 25 per month would not cause any lowering of connection frequency. If we further assume that there was strategic underbidding in Type A villages and overbidding in Type B2 villages we can expect that a tariff rate of between Rs 25 and Rs 30 per month would result in connection rates ranging from 95 percent to 85 percent.

14.10 At these connection rates and tariffs, the estimated monthly revenue would be approximately Rs 2500 per 100 households in the village. Using an average of 212 for the number of households in a typical village the total monthly revenue generated would be Rs 5,300, which is in the same neighborhood as the monthly O&M requirement estimated from cost data (Rs 5745).

14.11 It seems clear that tariffs can be raised to Rs 25 per month from the existing Rs 20 per month without any negative impact on connection rates. Tariff rates up to Rs 30 per month remain in the feasible range. Between Rs 25 to Rs 30 per month full recovery of O&M costs is possible. This would be even more certain with a very small increase in the number of households over the next few years (in calculating a relevant population base, the PHED projects population for 10 years ahead of the approval systems using projected populations ten years from the date of approval of a scheme as their relevant population base).

Provision of an Improved Piped Water System

14.12 The connection frequencies and revenue estimates pertaining to the provision of an improved piped water system at different monthly tariff rates are shown in Table I-5. The plots of connection frequencies and estimated revenues against monthly tariffs are shown separately for Type A and B1 villages in Figures 14.4 and 14.5, respectively.

14.13 The tariff threshold is Rs 35 per month. Beyond Rs 35 connection frequencies fall steeply from around 85 percent to around 65 percent. At Rs 35 per month the monthly revenues generated in a typical village of 212 households would be approximately Rs 6400.

14.14 We are not in a position to state the extent to which the O&M expenses would increase for the kind of improved system described earlier, but it seems likely that improved systems are premature in the typical arid zone village. However, households in larger villages with sufficient length of experience with standard piped water systems might be willing to pay tariff rates that could make the policy of providing selective improvements worth investigating.

Provision of a Piped Water System Based on Public Taps

14.15 Households in Type B2 villages were asked to bid on two different levels of service provision: public taps and a standard system with house connections. The comparative connection frequencies and revenue estimates are presented in Table I-6. The comparative plots of connection frequencies and revenue estimates against monthly tariff are shown in Figures 14.6 and 14.7.

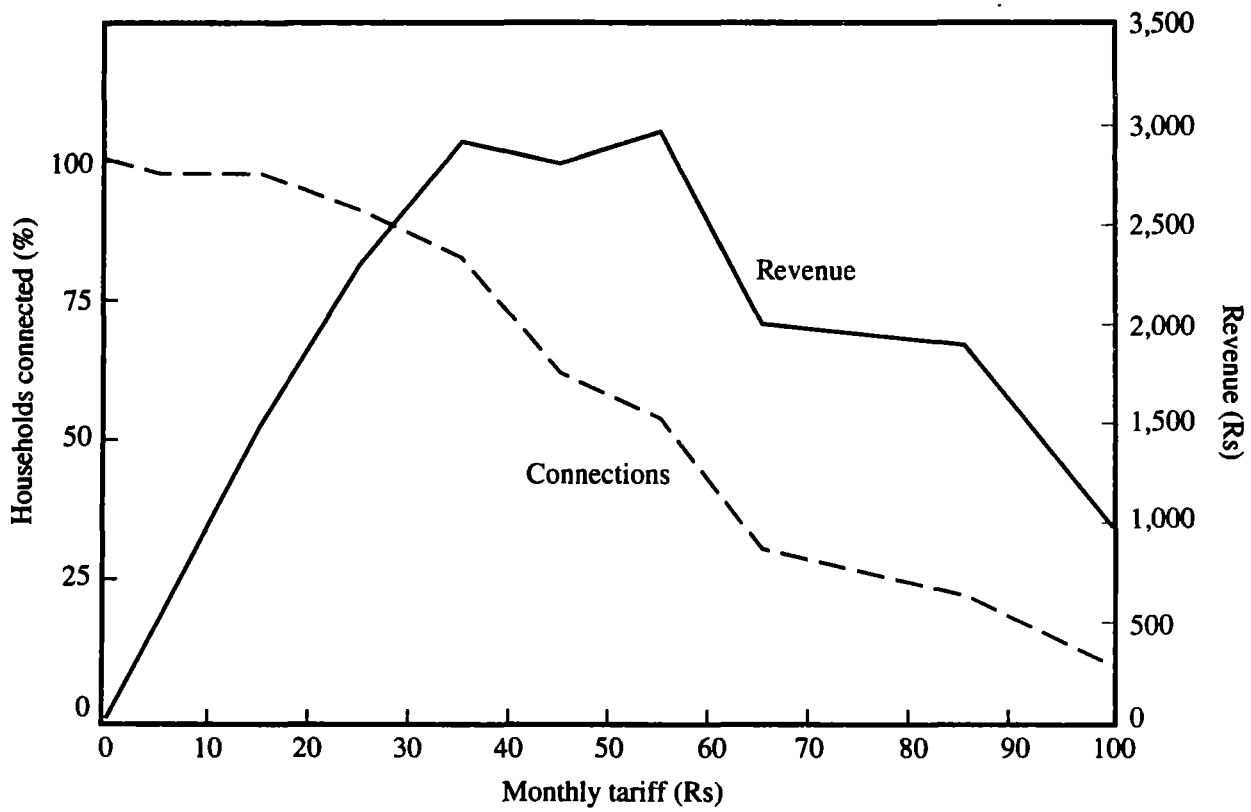

Figure 14.3 Connection frequencies and monthly revenue (per 100 households): Provision of a standard piped water system in a type B2 village

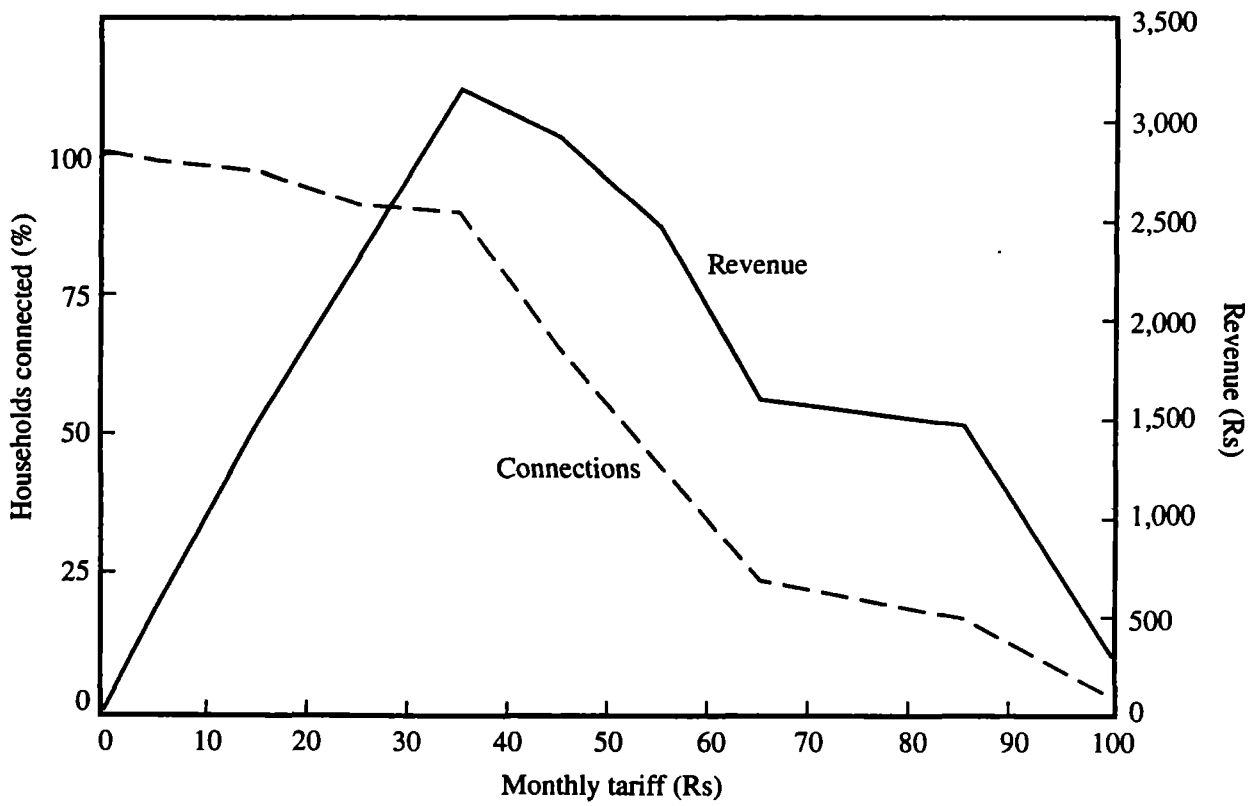

Figure 14.4 Connection frequencies and monthly revenue (per 100 households): Provision of an improved piped water system in a type A village

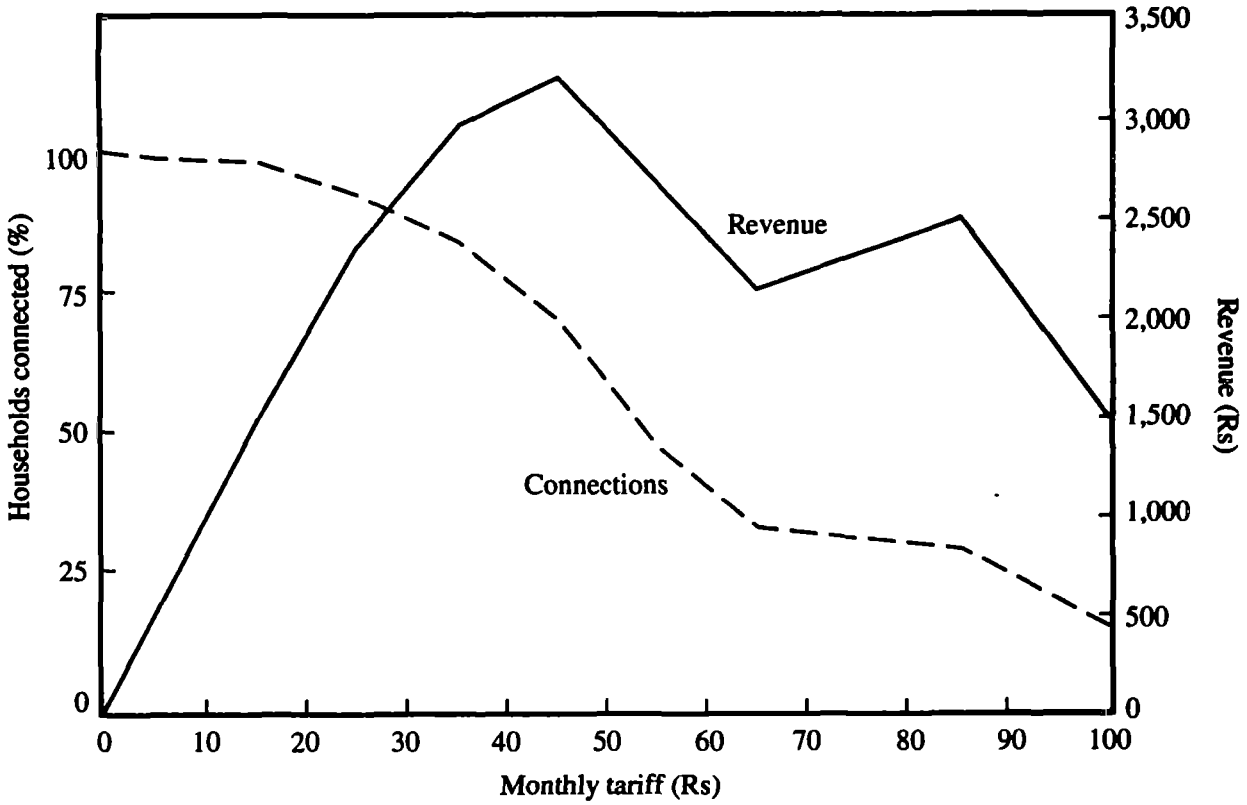

Figure 14.5 Connection frequencies and monthly revenue (per 100 households): Provision of an improved piped water system in a type B1 village

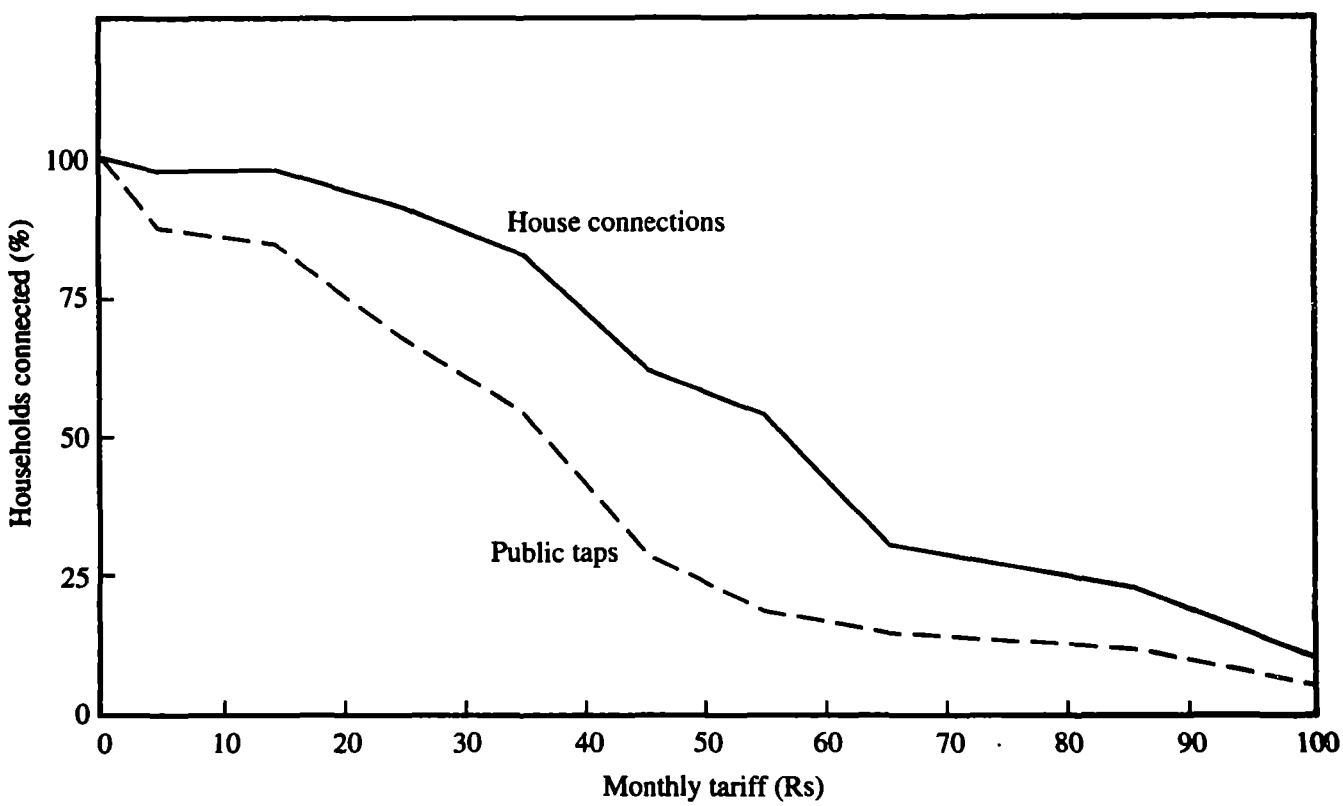

Figure 14.6 Connection frequencies in a type B2 village

14.16 If the target is to achieve at least a 85 percent connection rate, the monthly tariff for using public taps cannot exceed Rs 15 while the same percentage of households are willing to pay Rs 35 a month for house connections. The preference for a system based on house connections seems to be quite clear; over 13 percent households are not willing to pay anything for a system based on public taps while the comparable figure for house connections is 2.5 percent.

14.17 Although the revenues generated from a system with house connections in a Type B2 village would be sufficient to recover full O&M costs, this might not be the case for a system based on public taps since it is reasonable to assume that the O&M costs for the two systems would not be significantly different[19]. In addition, the difficulties in collecting payments from public tap systems are well known.

14.18 We have some evidence available for the difference in capital costs for the two options. PHED data revealed that a village in the same vicinity as the study villages was originally

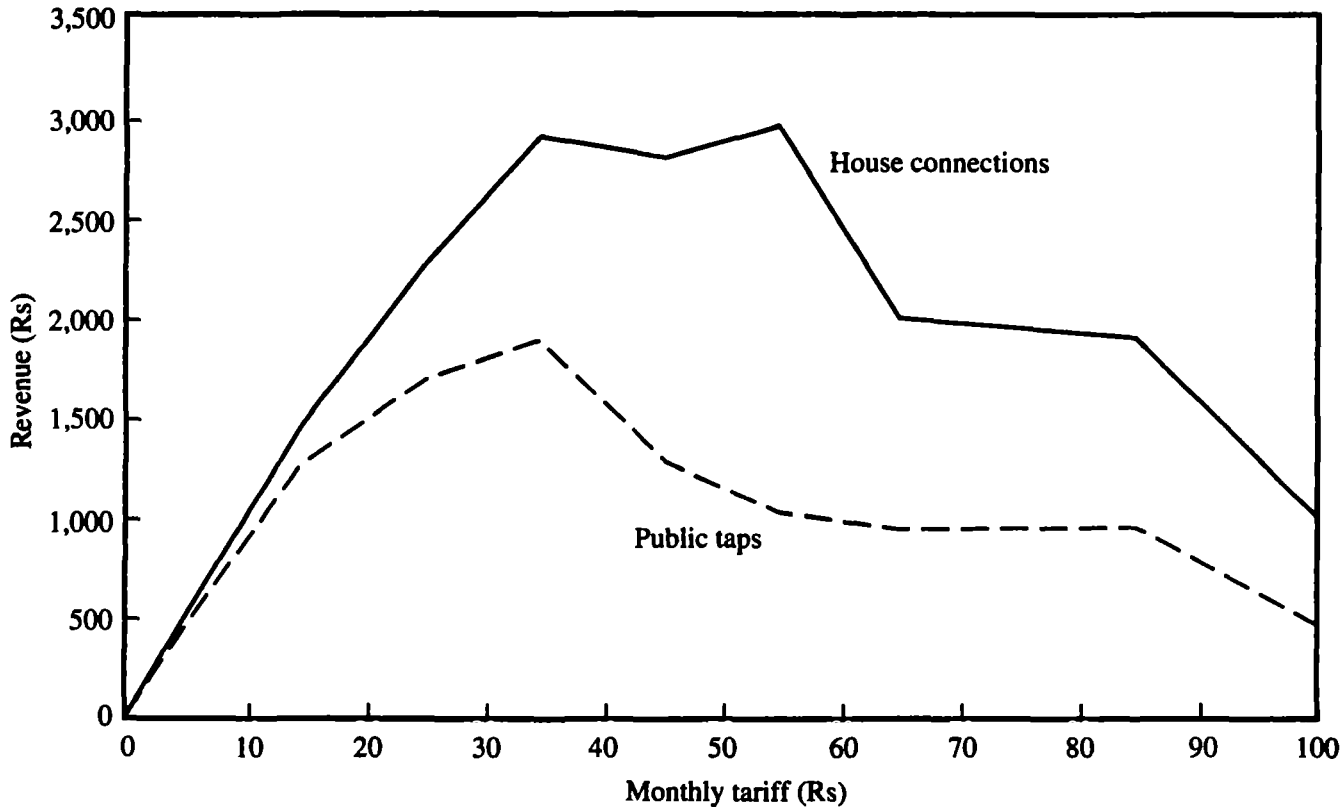

Figure 14.7 Monthly revenues (per 100 households) in a type B2 village

[19]Savings are likely only on distribution system repair. These are estimated at 1/12 percent per annum of the capital cost of the distribution system. A typical estimate of the latter is Rs 600,000. This would yield a saving of Rs 500 per year, which is less than 1 percent of the typical annual O&M cost.

scheduled to receive a system based on public taps.[20] The detailed cost estimate prepared in 1986 was for a sum of Rs 1,600,000. However, on the representation of village notables, supported by elected representatives from the area, it was decided to provide house connections instead.[21] The revised estimate was for the sum of Rs 2,280,200. The revision reflected a capital cost escalation of 42.5 percent. In per capita terms the capital cost rose from Rs 576 to Rs 821. (The per capita costs are based on an estimated 1987 population size of 2776).

[20]The scheme provided for four 2000 gallon capacity RCC ground storage tanks each with a battery of taps.

[21]Scheme based on one overhead 4000 gallon capacity tank.

15. Conclusions and Policy Suggestions

The Nature of Demand for Water in Rural Areas

15.1 The most important finding of this study pertains to the nature of the demand for water in rural Punjab. The actual water supply situation in many of the sample villages was considerably more complex than commonly assumed. It seems clear that the perspective within which policy-makers viewed rural water supply is in the process of being rendered out of date by the pace of development.

15.2 Within Pakistan, the policy regarding rural water supply has been motivated by the objectives of health improvements via the provision of better quality water and time savings via the location of more accessible sources. Implicit in this perspective is a categorization of water as an end product, a commodity required for such direct uses as drinking, cooking, bathing, etc. Within the study area, this perspective was found to be valid only in the arid zone.

15.3 In the central canal-irrigated part of Punjab, there was a growing demand, not for water as an end product, but for water-based amenities like indoor plumbing, showers, and flush toilets. However, this demand cannot be serviced by handpumps or even public standpipes. It requires a higher level of service. What rural households are doing to fulfill their aspirations has both important economic consequences and far-reaching policy implications.

15.4 *The Sweet Water Area as an Illustrative Case.* The sweet groundwater area of Central Punjab provides the best illustration of the above-mentioned issues. The quality of the groundwater is good and it is available at easily accessible depths. Households have already upgraded their service from the traditional source of supply, public wells, to private handpumps inside the house. These handpumps provide convenient access to good quality water fit for all usages. The service is reliable, being efficiently installed and maintained by the local private sector, and inexpensive to maintain. Every household in the sample had a private handpump inside the house. Households have made this expenditure (Rs 1000 capital costs, in current value, for the pump and the shallow well; Rs 6 per month for maintenance) to avoid the inconvenience of having to fetch water from outside the house.

15.5 The official policy in the sweet water zone is not to provide public piped water supplies. This policy is based on the reasoning that private initiative has succeeded in providing convenient access to good quality water. However, the survey results indicate that a second upgrading of service is well under way. Many households are willing and able to pay for a higher level of service and in the absence of reliable piped water supplies they have installed electric motors on their wells at considerable expense. The electric pumps lift water to private overhead tanks from which water can be used for showers, flush toilets and other indoor plumbing services. Thus, the services which could be provided by public piped water supply systems are being replicated at the individual household level. Does the official policy retain its validity in these changed circumstances?

Private Upgrading of Service in Central Punjab

15.6 In villages without piped water in the sweet water zone, 30 percent of the sample households had installed an electric motor. In the brackish water zone the comparable figure was 62 percent. The percentage is higher, perhaps, because, in addition to the other benefits, electric pumps

also provide somewhat better quality water than handpumps in the brackish zone by lifting water from greater depths. This is a very high percentage and clearly indicates the trend in the Central Punjab villages.

15.7 In villages with piped water, the percentage of households with electric motors falls to 11 percent in the sweet water zone and to 33 percent in the brackish water zone. This suggests that piped supply systems with house connections are clearly perceived as substitutes for electric motors. However, in such villages, 7 percent of the households in the sweet water zone and 29 percent in the brackish water zone continue to maintain both options. This brings to the fore the critical issue of the reliability of the various service options.

15.8 A household's decision on how to satisfy its water needs is heavily influenced by the reliability of the different service options. A private handpump is almost completely reliable because it can be repaired locally and is entirely under the control of the household. In the sweet water zone the water from the handpump is adequate for all usages, but the handpump cannot provide the amenities of indoor plumbing, showers and flush toilets. If the household wants and can afford such amenities, it has three choices in villages with public piped supplies: (1) to connect to the public system, (2) to install an electric motor, or (3) both.

15.9 In the brackish water zone, the first choice ought to be the dominant one. The piped supply not only provides better quality water but its private costs to the household are much less. The fact that 29 percent of households maintain both options is only due to the limited hours of supply from the public system and its poor reliability. This poor reliability imposes a high cost on households and, at the same time, undermines the economic viability of public piped water systems.

15.10 *Financial Cost to an Average Household of Different Service Options.* The approximate costs to an average household in the brackish water zone of various water supply options are shown in Table J-4.[22] The handpump provides a base of service at a total monthly cost of about Rs 18 per month. A household with both a handpump and a connection to a piped water supply would pay Rs 12 per month to the PHED for the water tariff and Rs 5 per month for operation and maintenance of its handpump. The monthly capital costs for both the handpump and the connection to the distribution supply would be Rs 19 per month for a total monthly cost of Rs 36. A household with an electric motor on its handpump would spend much more -- about Rs 58 per month. Households with both an electric motor and a domestic connection are estimated to pay Rs 76 per month.

15.11 A reliable piped water service ought to cost a household approximately Rs 18 per month at existing tariff rates. Instead, households wanting upgraded services are paying about Rs 76 per month for the same level of service. The piped water system is not fulfilling its potential. It is functioning as a supplement to the handpump in the sweet water zone and as a substitute (better quality water) for the handpump in the brackish water zone. Reliable upgraded services can only be secured at present through investment in a private motor-operated system.

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[22]For private connections the costs in the sweetwater zone are essentially the same as in the brackish water zone, except that the monthly tariff is Rs.10 instead of Rs.12. For the water supply options which require a private well, the costs are basically the same in the two zones for a well of a given depth.

15.12 *Who Demands Higher and More Reliable Service?* The survey results indicate (see Table J-5) that, as expected, it is the wealthier, more educated households that are demanding higher service. The average construction value of houses of households with only a private handpump in the brackish water zone (in villages with piped water supplies) was Rs 62,000. For households with both a private handpump and an electric motor it was Rs 115,000. For households with a handpump, electric motor and a domestic connection, it was Rs 145,000. In villages with a piped water system in the sweet water zone, in households with only a private handpump, the most educated member of the household had an average of 6 years of education. For households with a handpump and an electric motor, the average was 12 years of education.

15.13 Village elites have always exerted a powerful demonstration effect on the rest of the population. At one time the elite used to be recognized by the possession of a brick house or an electricity connection. Now the distinguishing characteristic is indoor plumbing and flush toilets. If historical experience is any guide, the choice of the elite is a clear pointer to the trend of the future.

15.14 *Willingness to Pay as a Percentage of Household Income.* The survey results indicate that the amount of money households are willing to pay for improved water supplies as a percent of household income (or expenditures) is lower than often assumed. In the sweet water zone the mean WTP bid was only 1.1 percent of average household income (see Table J-6). The percent of income respondents were willing to pay for improved water was higher in both the brackish zone (2.4 percent) and arid zone (3.5 percent), but both estimates are still well below the 5 percent rule of thumb often used to estimate how much households will pay for improved water supplies.

The Economics of Village Water Supply Options

15.15 The efforts by households to provide themselves individually with improved water services entail substantial expenditures in the aggregate. Table J-6 presents an estimate of the actual amount of money currently being spent on private water provision in a typical village with a population of 5000 people without a piped water supply in the brackish water zone. Assuming 62 percent of the households have a handpump with an electric motor and 38 percent have only a handpump, households in such a village have already invested over Rs 1 million (in current value) for private handpumps and electric motors. The operation and maintenance costs of these privately provided water systems is estimated to be Rs 9800 per month. The total monthly costs of these systems are about Rs 23,900.

15.16 Based on cost data from the PHED in Punjab, a new piped water system for a village with a population of 5000 would cost about Rs 1,800,000- including the cost of 100 percent of the households connecting to the distribution system. The monthly operation and maintenance costs of a piped water system are estimated to be about Rs 3800 for a total monthly cost of Rs 19,800. Given the approximate nature of these estimates, the total costs of a piped distribution system are essentially the same as the amount households are *already* spending for handpumps and electric motors.

15.17 The estimates of the costs of the piped system assume that 100 percent of the households in the village are connected, the estimates of actual expenditures assume that 38 percent of the households only have a handpump. In this sense the cost estimates are not comparable because the piped water system provides a higher level of service for a greater number of people.

15.18 *Willingness to Pay for Piped Water Supply.* It is in the above context that the willingness to pay for piped water ought to be evaluated. Once again we take a village of 5000 people (562 households) in the brackish zone as an example. In such a village without piped water, the mean willingness-to-pay bid for monthly tariff for a standard piped water system with house connections was

Rs 40 (this was in addition to the one-time costs of approximately Rs 600 required for connecting to the system). The summation of the households' willingness-to-pay bids yields a monthly total of Rs 22,500. This figure is essentially the same as the amount households are already spending on water (Rs 23,900). This correspondence increases the confidence in the credibility of the willingness-to-pay bids.

15.19 In practice, it is not possible to recover the entire willingness-to-pay amount because of the unfeasibility of enforcing differential tariffs in the same village. The survey results indicate that in a village of the type being discussed, 78 percent of the households would connect to a standard piped water system with house connections if the monthly tariff were set at Rs 25. In addition, they would bear the costs of connecting to the distribution line (Rs 500, approximately) and pay a connection fee to the PHED (Rs 80). The estimated revenue based on these numbers is Rs 11,300 per month (see Table J-7). If a piped water system is designed for 78 percent of the population, the total monthly cost to the PHED would amount to Rs 13,400 (Rs 10,500 capital, Rs 2900 O&M). These estimates suggest that a very substantial proportion (85 percent) of the total costs of a public piped water system can be recovered under the conditions described above.

15.20 The comparable computations for the sweet water zone are shown in Table J-8. Only 44 percent of the total costs of a piped water system are potentially recoverable compared to 85 percent in the brackish water zone. This is the result of much lower WTP bids in the sweet water zone, not of differences in the cost of the systems in the two zones. The WTP bids are lower in the sweet water zone because unreliable public water systems are much less attractive when good quality water is easily available from private handpumps. However, households are willing to pay a substantial premium for improved reliability, which suggests that a higher percentage of the costs can be recovered in the sweet water zone if reliability is improved.

15.21 *Willingness to Pay in Villages with Piped Water.* The willingness to pay for piped water in villages with existing supply systems is much lower compared to villages without piped water systems. This is, perhaps, because the latter are not aware of how the service would operate while the former have sufficient cause to be dissatisfied.[23] The mean WTP bid in a village with piped water in the brackish zone was only Rs 16 per month compared to Rs 40 per month in the village without piped water. However, when the option of an improved, more reliable service was offered to the households in the village with piped water, the mean bid increased to Rs 33 per month while the percentage of households willing to connect went up to 95 percent from 75 percent. This again underscores the premium which households place on system reliability.

The Arid Zone

15.22 The situation in the arid zone of Northern Punjab is quite different from the sweet water and brackish water zones of Central Punjab. In the arid zone at the present time the demand is for water itself and not for water-based amenities. This is because of the scarcity of water and the low base of service available to villages (public wells and surface water). Households spend an average of 5 hours per day to fulfill their water needs during the peak summer months compared to 4 hours per week in the brackish zone and even less in the sweet water zone.

[23]A contributory reason could be the anchoring effect of the existing tariff (Rs.12 pr month) which is known to the respondents in the village with piped water.

15.23 The demand for private sources is, however, quite strong; 24 percent of the households have installed private sources (e.g., wells or boreholes) while another 5 percent have made an unsuccessful attempt. This is despite the fact that the costs of installing private sources in the arid zone are much higher (approximately Rs 8000 with a monthly maintenance cost of Rs 40). However, these private sources, wells or boreholes, cannot, in general, provide access to higher service levels. The installation of private sources is not systematically related to socioeconomic characteristics of households since the very possibility is based on the fortuitous circumstance of an appropriate location of the house such that the groundwater is accessible.[24]

15.24 For the above reasons, connection rates to piped systems are almost 100 percent, much higher than in the sweet water and brackish water zones. This is so despite the fact that the arid zone is economically less developed than the other two zones, the average village size is much smaller and the monthly tariff is much higher (comparative information for the three zones is provided in Tables J-9 and J-10).

15.25 The official policy of the PHED, of not providing house connections to villages with less than 5000 inhabitants, is not being followed in the arid zone. This has resulted in much higher capital costs per capita (approximately Rs 840) because of the small village sizes. The survey results indicate that while O&M costs can be fully recovered, it is not possible to recover the capital costs to any significant extent.

Discussion

15.26 *Collective Water Supplies.* As long as the highest service demanded was the private handpump, the policy of leaving the sweet water area to be served by the private sector was justifiable. However, with a significant proportion of the population replicating a piped water system at the individual level, the policy is in need of fresh evaluation. As mentioned earlier, while the capital costs of a piped water system and private upgrading through the installation of electric pumps are comparable, the O&M costs of the latter are almost two and a half times the costs of the former. Private upgrading is not likely to be the socially optimal option.

15.27 The alternative to individual upgrading is not necessarily state run piped water supplies but other collective arrangements. Privately built and managed water systems should not only increase community participation but should also prove to be less expensive to build, thus enhancing the prospects of full cost recovery. In this context the observations of Briscoe (1987) need to reiterated:

> In government-built water supply projects the role of the private sector is much more problematic. In the Punjab and Sind the private sector has a major role -- drilling and civil and mechanical works are all contracted out to the private sector. In principle this should make for an efficient sector. In practice, however, the situation appears to be quite different. It is widely acknowledged -- by government officials and others knowledgeable about the sector -- that there is extensive collusion between the contractors and the government agencies, a relationship based on kickbacks to the government officials, and resulting in construction costs which are much higher than need be the case. In such a system there is an incentive for both officials and contractors to build over-designed, expensive systems. As an illustration of the

[24]There is very little residential mobility in these villages. Better-off households probably do not locate their houses in areas with easier access to ground water.

inefficiencies in this system, the Orangi Pilot Sewerage Project in Karachi, in which the community, not the government, finances the works, the costs of sewering houses has been reduced by over 80 percent.[25] Project officials attribute the cost reductions to two factors -- attention to reducing costs wherever possible, and elimination of the contractor-official corruption.

15.28 Moreover, it has been fairly well established that the transition to higher service levels (piped connections and electric pumps) leads to an increase in the use of water. This was confirmed in the sample villages where drainage has emerged as a serious problem. Although it is possible to upgrade the water supply at an individual level (even if socially inefficient), it is not possible to resolve the resulting drainage problem on an individual basis. Thus, a collective solution becomes unavoidable.

15.29 *Reliability.* Because of the poor quality of the groundwater, public piped water supplies are being built in the brackish water zone. In principle, because the amount being spent on private upgrading of services is so substantial, the discussion regarding private, collective water systems should be equally applicable to the brackish zone. However, as mentioned earlier, piped supplies, irrespective of whether they are public or private, have to be much more reliable to be able to compete effectively with the individual upgrading of service.

15.30 The survey suggests that the reliability of piped systems is a crucial element in achieving cost recovery. It is quite clear that people are willing to pay significantly more for a reliable system. This is demonstrated by household investment in multiple water systems: handpumps, piped connections and electric motors. It was mentioned earlier that in villages with piped water in the brackish water zone, almost 30 percent of the households maintained both electric motors and piped connections, spending Rs 76 per month as against the Rs 18 for the piped connection alone. It is quite clear that for public utilities to compete effectively against private providers of handpumps and electric motors, their reliability must be improved.

15.31 In a hot and dry agricultural area such as Punjab it does not seem possible for reliability to be effectively increased without the metering of household connections. This is because the demand for water at zero marginal cost (i.e., unmetered connections) is immense. One finding of the survey illustrates this point well. In villages with piped water supplies households with animals were willing to pay more for connections. Investigations indicated that the reason was the convenience in washing animals. Buffaloes, which need to be kept cool in the summer, could be hosed down at home, rather than be taken to the canal or the village pond, thus saving on time and supervision costs. Water for drinking by animals could also be provided through the domestic connection.

15.32 This finding highlights an oversight which has significant implications for the design of rural water supply systems in Pakistan. The PHED design criteria at present take into account human needs only and use a consumption benchmark of 10 to 15 gallons per capita per day. However, if households use the water to cater to animal needs also, including water-intensive ones like washing, the design estimate could be easily exceeded. It was estimated in the survey that while the minimum quantity of water required for essential human consumption varied between 20 to 30 liters per capita per day, the minimum quantity required for animal needs varied between 40 and 60 liters per animal per day (estimate based on the amount of water which, in situations of emergency, would have to be fetched from outside the house in the sweet and brackish zone and purchased from vendors in the arid

[25]This figure may be too high. The original costs of sewering a house were about Rs 2,500. The Orangi Project's cost was about Rs 800.

zone). This means that a household with 8 members and 2 cattle (the average in the arid zone) would need approximately 200 liters for human consumption and 100 liters for animal needs. This 50 percent increase, which should hold for normal, nonemergency consumption patterns also, is much more than the 5 percent to 10 percent margin added on by the PHED to total estimated human consumption for all other usages (public buildings, schools, mosques, animals, etc.). Perhaps, this is one explanation for the ubiquitous problem of low pressure which characterizes rural water supply systems in Pakistan.

15.33 In such an environment, if connections are not metered, then water must inevitably be rationed by reducing the reliability of the system. If reliability is reduced, people must secure other sources, and their domestic connection becomes a back-up supply. Table A-12 provides evidence from the sweet water zone. The majority of households stated that they would keep their handpumps operational either permanently or at least until such time as the piped water system could supply water with regularity. In a village in which the piped supply system had fallen into disuse, 12.5 percent of the households had dismantled their handpumps at the time of obtaining the connection. They were forced to reinstall them because of the poor performance of the system. It is not surprising, therefore, that 94 percent of the households in this village indicated a resolve to keep their handpumps operational permanently even if the piped supply was restored.

15.34 In such situations the willingness to pay for piped water is much reduced. The PHED then cannot collect the resources it needs to run the system efficiently. A vicious circle of system deterioration and lowered willingness to pay ensues.

15.35 The concept of metering household water connections is quite acceptable in the rural areas of Punjab. The percentage of households that favored metering varied from 54 percent in the sweet water zone to 81 percent in the brackish water zone. The statistical results also revealed that such households were consistently willing to pay more in tariff for piped water systems.

15.36 The economic viability of public piped water systems requires enhanced tariffs. Households are willing to pay significantly higher rates (see Table J-11) but only if they are accompanied by the improved performance of existing systems. A package of tariff increases tied to selective improvements would be quite acceptable to the households surveyed. This seems the only feasible way to move towards economic viability and to break the vicious circle mentioned earlier.

15.37 *Public Standpipe Systems.* Households prefer piped systems with domestic connections and are willing to pay much higher rates than thought possible earlier (see Tables J-11, J-12, and J-13). Even so, if such service is to be extended to small villages of 1000 to 1500 people, as is being done in the arid zone, it would have to be subsidized to a considerable extent.

15.38 It seems unlikely that the higher per capita capital expenditure can be recovered. In such situations it would be worthwhile to experiment with less expensive standpipe systems.

15.39 Standpipe systems should be adequate in the small villages of the arid zone since the overwhelming demand is for convenient access to water and not for water-based amenities. Contrary to the prevailing view about the acceptability of standpipe systems, households in villages without piped water were willing to pay reasonably high rates for such systems. The mean bid was Rs 35 per month and 68 percent of households would subscribe to the service at a tariff as high as Rs 25 per month (this tariff exceeds the present monthly tariff for piped systems with domestic connections (Rs 20) in the arid zone).

15.40 The main drawback of standpipe systems as they have been organized thus far relates to the problems of revenue collection owing to difficulties in monitoring actual usage. Some experimentation on a pilot basis with alternative structures is certainly warranted. For instance, a system based on manned kiosks should overcome the problem and require no more manpower than the present structure. Since piped systems operate for four hours a day at most, the existing full-time staff is under-utilized. The option of giving the kiosks on private contract could also be explored. Even if households purchase only 100 liters of water per day (about the average essential daily consumption for family needs in the winter) at Rs 0.10 per can of 16 liters (one tenth the existing price of vended water), the revenues realized per household would be of the order of Rs 20 per month. These would be sufficient to recover O&M costs and some part of the capital costs as well.

15.41 *Organizational Issues.* Any serious attempt to encourage communities privately to construct and manage water supply systems would involve difficult organizational issues. Experience has proved that collective responses to such needs do not arise by themselves but need patient groundwork, the availability of external technical expertise and accessible credit facilities.

15.42 The experience of the successful Orangi Pilot Sewerage Project in Karachi bears out the above point, even though the project required only an intermediate level of collective effort between the completely individual and the completely collective. In a sewerage project, the lane could function as the organizational unit, and a successful demonstration could induce other lanes to participate. This is not possible in a water supply project where a much larger proportion of the population has to reach an understanding before the project can be initiated.

15.43 The organizational problem is made more difficult by the fact that, contrary to the popular presumption in development circles, the villages were not willing to assume responsibility for the provision of water. Over 65 percent of households in all three environmental zones believed that a water supply system would be best managed by a government agency in preference to local political bodies, village water committees, or private entrepreneurs. This is perhaps a reflection of the sharp clan and political divisions that characterize villages (especially those with sizeable populations) in Punjab. These divisions affected the perceived effectiveness or fairness of elected political bodies or village committees to manage collective systems. It was considered a lesser evil to leave the system to a neutral agency, external to local village politics, even though it was inefficient. Perhaps a publicly provided but privately managed water utility would be just as acceptable and more efficient, although this alternative has not been experimented with in Pakistan. The concept was not familiar to respondents who remain wary of the lack of accountability of the private sector and the general failure of government attempts at its regulation in many other spheres of activity.

15.44 At the same time, it is clear that the solution does not lie in raising more revenues and giving them to the PHED as it is structured at present. The PHED is primarily an engineering agency and is not equipped to involve the community in decision-making or even to carry out the tasks of revenue accounting and collection in a satisfactory manner. In this, it is handicapped by the fact that in principle the PHED is supposed to hand over the management of the systems to local councils after an initial period of two years. However, the latter have neither access to the technical expertise required for maintenance and operations nor the political unity to impose effective revenue collection in the factional villages. As a result, the systems are inevitably handed back to the PHED after a period of mismanagement. The consequence of the lack of a clear policy in this regard has been that neither body has been equipped to the degree necessary to manage rural water supply systems in an effective manner. A resolution of this situation should be the first step in the reform of the rural water supply sector.

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Appendixes

Appendix A

Table A.1
Village Profiles

	Ghazi Minara	Bhaddroo Minara	Kharian Wala	Mirza Virkan	Jandiala Sher Khan
Area* (acres)	2087	1484	4852	3560	4868
Population*	4514	2173	8990	5630	7581
Household size*	6.7	6.2	6.7	6.9	6.6
(from sample, 1988)	(9)	(9)	(10)	(10)	(9)
Literacy ratio*	28.6	17.6	22.7	14.0	24.0
Males—school age or older (%)	8.9	5.4	6.0	4.7	9.5
Females—school age or older (%)	1.7	1.9	0.8	0.4	2.6
Distance from district Headquarters (km)	2	2	18	10	14
Road location	On main road	Off secondary road	On main road	Off secondary road	On secondary road
Presence of facilities					
Electricity	Yes	Yes	Yes	Yes	Yes
Telephone	Yes	No	Yes	No	Yes
Medical	No	No	Hospital	Clinic	Hospital
Male education	Middle school	Middle school	High school	High school	College
Female education	Middle school	Middle school	Middle school	Middle school	College
Bank	No	No	Yes	No	Yes
Union council members from village	5	2	4	5	9
District council members from village	0	0	1	2	1

* Figures from 1981 population census. All others from field visit.

Table A.2
Village Profiles

	Ghazi Minara	Bhaddroo Minara	Kharian Wala	Mirza Virkan	Jandiala Sher Khan
Household size	9	9	10	10	9
Adult women in household (%)	28	24	24	25	24
Children in household (%)	34	35	41	38	38
Years of education of most educated					
Member of household	9	7	9	7	8
Woman in household	4	4	2	2	4
Essential water consumption (liters/capita/day)	24	27	23	17	20
Households involved in farming (%)	21	29	19	42	26
Households with land or other property (%)	54	61	73	76	55
Construction value of house (000 Rs)	80	65	98	51	104
Households with external exposure (%)	43	23	31	29	37
Households that believe water should be supplied free (%)	64	48	22	44	50
Households that believe water can be supplied free (%)	64	35	29	34	39
Households that believe water supply systems should be managed by PHED (%)	54	71	71	78	72
Households that favor metering of water (%)	75	68	55	60	42

Note: All statistics are derived from the sample observations.

Table A.3
Profiles by Village and Household Type

	Village Type			Household Type				
	A	B1	B2	A1	A2	B11	B12	B2
Household size	9	10	9	11	8	10	10	9
Adult women in household (%)	24	24	26	24	24	25	22	26
Children in household (%)	38	41	34	42	34	40	44	34
Years of education of most educated								
Member of household	8	9	8	9	6	9	8	8
Woman in household	4	4	3	5	3	5	4	3
Essential water consumption (liters/capita/day)	19	23	26	20	17	22	25	26
Households involved in farming (%)	31	19	25	29	34	20	17	25
Households with land or other property (%)	61	72	58	68	52	75	67	58
Construction value of house (000 Rs)	87	97	73	110	57	113	60	73
Households with external exposure (%)	35	31	31	37	32	37	17	31
Households that believe water should be supplied free (%)	48	22	56	44	52	23	22	56
Households that believe water can be supplied free (%)	38	29	49	33	43	30	28	49
Households that believe water supply systems should be managed by PHED (%)	74	71	63	73	74	73	67	63
Households that favor metering of water (%)	47	55	71	47	48	63	39	71

Note: All statistics are derived from the sample observations.

Table A.4
Pattern of Household Choice over Available Service Options and Approximate Private Costs

Village Type	Available Service Options				
	Manual Handpump Only	Motorized Handpump Only*	Domestic Connection Only	Domestic Connection + Manual Handpump	Domestic Connection +Motorized Handpump
Type A village households:					
Number	59	6	0	69	10
Percentage	41.0	4.2	0	47.9	6.9
Type B village households:					
Number	82	35	NA**	NA	NA
Percentage	70.1	29.9	NA	NA	NA
Costs**** (Rs)					
Capital					
Handpump	1,000	1,000		1,000	1,000
Motor		2,000			2,000
Overhead tank		500			500
Connection cost			500	500	500
Total	1,000	3,500	500	1,500	4,000
O & M (per month)					
Handpump	6	6		6	6
Motor		16			16
Electricity		NA***			NA***
Tariff			10	10	10
Total	6	22+	10	16	32+

* A motorized handpump can be used manually in case of power failures.

** NA indicates service level not available. Domestic connections are not available in Type B villages.

*** Respondents were unable to estimate the electricity charges attributable to operating the motor.

**** Capital costs are approximate values in current prices; O&M costs are obtained from sample responses.

Table A.5
Reasons Mentioned by Households
for Obtaining a Domestic Connection to Piped Water System

	% of Households	
	Reason No.1	Reason No.2
Convenience	60.9	42.1
Better quality	20.9	29
Reliability	8.2	10.5
Other reasons	10	18.4

Table A.6
Reasons Mentioned by Households
for Not Obtaining a Domestic Connection — Type A Village

	% of Households		
	Reason No.1	Reason No.2	Reason No.3
Expense	57.8	44	0
No need	21.9	40	50
Not reliable	17.2	8	50
To avoid illegal transactions	3.1	4	0
Poor quality	0	4	0

Table A.7
Relationship between Economic Standing and Choice of Service Level — Type A Village

Choice of Service Level	Average Value* of House (Rs)
Manual handpump only	48,473
Manual handpump and domestic connection	96,174
Motorized handpump only	137,500
Motorized handpump and domestic connection	208,500

* The monetary amount that would be needed to reconstruct the type of house the respondent is living in is used as an indicator of economic standing. The average value of this indicator over all households in the Type A village is Rs 87,229.

Table A.8
Level of Satisfaction with Piped Water Supply System — Type A Village

	A1 Households		A2 Households		Total	
Level of Satisfaction	No.	%	No.	%	No.	%
Satisfied	48	60.8	44	67.7	92	63.9
Dissatisfied	31	39.2	19	29.2	50	34.7
No response	0	0	2	3.1	2	1.4
Total	79	100	65	100	144	100

Table A.9
Major Shortcomings of Piped Supply System Mentioned by Households — Type A Village

	% of Households			
	Shortcoming # 1		Shortcoming # 2	
	All Households	Connected Households	All Households	Connected Households
Reliability*	38.5	38.7	19.2	22.6
Maintenance/design**	28.8	25.8	13.5	16.1
Interaction with staff***	25.0	32.3	17.3	25.8
No response	7.7	3.2	50.0	35.5

* Includes insufficient pressure, frequent failures, and power breakdowns.
** Includes substandard material, poor distribution layout, and lack of cleanliness.
*** Includes irresponsible, uncooperative, and corrupt staff.

Table A.10
Most Important Improvement in Piped Supply System Desired by Households — Type A Village

Characteristic	% of Households*
Greater pressure	31.6
Cleanliness	10.1
Increased supply	7.6
Larger storage tank	6.3
Use of standard material	6.3
Reliability	5.0
More competent staff	3.8
Lower price	2.5
Improved billing procedure	1.3
Satisfied	11.4
No response	13.9

* Percentages do not add up to 100 because of rounding.

Table A.11
Household's Information/Beliefs Regarding Characteristics of Piped Water and Alternative Supply Systems

	Type of Household Characteristic				
	A1	A2	B11*	B12	B2**
Price charged (% responding yes)	98.7	—	100	—	—
Billing frequency (no. of times per year)					
Mean	12	—	9	—	—
Standard deviation	1.9	—	4	—	—
Existing monthly tariff (Rs)					
Mean	10	10	10	9.8	15.8
Standard deviation	0	0.1	1.8	1.1	16.5
Households responding (%)	97.4	76.9	100	61.1	6.8
Total no. of hours of water supply per day					
Mean	9	9	9.6	7.6	3.7
Standard deviation	6.3	5.1	4.5	5.3	3
Households with 4 hours/day or less (%)	30.6	23.3	10	31.3	91.2
Number of hours of additional supply required to meet needs					
Mean	9.1	—	—	—	—
Std. deviation	6.3	—	—	—	—
Frequency of supply failure***					
Mean	1.65	—	0.35	—	—
Standard deviation	1.50	—	0.02	—	—
Piped water (% responding yes)					
Satisfaction with taste	100	—	97.5	—	—
Satisfaction with cleanliness	97.4	—	95	—	—
Satisfaction with hygiene	98.7	—	95	—	—
Alternative water (% responding yes)					
Satisfaction with taste	89.7	100	87.5	88.9	96.6
Satisfaction with cleanliness	97.4	100	95	100	100
Satisfaction with hygiene	97.4	96.9	80	94.4	94.9

* Information regarding piped water pertains to period when scheme was operational.
** Information regarding piped water pertains to estimates.
*** Regular supply =0, < once a week =1, once a week =2, > once a week =3, Other = 4; index constructed by summing and taking mean.

Table A.12
Number of Years Households Would Keep Handpumps Operational If a Piped Water Supply System Existed in Their Village

	Village Type Response (%)		
	A	B1	B2
Until piped supply is regular	52.1	5.6	25.4
Forever	5.6	94.4	69.5
For up to 6 years	0	0	5.1
Dismantle immediately	1.4	0	0
No response	41	0	0

Table A.13
Household Preference Regarding Responsibility for Operation and Management of Piped Water Supply Systems

Management Option	Connected Households (%)	Unconnected Households (%)	All Households (%)
PHED (government agency)	73.1	68.3	70.5
Local councils (elected) political body)	11.8	9.9	10.7
Village committee	7.6	9.9	8.8
Private entrepreneur	4.2	4.2	4.2
No preference	3.3	7.7	5.7

Appendix B

Adjusted Willingness-to-Pay Bids

1. In the statistical analysis of the factors affecting the willingness to pay for improved services the dependent variable is the willingness-to-pay bid. Because of some incompleteness and inconsistency in the design of the bidding games certain adjustments have had to be made to a few of the bids elicited from the respondents. These adjustments are explained below.

2. When a respondent said "no" to the lowest bid value in a bidding game without having said "yes" at any stage it remained unclear whether his bid should be treated as a protest bid or a genuine zero bid or whether it ought to be assigned a value between zero and the lowest bid value. This issue was of some significance because in some games the lowest bid value was Rs 15 which is higher than the existing tariff of Rs 10 per month for a domestic connection.

3. This problem was resolved by relying on the response received to another question. The respondents had been asked to indicate the characteristics of what they considered to be an ideal piped water system and to indicate what monthly tariff they would be willing to pay if such a system were made available. The following rule was adopted for adjusting the bid received in the bidding game (only for those who did not say "yes" at any stage in the bidding game but said "no" at Rs 15 in the bidding game).

Bid Offered for Ideal System	Adjusted Bid Value for System Offered in Bidding Game
No Response	Protest Bid
Zero	Genuine Zero Bid
Rs 1- 5	Response placed in interval Rs 0-5
Rs 6-10	Response placed in interval Rs 5-10
Greater than or equal to Rs 11	Response placed in interval Rs 10-15

Similar adjustments were made for those bidding games where the lowest value in the bidding game was Rs 5 per month.

4. In one bidding game (Standard System Village B2) there was an inconsistency between the high and low starting point versions. The low starting point version did not contain a bid value of Rs 15 per month so that the bid interval was Rs 10-20, whereas the high starting point version contained both intervals Rs 10-15 and Rs 15-20. The two versions were made consistent by allocating a bid received in Rs 10-20 interval in the low starting point version to either the Rs 10-15 interval or the Rs 15-20 interval based on the value offered for the ideal system. If the latter was greater than Rs 15, the bid was placed in the Rs 15-20 interval. Otherwise it was placed in the Rs 10-15 interval.

Table B.1
Decision to Install an Electric Motor:
Results of a Logit Model

Dependent Variable: Probability that a household would install an electric motor

Independent Variables	Parameter Estimate	T-Ratio	Parameter Estimate	T-Ratio	Mean Values
Intercept	–4.71	–2.74**	–4.87	–5.40**	
Household size	–0.28E-1	–0.62			9.23
Water consumption	0.34E-2	–0.54			21.62
Proportion of adult women	0.43	0.20			0.26
Proportion of children	0.35	0.24			0.41
Construction value of house	0.67E-5	3.12**	0.65E-5	3.26**	84,432
Ownership of land or property (1 if yes)	1.43	2.46**	1.25	2.43**	0.63
Age	0.14E-1	–0.81			50.29
Education	0.34	4.25**	0.33	4.31**	8.26
Occupation (1 if farming)	–0.21	–0.42			0.27
Meter (1 if yes)	–0.78	–1.75*	–0.78	–1.82*	0.55
Free supply (1 if yes)	0.48	1.07	0.34	0.83	0.43
External exposure (1 if yes)	0.41	0.95			0.33
Household dummy					
A	–1.12	–1.72*	–1.23	–2.04**	0.56
A1	–1.39	–1.86*	–1.22	–1.74*	0.32
B11	–0.86	–1.39	–0.93	–1.65*	0.16
B12	–0.87E-1	–0.11			0.07
Number of observations		244		244	
Log-likelihood		–80.46		–82.22	
Restricted log-likelihood		–119.56		–119.56	
Chi-square	(16)	78.20	(8)	74.68	
Significance level		0.20E-11		0.32E-13	
Proportion of correct predictions		0.86		0.86	

Table B.2
Decision to Connect to a Piped Water Supply System: Results of a Logit Model

Dependent Variable: Probability that a household would connect to a piped water supply system

Independent Variables	Parameter Estimate	T-Ratio	Parameter Estimate	T-Ratio	Mean Values
Intercept	–2.12	–1.59	–2.25	–3.10**	
Household size	0.75E-1	1.38	0.68E-1	1.35	9.29
Water consumption	0.23E-1	1.90*	0.24E-1	2.02**	19.00
Proportion of adult women	1.23	0.65			0.25
Proportion of children	2.11	1.67*	1.86	1.88*	0.39
Construction value of house	0.46E-5	1.48	0.46E-5	1.56	84,394
Ownership of land or property (1 if Yes)	0.35	0.78			0.61
Private water source (1 if Motor)	–0.98	–1.37	–0.99	–1.39	0.12
Age	–0.70E-2	–0.48			49.80
Education	0.13	2.27**	0.13	2.44**	7.91
Occupation (1 if farming)	–0.84	–1.81*	–0.72	–1.65*	0.31
Meter (1 if yes)	–0.25	–0.58			0.49
Free Supply (1 if yes)	–0.26	–0.62			0.48
External Exposure (1 if yes)	–0.40	–0.85			0.34
Distance from distribution line	–0.26E-1	–2.16**	–0.26E-1	–2.26**	13.01
Number of observations		137		137	
Log-likelihood		–75.52		-76.77	
Restricted log-likelihood		–93.90		-93.90	
Chi-square	(14)	36.77	(8)	34.26	
Significance level		0.80E-3		0.36E-4	
Proportion of correct predictions		0.74		0.74	

Table B.3
Statistical Analysis of Willingness to Pay for a Standard Piped Water Supply System: Results of Ordinary Least Squares Regression Model

Dependent Variable: Midpoint of interval in bidding game within which respondent's WTP bid falls

Independent Variables	Parameter Estimate	T-Ratio	Parameter Estimate	T-Ratio	Mean Values
Intercept	21.31	2.40**	20.06	4.40**	
Household size	0.40	1.29	0.41	1.58	9.13
Water consumption	0.03	0.78			25.04
Proportion of adult women	–11.81	–0.98			0.26
Proportion of children	1.01	0.13			0.42
Construction value of house	–5.16E-6	–0.44			84,524
Ownership of land or property (1 if yes)	4.62	1.75*	5.15	2.08**	0.64
Private water source (1 if motor)	7.11	2.52**	6.76	2.56**	0.29
Age	–0.23	2.33**	–0.27	–3.28**	50.84
Education	0.59	1.82*	0.49	1.63	8.67
Occupation (1 if farming)	–4.02	–1.44	–4.27	–1.65	0.23
Meter (1 if yes)	5.18	2.11**	5.78	2.56**	0.63
Free supply (1 if yes)	–2.28	–0.89			0.38
External exposure (1 if yes)	0.55	0.23			0.33
Household dummy					
B11	–6.02	–1.98*	–5.49	–2.03**	0.36
B12	–1.88	–0.56			0.16
Starting point dummy (1 if low)	–6.19	–2.22**	–6.94	–2.60**	0.34
Number of observations		106		106	
Mean of dependent variable		18.16		18.16	
Stan. dev. of dependent variable		12.52		12.52	
F-value	(16,89)	3.31	(9,96)	5.83	
Significance of F-test		0.00		0.00	
R-squared		0.37		0.35	
Adjusted R-squared		0.26		0.29	

Table B.4
Statistical Analysis of Willingness to Pay for an Improved Piped Water Supply System by Households in Villages with an Existing Piped Water Supply System: Results of Ordinary Least Squares Regression Model

Dependent Variable: Midpoint of interval in bidding game within which respondent's WTP bid falls

Independent Variables	Parameter Estimate	T-Ratio	Parameter Estimate	T-Ratio	Mean Values
Intercept	4.56	0.62	2.10	0.44	
Household size	–0.19	–0.85	–0.21	–1.07	9.82
Water consumption	–0.08	–1.26	–0.07	–1.23	19.37
Proportion of adult women	14.69	1.54	15.33	1.68*	0.26
Proportion of children	6.54	1.00	7.86	1.31	0.41
Construction value of house	1.75E-5	1.35	1.93E-5	1.65	90,669
Ownership of land or property (1 if yes)	–0.68	–0.29			0.62
Private water source (1 if motor)	5.42	1.59	5.19	1.68*	0.14
Age	–0.04	–0.54			49.57
Education	0.02	0.05			8.22
Occupation (1 if farming)	3.63	1.55	3.18	1.49	0.33
Meter (1 if yes)	5.61	2.61**	5.87	2.90**	0.53
Free supply (1 if yes)	–0.88	–0.40			0.48
External exposure (1 if yes)	3.06	1.23	3.15	1.34	0.31
Satisfaction (1 if yes)	0.16	0.07			0.62
Household dummy A1	1.34	0.60			0.59
Starting point dummy (1 if low)	0.18	0.09			0.51
Number of observations		118		118	
Mean of dependent variable		13.41		13.41	
Stan. dev. of dependent variable		11.27		11.27	
F-value	(16,101)	1.57	(9,108)	2.84	
Significance of F-test		0.09		0.00	
R-squared		0.20		0.19	
Adjusted R-squared		0.07		0.12	

Appendix C

Table C.1
Distribution of WTP Bids for a Standard Piped Water System in Villages without an Operational Piped Water Supply

Mean Bid* (Rs)	Household Group B11 No.	B11 %**	B12 No.	B12 %	B2 No.	B2 %
0	1	2.5	0	0	2	3.4
2.5	0	0	1	5.6	0	0
7.5	10	25.0	2	11.1	12	20.3
12.5	5	12.5	4	22.2	17	28.8
17.5	14	35.0	8	44.4	5	8.5
22.5	6	15.0	2	11.1	9	15.3
27.5	0	0	0	0	1	1.7
32.5	1	2.5	0	0	1	1.7
37.5	0	0	0	0	0	0
45.0	0	0	0	0	0	0
50	2	5.0	1	5.6	11	18.6
No response	1	2.5	0	0	1	1.7
Total	40	100.0	18	100.0	59	100.0
Valid response	39	97.5	18	100.0	58	98.3
No. of bids > Rs 10	28	70.0	15	83.3	44	74.6
Mean Bid*** (Rs)	16.67		16.81		20.73	
Mean of Bids > Rs 10 (Rs)	20.54		19.00		25.28	

Note: The following applies to Tables C-1 to C-3.
* Mean bids are the midpoints of the intervals in which the respondent's bids fell (except 0 and 50).
** Computed over the number of total responses.
*** Computed over the number of valid responses.

Table C.2
Distribution of WTP Bids for a Standard Piped Water System with a Flexible Financing Arrangement in Villages without an Operational Piped Water Supply

Mean Bid	Household Group			
	B12		B2	
(Rs)	No.	%	No.	%
0	0	0	4	6.8
2.5	0	0	7	11.9
7.5	4	22.2	2	3.4
12.5	0	0	4	6.8
17.5	8	44.4	12	20.3
22.5	1	5.6	7	11.9
27.5	2	11.1	2	3.4
32.5	0	0	2	3.4
37.5	1	5.6	4	6.8
45.0	0	0	0	0
50	1	5.6	13	22.0
No response	1	5.6	2	3.4
Total	18	100.0	59	100.0
Valid response	17	94.4	57	96.6
No. of bids > Rs 10	13	72.2	44	74.6
Mean bid (Rs)	19.71		24.04	
Mean of bids > Rs 10 (Rs)	23.46		30.40	

Table C.3
Distribution of WTP Bids for an Improved Piped Water Supply in Villages with an Operational Piped Water System

Mean Bid (Rs)	Household Group A1 No.	A1 %	A2 No.	A2 %	A2* No.	A2* %
0	7	8.9	9	13.8	7	10.8
2.5	1	1.3	3	4.6	3	4.6
7.5	23	29.1	12	18.5	9	13.8
12.5	4	5.1	8	12.3	4	6.1
17.5	27	34.2	13	20.0	21	32.3
22.5	5	6.3	6	9.2	4	6.1
27.5	0	0	0	0	0	0
32.5	0	0	1	1.5	2	3.1
37.5	2	2.5	0	0	0	0
45.0	0	0	0	0	2	3.1
50	2	2.5	1	1.5	1	1.5
No response	8	10.1	12	18.5	12	18.5
Total	79	100.0	65	100.0	65	100.0
Valid response	71	89.9	53	81.5	53	81.5
No. of bids > Rs 10	40	50.6	29	44.6	34	52.3
Mean bid (Rs)	13.87**		12.12		14.86	
Mean of bids > Rs 10 (Rs)	20.25		18.79		20.96	

* WTP bids for a standard system with a flexible financing arrangement.

** Mean bid would be Rs 15.19 if it is assumed that nobody at present connected at a tariff of Rs 10 per month would disconnect if the service level is improved at the same tariff.

Table C.4
Connection Frequencies and Estimated Revenues: Provision of a Standard Piped Water System in a Type B1 Village

Monthly Tariff (Rs)	Households Connected (%)*	Estimated Revenue (Rs/100 households)
0	100	0
2.5	96.6	242
7.5	94.8	711
12.5	74.1	926
17.5	58.6	1026
22.5	20.7	466
27.5	6.9	190
32.5	6.9	224
37.5	5.2	195
45	5.2	234
50	5.2	260

* The overall connection frequency for the Type B1 village is derived from the responses of B11 and B12 households (Table C.1) based on their respective proportions in the sample, .69 and .31.

Table C.5
Connection Frequencies and Estimated Revenues: Provision of a Standard Piped Water System in a Type B2 Village

	Without Flexible Financing		With Flexible Financing	
Monthly Tariff (Rs)	Households Connected (%)	Estimated Revenue (Rs/100 households)	Households Connected (%)	Estimated Revenue (Rs/100 households)
0	100	0	100	0
2.5	94.9	237	89.8	225
7.5	94.9	712	77.9	584
12.5	74.6	933	74.5	931
17.5	45.8	802	67.7	1,185
22.5	37.3	839	47.4	1,067
27.5	22.0	605	35.5	976
32.5	20.3	660	32.1	1,043
37.5	18.6	698	28.7	1,076
45	18.6	837	21.9	986
50	18.6	930	21.9	1,096

Table C.6
Connection Frequencies and Estimated Revenues: Provision of an Improved Piped Water System in a Type A Village

Monthly Tariff (Rs)	Households Connected (%)*	Estimated Revenue (Rs/100 households)
0	100.0	0
2.5	75.0	188
7.5	72.2	542
12.5	47.9	599
17.5	39.6	693
22.5	11.8	266
27.5	4.1	113
32.5	4.1	133
37.5	3.5	131
45.0	2.1	95
50	2.1	105

* The overall connection frequency for the Type A village is derived from the responses of A1 and A2 households (Table C.3) based on their respective proportions in the sample, .55 and .45.

Table C.7
Connection Frequencies and Estimated Revenues: Responses to Different Options by Unconnected Households in a Village with an Operational Piped Water Supply

	Improved System		Standard System with Flexible Financing	
Monthly Tariff (Rs)	Households Connected (%)	Estimated Revenues (Rs/100 households)	Households Connected (%)	Estimated Revenues (Rs/100 households)
0	100	0	100	0
2.5	67.7	169	70.7	177
7.5	63.1	473	66.1	496
12.5	44.6	558	52.3	654
17.5	32.3	565	46.2	809
22.5	12.3	277	13.9	313
27.5	3.1	85	7.8	215
32.5	3.1	101	7.8	254
37.5	1.6	60	4.7	176
45	1.6	72	4.7	212
50	1.6	80	1.6	80

Appendix D

Table D.1
Village Profiles

	Gatwala	Santpura	Bhaiwala	Akalgarh	Manawala	Sudhar
Area* (acres)	1,899	1,999	2,342	2,384	—	2,121
Population*	6,181	7,339	11,049	7,885	20,586	8,333
Household size*	6.7	6.8	6.5	6.5	7.1	6.5
(from sample, 1988)	(10)	(8)	(9)	(9)	(9)	(9)
Literacy ratio*	38.6	32.3	32.8	30.1	58.5	19.7
Males—School age and above (%)	10.4	8.4	11.6	9.5	24	3.9
Females—School age and above (%)	3.1	1.4	2	2.6	14.1	0.6
Presence of facilities						
Electricity	Yes	Yes	Yes	Yes	Yes	Yes

* Figures from 1981 population census. All others from field visit.

Table D.2
Village Profiles

	Gatwala	Santpura	Bhaiwala	Akalgarh	Manawala	Sudhar
Household size	10.0	8.1	8.6	9.2	8.9	8.7
Adult women in household (%)	28	28	28	28	28	29
Children in household (%)	35	37	37	34	40	40
Years of education of most educated						
member of household	10	8	9	10	8	7
woman in household	6	4	5	6	4	2
Essential water consumption (liters/ capita/day)	30	35	32	29	31	31
Households involved in farming (%)	22	27	19	20	9	18
Households owning animals (%)	42	50	52	49	28	52
Water consumption of animals (liters/ animal/day)	62	63	63	50	76	35
Households with land or other property (%)	63	63	67	60	35	38
Construction value of house (000 Rs)	200	144	143	149	125	90
Households with external exposure (%)	46	48	32	52	25	28
Households that believe water should be supplied free (%)	59	52	53	54	47	52
Households that believe water can be supplied free (%)	27	29	33	24	19	31
Households that believe water supply systems should be managed by PHED (%)	61	75	62	62	72	67
Households that favor metering of water (%)	85	87	93	77	75	78

Note: All statistics are derived from the sample observations.

Table D.3
Profiles by Village and Household Type

	Village Type			Household Type	
	A	B1	B2	A1	A2
Household size	9	9	9	9	8
Adult women in household (%)	28	28	28	29	28
Children in household (%)	40	35	36	39	42
Years of education of most educated:					
Member of household	7	9	9	8	6
Woman in household	3	5	5	4	2
Essential water consumption (liters/capita/day)	31	31	33	31	31
Households involved in farming (%)	13	19	25	12	18
Households owning animals (%)	40	51	46	37	47
Water consumption of animals (liters/animal/day)	48	57	63	53	35
Households with land or other property (%)	37	64	63	40	27
Construction value of house (000 Rs)	108	146	169	121	69
Households with external exposure (%)	27	43	47	28	21
Households that believe water should be supplied free (%)	50	53	55	46	59
Households that believe water can be supplied free (%)	25	28	28	21	37
Households that believe water supply systems should be managed by PHED (%)	69	62	69	70	69
Households that favor metering of water (%)	76	85	86	80	65

Note: All statistics are derived from the sample observations.

Table D.4
Pattern of Household Choice over Available Service Options and Approximate Private Costs

Village Type	Service Options				
	Manual Handpump Only	Motorized Handpump Only*	Domestic Connection Only	Domestic Connection + Manual Handpump	Domestic Connection + Motorized Handpump
Type A Village households					
Number	42	8	13	80	58
Percentage	20.8	4.0	6.4	39.6	28.7
Type B Village households					
Number	112	181	NA**	NA	NA
Percentage	38.2	61.8	NA	NA	NA
Costs**** (Rs.)					
Capital					
Handpump	1,000	1,000		1,000	1,000
Motor		2,000			2,000
Overhead tank		500			500
Connection cost			500	500	500
Total	1,000	3,500	500	1,500	4,000
O & M (per month)					
Handpump	3.5	3.5		3.5	3.5
Motor		9.5			9.5
Electricity		NA***			NA***
Tariff			12	12	12
Total	3.5	13.0+	12	15.5	25.0+

* A motorized handpump can be used manually in case of power failures.

** NA indicates service level not available. Domestic connections are not available in Type B villages.

*** Respondents were unable to estimate the electricity charges attributable to operating the motor.

**** Capital costs are approximate values in current prices; O&M costs are obtained from sample responses.

Table D.5
Reasons Mentioned by Households for Obtaining a Domestic Connection—Type A Village

	% of Households	
	Reason No.1	Reason No.2
Health considerations	74.8	14.9
Clean water	11.9	39.6
Convenience	9.3	32.1
Other reasons	4	13.3

Table D.6
Reasons Mentioned by Households for Not Obtaining a Domestic Connection—Type A Village

	% of Households	
	Reason No.1	Reason No.2
High cost	74.5	7.8
High tariff	3.9	39.2
Low pressure	9.8	2
Low reliability	0	3.9
No need	11.8	0
No response	0	47.1

Table D.7
Relationship between Economic Standing and Choice of Service Level—Type A Village

	Village*					
	Manawala			Sudhar		
Choice of Service Level	No.	%	Average Value of House (Rs)	No.	%	Average Value of House (Rs)
No private facility	—	—	—	1	1	15,000
Manual handpump only	26	24.5	67,423	16	16.7	53,437
Motorized pump only	2	1.9	60,000	6	6.3	133,333
Domestic connection only	12	11.3	72,083	1	1	15,000
Manual handpump and domestic connection	44	41.5	142,380	36	37.5	75,735
Motorized pump and domestic connection	22	20.8	193,181	36	37.5	115,833
Total	106	100	124,692	96	100	89,680

* The average value of a house is significantly different in the two villages. Therefore, their statistics are presented separately.

Table D.8
Level of Satisfaction with Piped Water Supply System—Type A Village

	A1 Households		A2 Households		Total	
Level of Satisfaction	No.	%	No.	%	No.	%
Satisfied	51	33.8	28	54.9	79	39.1
Dissatisfied	100	66.2	20	39.2	120	59.4
No response	0	0	3	5.9	3	1.5
Total	151	100	51	100	202	100

Table D.9
Major Shortcomings of Piped Water Supply System Mentioned by Households
Type A Village

	% of Households Indicating Characteristic as			
	Shortcoming # 1		Shortcoming # 2	
Characteristic	All Households	Connected Households	All Households	Connected Households
Reliability*	70	69	32.5	33
Insufficient supply**	15.8	17	21.7	22
Maintenance/design***	10	10	15.8	15
Interaction with staff****	4.2	4	20.8	21
No response	0	0	9.2	9

* Includes Insufficient pressure, frequent failures, and power breakdowns.
** Includes Insufficient hours and low storage capacity.
*** Includes Substandard material and lack of cleanliness.
**** Includes Irresponsible, uncooperative, and corrupt staff.

Table D.10
Extent of Information Regarding Parameters of Piped Water Systems

	Village Type					
	Manawala		Sudhar			
Parameter	A1	A2	A1	A2	B1	B2
Price charged (% responding yes)	96	—	NA*	—	—	—
Billing frequency (no. of times per year)						
Mean	2.0	—	NA	—	—	—
Standard deviation	0.2	—	NA	—	—	—
Households responding (%)	96	—	NA	—	—	—
Existing monthly tariff (Rs)						
Mean	12.0	12.0	NA	11.0	15.6	16.9
Standard deviation	2.3	1.0	NA	1.0	7.0	11.9
Households responding (%)	100	68	NA	30	18	14
Connection fee (Rs)						
Mean	180	257	85	86	79	144
Standard deviation	224	203	2.8	6.3	42	129
Households responding (%)	87	57	100	78	4	9
Connection costs (Rs)						
Mean	721	947	443	445	453	503
Standard deviation	357	782	204	267	634	495
Households responding (%)	100	82	100	87	42	17
Total no. of hours of water supply per day						
Mean	5.6	5.5	3.0	3.1	4.8	5.3
Standard deviation	1.0	1.1	0.8	1.6	2.0	1.9
Households responding (%)	100	86	97	74	28	43
No. of hours of additional supply required to meet needs						
Mean	3.4	—	2.4	—	—	—
Standard deviation	4.6	—	2.9	—	—	—
Households responding (%)	99		99	—	—	—
Frequency of supply failure**						
Mean	0.5	—	1.8	—	—	—
Standard deviation	0.9	—	0.9	—	—	—
Households responding (%)*	100	—	100	—	—	—

* The supply in Sudhar was less than 6 months old and the first billing had not been made at the time of the survey. Responses to some questions were not obtained because of the misinterpretation of a skip instruction in the questionnaire.

** For explanation of index see Table A-11.

Table D.11
Cost of Piped Water Systems

Costs		Tubewell Based	Canal Water Based
Capital Cost (Rs/Capita)		300	500
Total Capital Cost* (000 Rs)		3,000	5,000
O&M Costs at 3% of Capital Costs (Rs/Month)		7,500	12,500
Charges/hh/month** for full recovery of O&M costs at a connection frequency of:			
(Rs)	100%	6.67	11.12
	75%	8.90	14.83
	50%	13.35	22.24
O&M Costs at 5% of Capital Costs (Rs/Month)		12,500	20,833
Charges/hh/month for full recovery of O&M costs at a connection frequency of:			
(Rs)	100%	11.12	18.53
	75%	14.83	24.71
	50%	22.24	37.07

* For average village size of 10,000 inhabitants.
** Average household size in the brackish-water zone is 8.9.

Table D.12
Perceptions Regarding Quality of Water

Perceptions	Type of Household			
	A1	A2	B1	B2
Piped water (% responding yes)				
Satisfied with taste	98.7	—	—	—
Satisfied with cleanliness	97.4	—	—	—
Satisfied with hygiene	93.4	—	—	—
Alternative water (% responding yes)				
Satisfied with taste	19.2	41.2	23.5	72
Satisfied with cleanliness	92.7	96.1	89.5	94.6
Satisfied with hygiene	17.9	37.3	14	36.6
Households that have visited village with operational piped water system (%)	—	—	52	63
Households that feel piped water would be superior to available water (%)	—	—	90	92

Table D.13
Household Preference Regarding Responsibility for Operation and Maintenance of Piped Water Systems

	Type of Household				
Management Option	A1 (%)	A2 (%)	B1 (%)	B2 (%)	Total (%)
PHED (government agency)	69.5	68.6	62.0	68.8	66.3
Local councils (elected political body)	9.3	9.8	14.5	7.5	11.1
Village committee	9.9	9.8	11.0	6.5	9.7
Private entrepreneur	2.0	0	2.0	3.2	2.0
No preference	9.3	11.8	10.5	14.0	10.9

Appendix E

Table E.1
Decision to Install an Electric Motor:
Results of a Logit Model

Dependent Variable: Probability that a household would install an electric motor

Independent Variables	Parameter Estimate	T-Ratio	Parameter Estimate	T-Ratio	Mean Values
Intercept	–1.54	–1.60	–1.72	–3.67**	
Household size	0.38E-1	1.21	0.19E-1	0.74	8.87
Water consumption	0.20E-2	0.49			31.23
Animals	–0.97E-1	–1.48	–0.11	–1.74*	0.88
Proportion of adult women	–1.49	–1.32	–1.05	–1.19	0.28
Proportion of children	–0.42	–0.58			0.37
Expenditure per capita	0.53E-3	0.22			216.81
Expenditure per capita squared	0.62E-6	0.20			72,939
Construction value of house	0.36e-5	2.46**	0.41e-5	2.85**	135,330
Ownership of land or property (1 if yes)	0.79	3.30**	0.76	3.30**	0.53
Quality of alternative water (1 if satisfied)	–0.23	–0.86	–0.20	–0.76	0.23
Time	0.10E-2	1.50	0.83E-3	1.25	93.78
Age	0.37E-3	0.04			51.38
Education	0.13	4.26**	0.14	4.63**	9.12
Occupation (1 if farming)	–0.15	–0.48			0.18
Free supply (1 if yes)	–0.12	–0.57			0.52
External exposure (1 if yes)	0.49E-1	–0.21			0.38
Household dummy					
A1	–0.60	–1.88*	0.47	1.88*	0.30
A2	–1.36	–2.81**	–1.29	–2.93**	0.11
B1	–0.19	–0.62			0.40
Number of observations		481		481	
Log-likelihood		–264.51		–266.02	
Restricted log-likelihood		–333.38		–333.38	
Chi-square	(19)	137.73	(10)	134.72	
Significance level		0.32E-13		0.32E-13	
Proportion of correct predictions		0.73		0.74	

Table E.2
Decision to Connect to a Piped Water Supply System: Results of a Logit Model

Dependent Variable: Probability that a household would connect to a piped water supply system

Independent Variables	Parameter Estimate	T-Ratio	Parameter Estimate	T-Ratio	Mean Values
Intercept	3.29	1.38	0.96	0.75	
Household size	0.87E-1	1.36	0.66E-1	1.09	8.82
Water consumption	–0.69E-2	–0.86			31.08
Animals	0.11	0.61			0.68
Proportion of adult women	–2.57	–0.88			0.28
Proportion of children	–4.03	–2.08**	–2.29	–2.34**	0.40
Expenditure per capita	–0.12E-1	–1.45	–0.13E-1	–1.60	203.67
Expenditure per capita squared	0.23E-4	–1.56	0.25E-4	1.59	57,177
Construction value of house	0.76E-5	1.64	0.82E-5	1.87*	108,640
Ownership of land or property (1 if yes)	–0.13	–0.22			0.37
Quality of alternative water (1 if satisfied)	–0.78	–1.75*	–0.68	–1.54	0.26
Private water source (1 if motor)	0.77	1.37	0.67	1.24	0.34
Age	–0.17E-1	–1.09	51.12		
Education	0.12	2.14**	0.12	2.32**	7.83
Occupation (1 if farming)	–1.95	–2.66**	–1.74	–2.81**	0.13
Meter (1 if yes)	1.02	2.19**	0.95	2.12**	0.77
Free supply (1 if yes)	–0.28	–0.68			0.50
External exposure (1 if yes)	–0.44E-1	–0.09			0.28
Distance from distribution line	0.66E-1	–2.18**	–0.64E-1	–2.23**	5.86
Village dummy Sudhar	0.49	1.13	0.43	1.05	0.48
Number of observations		196		196	
Log-likelihood		–82.38		–84.04	
Restricted log-likelihood		–112.36		–112.36	
Chi-square	(19)	59.96	(12)	56.64	
Significance level		0.39E-5		0.25E-8	
Proportion of correct predictions		0.82		0.81	

Table E.3
Statistical Analysis of Willingness to Pay for a Standard Piped Water System: Results of Ordinary Least Squares Regression Model

Dependent Variable: Midpoint of interval in bidding game within which respondent's WTP bid falls

Independent Variables	Parameter Estimate	T-Ratio	Parameter Estimate	T-Ratio	Mean Values
Intercept	34.99	4.00**	32.51	5.50*	
Household size	0.48	1.63	0.57	2.16**	8.87
Water consumption	0.08	1.96*	0.08	2.10**	31.23
Animals	0.31	0.50			0.88
Proportion of adult women	–6.48	–0.60			0.28
Proportion of children	–2.18	–0.31			0.37
Expenditure per capita	0.02	1.37	0.02	1.73*	216.81
Expenditure per capita squared	–1.20	–1.25	–1.31E-5	–1.41	72,939
Construction value of house	8.00E-6	0.84			135,326
Ownership of land or property (1 if yes)	–2.04	–0.84			0.53
Quality of alternative water (1 if satisfied)	–3.27	–1.30	–3.47	–1.41	0.23
Private water source (1 if motor)	0.95	0.41			0.51
Time	0.01	1.99**	0.01	2.10**	93.78
Age	–0.21	–2.71**	–0.20	–2.88**	51.38
Education	0.12	0.43			9.12
Occupation (1 if farming)	0.86	0.30			0.18
Meter (1 if yes)	5.58	2.11**	5.36	2.06**	0.82
Free supply (1 if yes)	–0.42	–0.21			0.52
External exposure (1 if yes)	4.04	1.79*	4.09	1.88*	0.38
Awareness of water systems (1 if yes)	0.01	0.01			0.74
Household dummy					
A1	–17.18	–5.62**	–17.52	–6.64**	0.30
A2	–31.57	–7.58**	–32.60	–9.00**	0.11
B2	–3.03	–1.03	–2.97	–1.04	0.19
Starting point dummy (1 if high)	0.10	0.05			0.50
Number of observations		481		481	
Mean of dependent variable		30.47		30.47	
Stan. dev. of dependent variable		25.63		25.63	
F-value	(23,457)	8.62	(12,468)	16.61	
Significance of F-test		0.00		0.00	
R-squared		0.30		0.30	
Adjusted R-squared	0.27	0.28			

Table E.4
Statistical Analysis of Willingness to Pay for an Improved Piped Water System: Results of Ordinary Least Squares Regression Model

Dependent Variable: Midpoint of interval in bidding game within which respondent's WTP bid falls

Independent Variables	Parameter Estimate	T-Ratio	Parameter Estimate	T-Ratio	Mean Values
Intercept	37.46	3.39**	36.32	4.71**	
Household size	0.89	2.36**	0.92	2.64**	8.87
Water consumption	0.11	2.31**	0.11	2.29**	31.23
Animals	0.45	0.57			0.88
Proportion of adult women	–1.13	–0.08			0.28
Proportion of children	–2.24	–0.26			0.37
Expenditure per capita	0.03	1.97**	0.04	2.12**	216.81
Expenditure per capita squared	–2.08E-5	–1.72*	–2.19E-5	–1.83*	72,939
Construction value of house	1.77E-5	1.47	1.97E-5	1.72*	135,326
Ownership of land or property (1 if yes)	1.94	0.63			0.53
Quality of alternative water (1 if satisfied)	–8.55	–2.69**	–8.52	–2.73**	0.23
Private water source (1 if motor)	1.75	0.60			0.51
Time	0.02	1.96*	0.01	1.99**	93.78
Age	–0.31	–3.09**	–0.31	–3.44**	51.38
Education	0.69	1.98**	0.77	2.31**	9.12
Occupation (1 if farming)	–2.44	–0.67			0.18
Meter (1 if yes)	7.14	2.14**	7.03	2.14**	0.82
Free supply (1 if yes)	–0.41	–0.16			0.52
External exposure (1 if yes)	5.28	1.86*	5.51	1.97**	0.38
Awareness of water systems (1 if yes)	–2.70	–0.78			0.74
Household dummy					
A1	–14.30	–3.70**	–16.25	–4.84**	0.30
A2	–20.82	–3.96**	–23.48	–4.95**	0.11
B2	–4.52	–1.22	–5.19	–1.43	0.19
Startring point dummy (1 if high)	1.29	0.50			0.50
Number of observations		481		481	
Mean of dependent variable		46.77		46.77	
Stan. dev. of dependent variable		31.72		31.72	
F-Value	(23,457)	7.51	(14,466)	12.35	
Significance of F-test		0.00		0.00	
R-squared		0.27		0.27	
Adjusted R-squared	0.24	0.25			

Table E.5
Statistical Analysis of Willingness to Pay for a Standard Piped Water System—Type A Village: Results of Ordinary Least Squares Regression Model

Dependent Variable: Midpoint of interval in bidding game within which respondent's WTP bid falls

Independent Variables	Parameter Estimate	T-Ratio	Parameter Estimate	T-Ratio	Mean Values
Intercept	–6.79	–0.79	–3.18	–0.77	
Household size	0.11	0.48			8.82
Water consumption	–0.05	–1.53	–0.04	–1.43	31.08
Animals	1.93	3.50**	1.96	3.73**	0.68
Proportion of adult women	0.39	0.04			0.29
Proportion of children	3.19	0.47			0.40
Expenditure per capita	0.07	3.21**	0.06	3.39**	203.67
Expenditure per capita squared	–6.55E-5	–2.42**	–5.90E-5	–2.47**	57,177
Construction value of house	–5.81E-6	–0.87			108,638
Ownership of land or property (1 if yes)	–0.41	–0.21			0.37
Quality of alternative water (1 if satisfied)	–0.60	–0.32			0.26
Private water source (1 if motor)	0.03	0.02			0.34
Time	2.13E-3	0.09			12.16
Age	–0.06	–1.07	–0.07	–1.39	51.12
Education	–0.05	–0.26			7.83
Occupation (1 if farming)	–2.52	–0.91	–3.67	–1.59	0.13
Meter (1 if yes)	2.70	1.45	2.57	1.46	0.77
Free supply (1 if yes)	0.72	0.45			0.50
External exposure (1 if yes)	1.66	0.92			0.28
Satisfaction (1 if yes)	–1.05	–0.64			0.39
Village dummy Sudhar	2.85	1.64	3.03	2.02**	0.48
Household dummy A1	16.19	7.13**	16.00	9.38**	0.74
Starting point dummy (1 if high)	0.48	0.30			0.50
Number of observations		196		196	
Mean of dependent variable		16.49		16.49	
Stan. dev. of dependent variable		13.18		13.18	
F-value	(22,173)	6.32	(9,186)	15.96	
Significance of F-test		0.00		0.00	
R-squared		0.45		0.44	
Adjusted R-squared		0.38		0.41	

Table E.6
Statistical Analysis of Willingness to Pay for an Improved Piped Water System—Type A Village: Results of Ordinary Least Squares Regression Model

Dependent Variable: Midpoint of interval in bidding game within which respondent's WTP bid falls

Independent Variables	Parameter Estimate	T-Ratio	Parameter Estimate	T-Ratio	Mean Values
Intercept	9.53	0.59	3.22	0.35	
Household size	0.89	2.08**	0.99	2.44**	8.82
Water consumption	–0.06	–0.92			31.08
Animals	0.31	0.30			0.68
Proportion of adult women	–21.94	–1.12	-22.03	–1.86*	0.29
Proportion of children	–2.69	–0.21			0.40
Expenditure per capita	0.14	3.47**	0.14	3.91**	203.67
Expenditure per capita squared	–1.28E-4	–2.51**	–1.42E-4	–2.97**	57,177
Construction value of house	–1.44E-5	–1.14	–1.22E-5	–1.02	108,638
Ownership of land or property (1 if yes)	7.05	1.91*	6.40	2.04**	0.37
Quality of alternative water (1 if satisfied)	–9.30	–2.63**	–9.56	–2.80**	0.26
Private water source (1 if motor)	1.50	0.42			0.34
Time	0.05	1.06	0.05	1.24	12.16
Age	–0.19	–1.75*	–0.19	–1.90*	51.12
Education	0.11	0.30			7.83
Occupation (1 if farming)	–4.95	–0.95			0.13
Meter (1 if yes)	5.44	1.55	5.65	1.69*	0.77
Free supply (1 if yes)	–1.03	–0.34			0.50
External exposure (1 if yes)	4.03	1.19	3.88	1.21	0.28
Satisfaction (1 if yes)	–1.43	–0.47			0.39
Village dummy Sudhar	–0.41	–0.13			0.48
Household dummy A1	10.63	2.49**	12.30	3.15**	0.74
Starting point dummy (1 if high)	4.01	1.36	4.02	1.42	0.50
Number of observations		196		196	
Mean of dependent variable		33.06		33.06	
Stan. dev. of dependent variable		22.02		22.02	
F-value	(22,173)	3.35	(13,182)	5.66	
Significance of F-test		0.00		0.00	
R-squared		0.30		0.29	
Adjusted R-squared		0.21		0.24	

Table E.7
Statistical Analysis of Willingness to Pay for a Standard Piped Water System—Type B Village:
Results of Ordinary Least Squares Regression Model

Dependent Variable: Midpoint of interval in bidding game within which respondent's WTP bid falls

Independent Variables	Parameter Estimate	T-Ratio	Parameter Estimate	T-Ratio	Mean Values
Intercept	33.36	2.42**	33.06	4.00**	
Household size	0.90	1.86*	0.67	1.76*	8.90
Water consumption	0.15	2.46**	0.15	2.65**	31.34
Animals	–0.76	–0.80			1.02
Proportion of adult women	–11.38	–0.73			0.28
Proportion of children	–6.59	–0.64			0.36
Expenditure per capita	0.01	0.67			225.86
Expenditure per capita squared	–9.61E-6	–0.74			83,779
Construction value of house	2.10E-5	1.26	2.07E-5	1.41	153,681
Ownership of land or property (1 if yes)	–2.04	–0.54			0.64
Quality of alternative water (1 if satisfied)	–5.59	–1.32	–6.42	–1.63	0.21
Private water source (1 if motor)	–0.80	–0.22			0.62
Time	0.01	1.58	0.01	1.64	149.92
Age	–0.35	–2.73**	–0.31	–2.69**	51.56
Education	0.41	0.86			10.01
Occupation (1 if farming)	2.43	0.57			0.22
Meter (1 if yes)	7.99	1.75*	7.40	1.67*	0.85
Free supply (1 if yes)	–0.39	–0.12			0.54
External exposure (1 if yes)	4.93	1.40	5.11	1.55	0.45
Awareness of water systems (1 if yes)	–1.40	–0.41			0.57
Household dummy B1	3.00	0.82			0.68
Starting point dummy (1 if high)	–1.00	–0.31			0.50
Number of observations		285		285	
Mean of dependent variable		40.09		40.09	
Stan. dev. of dependent variable		27.62		27.62	
F-value	(21,263)	1.75	(8,276)	4.20	
Significance of F-test		0.02		0.00	
R-squared		0.12		0.11	
Adjusted R-squared		0.05		0.08	

Appendix F

Table F.1
Distribution of WTP Bids for a Standard Piped Water System

Mean bid* (Rs)	Village type A No.	A %	B1 No.	B1 %	B2 No.	B2 %
0	16	7.9	3	1.5	3	3.2
5.0	13	6.4	0	0	1	1.1
7.5	22	10.9	4	2	5	5.4
12.5	50	24.8	25	12.5	11	11.8
17.5	53	26.2	9	4.5	3	3.2
25.0	29	14.4	47	23.5	22	23.7
35.0	14	6.9	20	10	11	11.8
45.0	2	1	39	19.5	18	19.4
62.5	1	0.5	38	19	13	14
87.5	1	0.5	2	1	2	2.2
100+	1	0.5	13	6.5	4	4.3
Total	202	100	200	100	93	100
No. of bids > Rs 12	151	74.8	193	96.5	84	90.3
Mean bid (Rs)	16.42		41.19		36.92	
Mean of bids > Rs 12 (Rs)	20.65		42.52		40.40	
Mean of bids < Rs 12 (Rs)	3.91		4.29		4.50	

Note: The following applies to Tables F-1 to F-4.

* Mean bids are the mid-points of the intervals in which the respondent's bids fell (except 0, 5, and 100). All genuine zero bids are included in 0; all bids greater than zero and less than or equal to Rs 5 are included in 5; and all bids equal to or greater than Rs 100 are included in 100+.

Table F.2
Distribution of WTP Bids for an Improved Piped Water System

Mean bid (Rs)	Village type A No.	A %	B1 No.	B1 %	B2 No.	B2 %
0	4	2	0	0	1	1.1
5.0	0	0	0	0	0	0
7.5	6	3	2	1	2	2.2
12.5	26	12.9	6	3	3	3.2
17.5	29	14.4	11	5.5	6	6.5
25.0	47	23.3	22	11	8	8.6
35.0	32	15.8	29	14.5	15	16.1
45.0	32	15.8	37	18.5	23	24.7
62.5	19	9.4	43	21.5	22	23.7
87.5	2	1	24	12	5	5.4
100+	5	2.5	26	13	8	8.6
Total	202	100	200	100	93	100
No. of bids > Rs 12	192	95	198	99	90	96.8
Mean bid (Rs)	32.60		58.04		50.81	
Mean of bids > Rs 12 (Rs)	34.06		58.55		52.33	
Mean of bids < Rs 12 (Rs)	4.50		7.50		5.00	

Table F.3
Distribution of WTP Bids for a Standard Piped Water System with Alternative Financing Arrangements: A2 Households

Mean bid (Rs)	Financing arrangement: Existing system No.	Existing system %	Arrangement 1* No.	Arrangement 1* %	Arrangement 2** No.	Arrangement 2** %
0	16	31.4	7	13.7	4	7.8
5.0	13	25.5	8	15.7	2	3.9
7.5	22	43.2	12	23.6	13	25.4
12.5	0	0	15	29.4	9	17.6
17.5	0	0	5	9.8	12	23.5
25.0	0	0	3	5.9	7	13.7
35.0	0	0	1	2	3	5.9
45.0	0	0	0	0	0	0
62.5	0	0	0	0	1	2
87.5	0	0	0	0	0	0
100+	0	0	0	0	0	0
Total	51	100	51	100	51	100
No. of bids > Rs 12	0	0	24	47.06	32	62.75
Mean bid (Rs)	3.91		9.76		15.24	
Mean of bids > Rs 12 (Rs)	-		16.04		20.78	
Mean of bids < Rs 12 (Rs)	3.91		4.19		5.89	

* Under Arrangement 1 the water authorities bear 50% of the connection cost.
** Under Arrangement 2 the water authorities bear 100% of the connection cost.

Table F.4
Distribution of WTP Bids for Standard and Improved Piped Water Systems in Villages with Operating Piped Water Systems

Mean bid (Rs)	Standard system				Improved system			
	Type A1 Households		Type A2 Households		Type A1 Households		Type A2 Households	
	No.	%	No.	%	No.	%	No.	%
0	0	0	16	31.4	0	0	4	7.8
5.0	0	0	13	25.5	0	0	0	0
7.5	0	0	22	43.2	1	0.7	5	9.8
12.5	50	33.1	0	0	16	10.6	10	19.6
17.5	53	35.1	0	0	21	13.9	8	15.7
25.0	29	19.2	0	0	36	23.8	11	21.6
35.0	14	9.3	0	0	28	18.5	4	7.8
45.0	2	1.3	0	0	25	16.6	7	13.7
62.5	1	0.7	0	0	17	11.3	2	3.9
87.5	1	0.7	0	0	2	1.3	0	0
100+	1	0.7	0	0	5	3.3	0	0
Total	151	100	51	100	151	100	51	100
No. of bids > Rs 12	151	100	0	0	150	99.3	42	82.4
Mean bid (Rs)	20.65		3.91		35.94		22.70	
Mean of bids > Rs 12 (Rs)	20.65		-		36.13		26.67	
Mean of bids < Rs 12 (Rs)	-		3.91		7.50		4.17	

Table F.5
Connection Frequencies and Estimated Revenues:
Provision of a Standard Piped Water System

Monthly tariff (Rs)	Village type A: Households Conn. (%)	A: Est. Rev. (Rs/100 households)	B1: Households Conn. (%)	B1: Est. Rev. (Rs/100 households)	B2: Households Conn. (%)	B2: Est. Rev. (Rs/100 households)
0	100	0	100	0	100	0
5.0*	92.1	461	98.5	493	96.8	484
7.5	85.7	643	98.5	739	95.7	718
12.5	74.8	935	96.5	1,206	90.3	1,129
17.5	50.0	875	84	1,470	78.5	1,374
25.0	23.8	595	79.5	1,988	75.3	1,883
35.0	9.4	329	56	1,960	51.6	1,806
45.0	2.5	113	46	2,070	39.8	1,791
62.5	2	125	26.5	1,656	20.4	1,275
87.5	1.5	131	7.5	656	6.4	560
100**	0.5	50	6.5	650	4.2	420

Note: The following apply to Tables F-5 to F-7.
* All bids between Rs 0 and Rs 5 are consolidated in the Rs 5 category.
** All bids greater than Rs 100 are consolidated in the Rs 100 category.

Table F.6
Connection Frequencies and Estimated Revenues:
Provision of an Improved Piped Water System

Monthly tariff (Rs)	Village type A: Households Conn. (%)	A: Est. Rev. (Rs/100 households)	B1: Households Conn. (%)	B1: Est. Rev. (Rs/100 households)	B2: Households Conn. (%)	B2: Est. Rev. (Rs/100 households)
0	100	0	100	0	100	0
5.0	98	490	100	500	98.9	495
7.5	98	735	100	750	98.9	742
12.5	95	1,188	99	1,238	96.7	1,209
17.5	82.1	1,437	96	1,680	93.5	1,636
25.0	67.7	1,693	90.5	2,263	87	2,175
35.0	44.4	1,554	79.5	2,783	78.4	2,744
45.0	28.6	1,287	65	2,925	62.3	2,804
62.5	12.8	800	46.5	2,906	37.6	2,350
87.5	3.4	298	25	2,188	13.9	1,216
100*	2.4	240	13	1,300	8.5	850

Table F.7
Connection Frequencies and Estimated Revenues: Provision of Options to A2 Households

Monthly tariff (Rs)	Option: Standard system Households Conn. (%)	Standard system Est. Rev. (Rs/100 households)	Standard system (Arrangement 1)+ Households Conn. (%)	Standard system (Arrangement 1)+ Est. Rev. (Rs/100 households)	Standard system (Arrangement 2)++ Households Conn. (%)	Standard system (Arrangement 2)++ Est. Rev. (Rs/100 households)	Improved system Households Conn (%)	Improved system Est. Rev. (Rs /100 households)
0	100	0	100	0	100	0	100	0
5.0	68.6	343	86.3	432	92.2	461	92.2	461
7.5	43.1	323	70.6	530	88.3	662	92.2	692
12.5	0	0	47	588	62.9	786	82.4	1,030
17.5	0	0	17.6	308	45.3	793	62.8	1,099
25.0	0	0	7.8	195	21.8	545	47.1	1,178
35.0	0	0	1.9	67	8.1	284	25.5	893
45.0	0	0	0	0	2.2	99	17.7	797
62.5	0	0	0	0	2.2	138	4.0	250
87.5	0	0	0	0	0	0	0	0
100	0	0	0	0	0	0	0	0

\+ Under Arrangement 1 the water authorities bear 50% of the connection cost.
++ Under arrangement 2 the water authorities bear 100% of the connection cost.

Appendix G

Table G.1
Village Profiles

	Jawa	Banda	Dhalla	Papın	Payal	Gorakh-pur	Dhud-dian	Mohra	Bodhial
Area* (acres)	1263	3664	2801	3298	508	2228	277	629	1441
Population*	835	2129	1129	941	854	1563	610	1222	480
Household size* (from sample, 1989)	5.8 (7.9)	6.0 (7.3)	5.2 (7.2)	7.1 (6.5)	6.0 (8.0)	6.2 (7.6)	5.5 (7.1)	4.4 (6.8)	6.3 (6.5)
Literacy ratio*	30.9	36.1	25.8	15.6	33.4	28.2	59.6	36.9	38.0
Males - school age and above (%)	5.5	11.3	7.2	1.0	7.9	6.0	16.8	9.0	10.4
Females - school age and above (%)	0.9	2.0	1.1	0.2	1.6	0.6	8.3	4.4	0
Distance from district headquarters (km)	24	45	24	56	35	14	37	48	25
Road location	off Rawat-Banda Link Road	Rawat-Chak Beli Link Road	main Adiala Road	off Rawat-Chak Beli Road	off Rawat-Chak Beli Road	main Adiala Road	Rawat-Chak Beli Link Road	main Rawat-Chak Beli Road	off Adiala Road
Presence of facilities									
Electricity	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Clinic	No	No	No	No	No	No	Yes	No	No
Education (boys)	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	No
Education (girls)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

* Figures from 1981 population census. All others from field visit.

Table G.2
Village Profiles*

	Jawa	Banda	Dhalla	Papin	Payal	Gorakh-pur	Dhud-dian	Mohra	Bodhial
Household size	8	7	7	6	8	8	7	7	7
Age of head of household (years)	53	50	49	56	55	51	54	52	49
Adult women in household (%)	30	30	33	37	28	28	32	30	28
Children in household (%)	39	37	35	32	43	42	32	36	38
Years of education of most educated:									
Member of household	8	8	9	8	8	8	10	8	7
Woman in household	2	3	3	2	3	4	4	2	2
Essential water consumption (liters/capita/day)									
Summer	20	23	25	21	23	20	23	29	23
Winter	13	16	18	14	17	14	15	21	17
Households involved in farming (%)	30	15	23	52	40	38	10	44	56
Households owning animals (%)	77	63	73	86	86	58	83	86	83
Water consumption of animals (liters/animal/day)									
Summer	42	40	26	44	47	20	34	70	41
Winter	29	24	20	26	31	15	23	51	27
Households with land or other property (%)	73	52	56	83	88	90	60	93	83
Construction value of house (000 Rs)	91	75	85	69	115	116	102	95	77
Per capita monthly expenditure (Rs)	238	232	201	188	204	182	268	212	238
Households with external exposure (%)	27	23	25	36	31	16	43	26	25
Households that believe water should be supplied free (%)	93	85	83	100	90	80	100	95	90
Households that believe water can be supplied free (%)	66	58	54	71	79	56	77	77	83
Households that believe water supply systems should be managed by PHED (%)	91	100	90	55	67	86	60	77	71
Households that favor metering of water (%)	68	44	46	57	67	68	70	67	63

* All statistics are derived from the sample observations.

Table G.3
Profiles by Village Type*

	Village type A	B1	B2
Household size	8	7	7
Age of head of household	51	54	51
Adult women in household (%)	31	31	30
Children in household (%)	37	39	36
Years of education of most educated			
Member of household	8	8	8
Woman in household	3	3	3
Essential water consumption (liters/capita/day)			
Summer	23	21	25
Winter	16	15	18
Households involved in farming (%)	22	43	41
Households owning animals (%)	71	76	84
Water consumption of animals (liters/animal/day)			
Summer	36	37	50
Winter	24	24	35
Households with land or other property (%)	60	87	81
Construction value of house (000 Rs)	84	102	90
Per capita monthly expenditure (Rs)	224	191	236
Households with external exposure (%)	25	27	30
Households that believe water should be supplied free (%)	87	89	94
Households that belive water can be supplied free (%)	59	69	79
Households that believe water supply systems should be managed by PHED (%)	94	70	70
Households that favor metering of water (%)	52	64	66

* All statistics are derived from the sample observations.

Table G.4
Level of Satisfaction with Piped Water Supply System —Type A Village*

	Villages							
	Jawa		Banda		Dhalla		Total	
Level of satisfaction	No.	%	No.	%	No.	%	No.	%
Satisfied	10	24.4	33	71.7	47	100	90	67.2
Not satisfied	31	75.6	13	28.3	0	0	44	32.8
Total	41	100	44	100	47	100	134	100

* Water supplies were installed in Jawa, Banda, and Dhalla in 1989, 1987, and 1988, respectively.

Table G.5
Major Shortcomings of Piped Supply System Mentioned by Connected Households—Type A Villages

	% of Households Indicating Characteristic as			
	Shortcoming # 1		Shortcoming # 2	
Characteristic	Jawa	Banda	Jawa	Banda
Reliability*	61.3	38.5	29	0
Insufficient supply**	16.1	7.7	29	46.2
Maintenance/design***	3.2	0	0	0
Interaction with staff****	19.4	53.8	35.5	15.4
No response			6.5	38.5

* Includes insufficient pressure,frequent failures, and power breakdowns.
** Includes insufficient hours and low storage capacity.
*** Includes substandard material and lack of cleanliness.
**** Includes irresponsible, uncooperative, and corrupt staff.

Table G.6
Cost of Piped Water Systems in the Arid Zone

	Village type A			Village type B1			Averages	
	Jawa	Banda	Dhalla	Papin	Payal	Gorakh-pur	Type A villages	Type A & B1 villages
Population (1981)	835	1,974	1,129	941	935	1,563	1,312	1,238
Population (1989)							1,667	1,562
Capital cost* (000 Rs)	1,704.7	1,152.8	1,461.8	783.3	1,713.3	1,035.8	1,439.8	1,308.6
O&M cost* per year (000 Rs)	72.51	56.2	78.1	—	—	—	68.94	—
Year completed*	1989	1988	1989	1989-90	1989-90	1989-90	—	—
Household size (1981)	7.1	6.0	5.2	7.1	6.0	6.2	6.1	6.3
(from sample, 1989)	(7.8)	(7.5)	(7.3)	(6.5)	(8.0)	(7.6)	(7.5)	(7.5)
No. of houses (1989)							222	208
No. of households connected [Using 0.957 connection ratio of A villages]							212	199
O&M cost per household per month								
at 100% connection rate (Rs)							25.9	27.6
at 95.7% connection rate (Rs)							27.1	28.9

* From PHED project documents.

Table G.7
Reasons Mentioned by Households for Obtaining a Domestic Connection—Type A Village

Reasons	% of households indicating reason as	
	Reason No.1	Reason No.2
Need	82.1	12.1
Convenience	15.7	56.4
Cleanliness	0.7	14.5
Other	1.5	17.0

Table G.8
Extent of Information Regarding Parameters of Piped Water Systems

	Village type				
	A			B1	B2
	Jawa	Banda	Dhalla		
Price charged (% responding yes)	51	100	87	—	—
Billing frequency (no. of times per year) Mean	2	2	2	—	—
Standard deviation	0	0	0	—	—
Households responding (%)	51	100	85	—	—
Existing monthly tariff (Rs)					
Mean	20	20	20	19.30	22
Standard deviation	0	0	1.07	8.08	9
Households responding (%)	71	100	89	35	33
Connection fee (Rs)					
Mean	238	229	204	150	325
Standard deviation	91	82	46	107	340
Households responding (%)	100	100	100	18	6
Connection costs (Rs)					
Mean	725	835	715	431	1396
Standard deviation	462	438	581	316	1652
Households responding (%)	100	100	100	35	16
Total No. of hours of water supply per day Mean	0.84	2.37	2.10	4	4
Standard deviation	0.68	1.16	0.73	3	4
Households responding (%)	100	100	100	57	49
No. of hours of additional supply required to meet needs					
Mean	2	2.6	2	—	—
Standard deviation	1.2	1.5	0	—	—
Households responding (%)	36	10	1	—	—
Frequency of supply failure*					
Mean	2	0.35	0.17	—	—
Standard deviation	1.2	0.76	0.60	—	—
Households responding (%)	100	100	100	—	—

* For explanation of index see Table A-11.

Table G.9
Household Preference Regarding Responsibility for Operation and Maintenance of Piped Water Systems

Management option	Village type A1 (%)	B1 (%)	B2 (%)	Total (%)
PHED (government agency)	93.4	70.0	70.0	78.3
Local councils (Elected political body)	2.2	8.6	10.7	7.0
Village committee	3.7	11.4	7.3	7.5
Private entrepreneur	0.7	0.7	12.0	0.2
Indifferent	0.0	9.3	0.0	7.0

Appendix H

Table H.1
Statistical Analysis of Willingness to Pay for a Piped Water System Based on Public Taps—Type B2 Villages: Results of Ordinary Least Squares Regression Model

Dependent Variable: Midpoint of interval in bidding game within which respondent's WTP bid falls.

Independent Variables	Parameter Estimate	T-Ratio	Parameter Estimate	T-Ratio	Mean Values
Intercept	126.78	3.00**	116.54	3.38**	
Household size	3.27	3.12**	2.82	3.57**	6.77
Water consumption	0.07	0.27			25.25
Animals	1.67	1.36	1.45	1.40	2.33
Proportion of adult women	-8.31	-0.40			0.30
Proportion of children	-12.09	-0.79			0.36
Expenditure per capita	0.05	2.07**	0.05	2.52**	236.05
Construction value of house	- 2.18E-5	-0.47			89,661.16
Ownership of land or property (1 if yes)	0.91	0.12			0.81
Quality of alternative water (1 if satisfied)	-28.77	-1.94	-29.61	-2.17**	0.97
Private water source (1 if yes)	0.57	0.09			0.37
Vendor usage (1 if yes)	2.87	0.27			0.07
Age	- 0.20	-1.00			51.39
Education	- 0.12	-0.14			8.01
Occupation (1 if farming)	- 1.68	-0.26			0.41
Meter (1 if yes)	13.12	2.23**	13.48	2.58**	0.66
Free supply (1 if yes)	-10.32	-0.91	-12.33	-1.19	0.94
External exposure (1 if yes)	- 5.50	-1.03	- 6.09	-1.26	0.53
Awareness of water systems (1 if yes)	3.07	0.56			0.65
Sex (1 if male)	0.81	0.10			0.86
Distance of village from dist. headquarters	- 1.79	-2.39**	- 1.76	-2.91**	36.15
Village dummy					
Bodhial	-45.53	-2.99**	-44.95	-3.66**	0.40
Number of observations		121		121	
Mean of dependent variable		34.92		34.92	
Standard deviation of dependent variable		30.19		30.19	
F-Value	(21,99)	2.43	(9,111)	5.94	
Significance of F-test		0.00		0.00	
R-squared		0.34		0.32	
Adjusted R-squared		0.20		0.27	

Table H.2
Statistical Analysis of Willingness to Pay for a Standard Piped Water System—Type B2 Villages:
Results of Ordinary Least Squares Regression Model

Dependent Variable: Midpoint of interval in bidding game within which respondent's WTP bid falls.

Independent variables	Parameter estimate	T-Ratio	Parameter estimate	T-Ratio	Mean values
Intercept	124.53	2.37**	103.12	2.40**	
Household size	4.00	3.07**	4.37	4.12**	6.77
Water consumption	0.37	1.11	0.43	1.41	25.25
Animals	1.75	1.15			2.33
Proportion of adult women	-44.64	-1.71*	-43.04	-1.77*	0.30
Proportion of children	-33.60	-1.78*	-34.05	-2.11**	0.36
Expenditure per capita	0.08	2.83**	0.07	2.85**	236.05
Construction value of house	- 7.57E-6	-0.13			89,661.16
Ownership of land or property (1 if yes)	- 3.15	-0.33			0.81
Quality of alternative water (1 if satisfied)	-20.03	-1.09	-18.75	-1.10	0.97
Private water source (1 if yes)	3.96	0.53			0.37
Vendor usage (1 if yes)	11.93	0.84	12.71	1.06	0.07
Age	- 0.16	-0.66			51.39
Education	0.57	0.54			8.01
Occupation (1 if farming)	- 3.21	-0.41			0.41
Meter (1 if yes)	9.01	1.23	7.89	1.19	0.66
Free supply (1 if yes)	- 6.19	-0.44			0.94
External exposure (1 if yes)	- 3.46	-0.52			0.53
Awareness of water systems (1 if yes)	- 4.02	-0.59			0.65
Sex (1 if male)	3.18	0.32			0.86
Distance of village from dist. headquarters	- 1.65	-1.77*	-1.45	-1.88*	36.15
Village dummy					
Bodhial	-40.67	-2.15**	-38.54	-2.47**	0.40
Number of observations		121		121	
Mean of dependent variable		56.45		56.45	
Standard deviation of dependent variable		37.21		37.21	
F-value	(21,99)	2.31	(10,110)	4.88	
Significance of F-test		0.00		0.00	
R-squared		0.33		0.31	
Adjusted R-squared		0.19		0.24	

Tables H.3
Statistical Analysis of Willingness to Pay for a Standard Piped Water System — Type B1 Villages—
Results of Ordinary Least Squares Regression Model

Dependent Variable: Midpoint of interval in bidding game within which respondent's WTP bid falls.

Independent variables	Parameter estimate	T-ratio	Parameter estimate	T-ratio	Mean values
Intercept	-23.43	-0.67	12.09	0.77	
Household size	1.76	1.71*	1.53	1.97*	7.42
Water consumption	0.04	0.15			21.23
Animals	- 1.74	-1.30	- 2.13	1.80*	2.02
Proportion of adult women	23.89	0.78			0.31
Proportion of children	5.39	0.27			0.39
Expenditure per capita	8.94E-3	0.30			192.21
Construction value of house	7.03E-5	1.88*	7.60E-5	2.42**	101,742.65
Ownership of land or property (1 if yes)	9.87	1.14	10.30	1.36	0.88
Quality of alternative water (1 if satisfied)	18.33	1.57	16.76	1.62	0.94
Private water source (1 if yes)	3.04	0.45			0.29
Vendor usage (1 if yes)	13.39	1.07	14.17	1.27	0.05
Age	- 9.52E-4	-0.01			54.06
Education	0.01	0.02			7.79
Occupation (1 if farming)	- 7.56	-1.25	- 8.47	-1.60	0.43
Meter (1 if yes)	0.93	0.17			0.65
Free supply (1 if yes)	- 7.49	-0.82	- 8.37	-1.05	0.89
External exposure (1 if yes)	1.41	0.24			0.46
Awareness of water systems (1 if yes)	2.92	0.46			0.74
Sex (1 if male)	5.77	0.60			0.90
Distance of village from dist. headquarters	0.16	0.42			33.61
Village dummy					
Gorakhpur	12.00	0.91			0.36
Number of observations		136		136	
Mean of dependent variable		41.31		41.31	
Standard deviation of dependent variable		29.75		29.75	
F-value	(21,114)	1.34	(8,127)	3.41	
Significance of F-test		0.16		0.00	
R-squared		0.20		0.18	
Adjusted R-squared		0.05		0.12	

Table H.4
Statistical Analysis of Willingness to Pay for an Improved Piped Water System—Type B1 Villages:
Results of Ordinary Least Squares Regression Model

Dependent Variable: Midpoint of interval in bidding game within which respondent's WTP bid falls.

Independent variables	Parameter estimate	T-Ratio	Parameter estimate	T-Ratio	Mean values
Intercept	- 4.94	-0.13	- 7.35	-0.37	
Household size	2.17	1.94*	2.19	2.34**	7.42
Water consumption	0.24	0.75			21.23
Animals	- 1.90	-1.30	- 2.13	-1.63	2.02
Proportion of adult women	17.20	0.51	26.61	1.24	0.31
Proportion of children	- 5.09	-0.23			0.39
Expenditure per capita	0.05	1.45	0.06	2.13**	192.21
Construction value of house	9.84E-5	2.42**	1.09E-4	2.99**	101,742.65
Ownership of land or property (1 if yes)	2.44	0.26			0.88
Quality of alternative water (1 if satisfied)	21.59	1.70*	23.02	1.98*	0.94
Private water source (1 if yes)	- 1.27	-0.17			0.29
Vendor usage (1 if yes)	5.33	0.39			0.05
Age	- 0.03	-0.13			54.06
Education	0.54	0.61	0.84	1.06	7.79
Occupation (1 if farming)	- 4.71	-0.72			0.43
Meter (1 if yes)	0.02	0.00			0.65
Free supply (1 if yes)	-13.66	-1.37	-15.27	-1.68*	0.89
External exposure (1 if yes)	5.81	0.90	6.55	1.14	0.49
Awareness of water systems (1 if yes)	8.76	1.27	10.33	1.70*	0.74
Sex (1 if male)	7.29	0.70			0.90
Distance of village from dist. headquarters	- 0.16	-0.38			33.61
Village dummy					
Gorakhpur	6.97	0.49	11.28	1.79*	0.36
Number of observations		136		136	
Mean of dependent variable		58.72		58.72	
Standard deviation of dependent variable		34.46		34.46	
F-value	(21,114)	2.24	(10,125)	4.77	
Significance of F-test		0.00		0.00	
R-squared		0.29		0.28	
Adjusted R-squared		0.16		0.22	

Table H.5
Statistical Analysis of Willingness to Pay for a Standard Piped Water System —Type A Villages: Results of Ordinary Least Squares Regression Model

Dependent Variable: Midpoint of interval in bidding game within which respondent's WTP bid falls.

Independent variables	Parameter estimate	T-Ratio	Parameter estimate	T-Ratio	Mean values
Intercept	82.33	3.62**	74.03	4.85**	
Household size	0.59	0.78			7.52
Water consumption	0.03	0.20			22.83
Animals	0.40	0.41			2.07
Proportion of adult women	-47.03	-1.97*	-42.74	-2.08**	0.31
Proportion of children	-44.22	-2.73**	-38.10	-2.79**	0.37
Expenditure per capita	0.03	1.68*	0.03	1.83*	220.62
Construction value of house	- 4.26E-6	-0.13			84,458.65
Ownership of land or property (1 if yes)	1.83	0.42			0.61
Private water source (1 if yes)	- 3.14	-0.41			0.08
Age	- 0.08	-0.60			50.45
Education	0.03	0.04			8.51
Occupation (1 if farming)	- 4.50	-0.85			0.23
Meter (1 if yes)	0.15	0.04			0.51
Free supply (1 if yes)	2.90	0.50			0.87
External exposure (1 if yes)	- 3.14	-0.78	- 4.16	-1.13	0.53
Sex (1 if male)	- 9.62	-1.30	-10.96	-1.63	0.91
Distance of village from dist. headquarters	- 0.32	-1.41			31.26
Village dummy					
Jawa	- 4.95	-0.95			0.30
Number of observations		133		133	
Mean of dependent variable		40.56		40.56	
Standard deviation of dependent variable		21.20		21.20	
F-value	(18,114)	0.98	(5,127)	2.85	
Significance of F-test		0.48		0.02	
R-squared		0.13		0.10	
Adjusted R-squared		0.00		0.07	

Table H.6
Statistical Analysis of Willingness to Pay for an Improved Piped Water System —Type A Villages: Results of Ordinary Least Squares Regression Model

Dependent Variable: Midpoint of interval in bidding game within which respondent's WTP bid falls.

Independent variables	Parameter estimate	T-Ratio	Parameter estimate	T-Ratio	Mean values
Intercept	83.49	3.12**	88.98	4.81**	
Household size	0.80	0.89	1.03	1.32	7.55
Water consumption	0.02	0.14			22.77
Animals	1.03	0.90			2.08
Proportion of adult women	-28.24	-1.01	-29.15	-1.25	0.31
Proportion of children	-49.31	-2.58**	-50.63	-3.18**	0.37
Expenditure per capita	0.03	1.23	0.03	1.61	220.78
Construction value of house	2.00E-5	0.53			84,643.94
Ownership of land or property (1 if yes)	-1.03	-0.20			0.61
Private water source (1 if yes)	1.16	0.13			0.08
Age	-0.25	-1.49	- 0.29	-1.88*	50.58
Education	0.78	0.99			8.51
Occupation (1 if farming)	-4.51	-0.73			0.24
Meter (1 if yes)	1.53	0.31			0.51
Free supply (1 if yes)	-2.08	-0.31			0.86
External exposure (1 if yes)	-6.67	-1.40	- 5.93	-1.37	0.52
Sex (1 if male)	-6.87	-0.79			0.91
Distance of village from dist. headquarters	-0.12	-0.43	31.16		
Village dummy					
Jawa	6.19	1.01	6.13	1.31	0.30
Number of observations		132		132	
Mean of dependent variable		53.14		53.14	
Standard deviation of dependent variable		25.21		25.21	
F-value	(18,114)	1.17	2.65		
Significance of F-test		0.30		0.01	
R-squared		0.16		0.13	
Adjusted R-squared		0.02		0.08	

Appendix I

Table I.1
Distribution of WTP Bids for a Public Tap System and a Standard System with House Connections in Villages without Plans for Installation of Public Water Supplies

Mean* bid (Rs)	Public taps		Standard system	
	No.	%	No.	%
0	16	13.2	3	2.5
5	3	2.5	0	0
15	20	16.5	8	6.6
25	17	14	10	8.3
35	31	25.6	25	20.7
45	12	9.9	10	8.3
55	5	4.1	28	23.1
65	4	3.3	10	8.3
85	8	6.6	15	12.4
100+	5	4.1	12	9.9
Total	121	100	121	100
No. of bids Rs 20	82	67.8	110	90.9
Mean bid (Rs)	34.92		55.21	

Note: The following applies to Tables I-1 to I-3.

* Mean bids are the mid-points of the intervals in which the respondent's bids fell (except 0, 5, and 100). All genuine zero bids are included in 0; all bids greater than zero and less than or equal to Rs 5 are included in 5; and all bids equal to or greater than Rs 100 are included in 100+.

Table I.2
Distribution of WTP Bids for a Standard Piped Water System with House Connections in Types A, B1, and B2 Villages

Mean bid (Rs)	Village type A No.	A %	B1 No.	B1 %	B2 No.	B2 %
0	2	1.4	1	0.7	3	2.5
5.0	3	2.1	5	3.6	0	0
15.0	1	0.7	24	17.1	8	6.6
25.0	47	33.6	31	22.1	10	8.3
35.0	31	22.1	29	20.7	25	20.7
45.0	34	24.3	12	8.6	10	8.3
55.0	10	37.1	10	7.1	28	23.1
65.0	4	2.9	5	3.6	10	8.3
85.0	6	4.3	13	9.3	15	12.4
100+	2	1.4	10	7.1	12	9.9
Total	140	100	140	100	121	100
No. of bids > Rs 20	134	95.7	110	78.6	110	90.9
Mean bid (Rs)	39.07		42.16		55.21	

Table I.3
Distribution of WTP Bids for an Improved Piped Water System with House Connections in Types A and B1 Villages

Mean bid (Rs)	Village type A No.	A %	B1 No.	B1 %
0	2	1.4	1	0.7
5.0	3	2.1	1	0.7
15.0	8	5.7	8	5.7
25.0	2	1.4	12	8.6
35.0	35	25	19	13.6
45.0	28	20.8	32	22.9
55.0	28	20	21	15
65.0	10	7.1	5	3.6
85.0	20	14.3	20	14.3
100+	4	2.9	21	15
Total	140	100	140	100
No. of bids Rs 20	133	95	130	92.9
Mean bid (Rs)	51.18		59.44	

Table I.4
Connection Frequencies and Estimated Revenues: Provision of Standard Piped Water System with House Connections in Types A, B1, and B2 Villages

Monthly tariff (Rs)	Village type A: Households connected (%)	A: Estimated revenues (Rs/100 households)	Village type B1: Households connected (%)	B1: Estimated revenues (Rs/100 households)	Village type B2: Households connected (%)	B2: Estimated revenues (Rs/100 households)
0	100	0	100.0	0	100.0	0
5.0*	98.6	493	99.3	497	97.5	488
15.0	96.5	1,448	95.7	1,436	97.5	1,463
25.0	95.8	2,395	78.6	1,965	90.9	2,273
35.0	62.2	2,177	56.5	1,978	82.6	2,891
45.0	40.1	1,805	35.8	1,611	61.9	2,786
55.0	15.8	869	27.2	1,496	53.6	2,948
65.0	8.7	566	20.1	1,307	30.5	1,983
85.0	5.8	493	16.5	1,403	22.2	1,887
100+**	1.5	150	7.2	720	9.8	980

Note: The following applies to Tables I-4 to I-6.
* All bids between Rs 0 and Rs 5 are consolidated in the Rs 5 category.
** All bids greater than Rs 100 are consolidated in the Rs 100 category.

Table I.5
Connection Frequencies and Estimated Revenues: Provision of Improved Piped Water Systems with House Connections in Types A and B1 Villages

Monthly tariff (Rs)	Village type A: Households connected (%)	A: Estimated revenue (Rs/100 households)	Village type B1: Households connected (%)	B1: Estimated revenue (Rs/100 households)
0	100	0	100	0
5.0	98.6	493	99.3	497
15.0	96.5	1,448	98.6	1,479
25.0	90.8	2,270	92.9	2,323
35.0	89.4	3,129	84.3	2,951
45.0	64.4	2,898	70.7	3,182
55.0	44.4	2,442	47.8	2,629
65.0	24.4	1,586	32.8	2,132
85.0	17.3	1,471	29.2	2,482
100+	3.0	300	14.9	1,490

Table I.6
Connection Frequencies and Estimated Revenues: Provision of Public Taps and Standard House Connections in Type B2 Villages

Monthly tariff (Rs)	Public taps		Standard system	
	Households connected (%)	Estimated revenue (Rs/100 households)	Households connected (%)	Estimated revenue (Rs/100 households)
0	100	0	100	0
5.0	86.8	434	97.5	488
15.0	84.3	1265	97.5	1463
25.0	67.8	1695	90.9	2273
35.0	53.8	1883	82.6	2891
45.0	28.2	1269	61.9	2786
55.0	18.3	1007	53.6	2948
65.0	14.2	923	30.5	1983
85.0	10.9	927	22.2	1887
100+	4.3	430	9.8	980

Appendix J

Table J.1
Comparative Size of Rural Localities in the Three Environmental Zones by Population Size (1981)

Zone	Total rural localities	% of rural localities by population size						
		>5,000	2000–4999	1000–1999	500–999	200–499	<200	Uninhabited
Pakistan	45,167	3.2	17	22	20.6	18.7	14.1	4.4
Punjab	25,266	3.1	18	24.4	22.8	17.4	10.2	3.9
(% of population living in village size category)		(16.6)	(40.4)	(25.7)	(12.1)	(4.5)	(0.7)	-
Sweet water zone								
Sheikhupura district	1,090	5	21.1	23.4	19.9	15	8.6	6.9
(% of population living in village size category)		(26.1)	(40.1)	(20.9)	(9.2)	(3.3)	(0.5)	-
Sheikhupura subdistrict	284	11.3	44.4	24.6	12.7	5.6	0.4	1.1
Brackish water zone								
Faisalabad district	1,350	4.6	55.5	25.6	7.5	3.2	2.7	0.9
(% of population living in village size category)		(13.9)	(66.5)	(16.6)	(2.4)	(0.5)	(0.1)	-
Faisalabad subdistrict	259	15.4	65.6	15.4	2.3	0.4	0.8	0.0
Arid zone								
Rawalpindi district	1,177	1.4	9.3	20.6	25.2	22.9	11.9	8.9
(% of population living in village size category)		(12.5)	(28.9)	(29.4)	(19.5)	(8.3)	(1.3)	-
Rawalpindi subdistrict	362	1.4	8.3	18.5	28.7	27.9	11.9	3.3

Source: Handbook of Population Census Data, Pakistan Census Organization, Statistics Division, Government of Pakistan, 1985. Population census, 1981.

Table J.2
Sources of Water and Light in the Three Environmental Zones (1981)
(% of Housing Units with Access)

Zone	Source of drinking water: Inside house: Piped	Inside house: Hand-pump	Inside house: Well	Outside house: Piped	Outside house: Hand-pump	Outside house: Well	Outside house: Pond	Outside house: Spring/river/ stream etc.	Outside house: Elec-tricity
Punjab	3	37	5	3	15	16	4	17	15
Sweet water zone									
Sheikhupura District	2.1	72	0.8	0.5	19.1	5.2	0	0.4	23.6
Brackish water zone									
Faisalabad District	2.0	64.4	0.6	0.8	18.1	2.8	9.2	2.1	16.7
Arid zone									
Rawalpindi District	3.2	1.1	4.6	2.7	0.4	62.3	0.1	25.4	16.7

Source: Housing census, 1980. Population census, 1981.

Table J.3
Occupational Profile of the Three Environmental Zones

Zone	Sweet water zone (Sheikhupura Dist.)	Brackish-water zone (Faisalabad Dist.)	Arid zone (Rawalpindi Dist.)
Total working population (age 10 years and above)	516,838	920,700	245,440
Percentage of working Population engaged in:			
Agriculture	54	54.9	52.9
Manufacturing	16.9	13.7	5.8
Construction	4.4	4.2	5.4
Trade	6.1	6.6	6.7
Transport	3.4	3	5.1
Services	13.4	12.2	17.6
Others	1.8	5.5	6.5

Source: Population census, 1981.

Table J.4
Financial Cost* (Rs) to an Average Household for Different Service Options (Brackish-Water Zone)

Service Option		Total capital	Monthly capital	Monthly O & M	Total monthly
(1)	Handpump[a]	1000	13	5	18
(2)	Domestic connection[b]	600[c]	6	12[d]	18
(3)	Electric motor[e]	1500	20	20	40
(1+2)	Handpump and domestic Connection	1600	19	17	36
(1+3)	Handpump and electric Motor	2500	33	25	58
(1+2+3)	Handpump, electric motor and domestic connection	3100	39	37	76

Not included in the above estimates are average capital costs of indoor plumbing often associated with service options (1+2), (1+3), and (1+2+3): Overhead Tank, Rs 500; Indoor Piping, Rs 500; Flush Toilet + Septic Pit Rs 4,000–10,000.

a Assumes an economic life of 10 years; 10% real interest. Includes cost of shallow well.
b Twenty years; 10% interest.
c Connection fee, Rs 100; Connection costs, Rs 500.
d Monthly tariff paid by household for an unmetered connection.
e Ten years; 10% interest.

* There is a lot of variation in the cost depending upon the size of the septic tank and whether soak pit included.

Table J.5
Households' Choice of Service Level by Socioeconomic Characteristics (Villages with Piped Water Supply)

	Sweet water zone		Brackish-water zone	
Service level	Value of house (Rs)	Years of education (most educated member of household)	Value of house (Rs)	Years of education (most educated member of household)
Handpump	48,500	6	62,100	5
Handpump and domestic connection	96,100	9	112,400	7
Handpump and electric motor	137,500	12	115,000	8
Handpump, electric motor and domestic connection	208,500	12	145,200	10

Table J.6
Mean WTP Bids for House Connections as a Percent of Household Income

	Sweet water zone	Brackish-water zone	Arid zone
1. Mean WTP bid (Rs)	21	40	49
2. Date bids obtained	March 1988	August 1988	June 1989
3. Monthly household income (Rs)[a]	1,995	1,679	1,409
4. Monthly household expenditure (from survey data 1988-89)	—	1,944	1,589
Based on this information:			
WTP as a percent of income is:	1.1	2.4	3.5
WTP as percent of expenditure is:	—	2.1	3.1

a The income in the survey villages is likely to be somewhat higher than the district average because of proximity to the district headquarters. Also the adjustment for inflation would raise income. Therefore, the percentages would be lower than the already low values. These are average rural household incomes for the study districts from the 1984-85 Household Income and Expenditure Survey.

Table J.7
Costs of Village-Level Water Supply Options (Rs)

Service option	Typical Village with 5,000 Population (Sweet water zone) Total capital	Monthly capital	Monthly O & M	Total monthly
(1) Piped water system (100% of households connected)				
Cost to PHED	1,500,000	13,500	3,800	17,300
Cost to households	281,000	2,500	—	2,500
Total				19,800
(2) Actual current water expenditures 30% - Handpump and electric motor 70% - Handpump only	815,500	10,600	6,200	16,800
(3) Summation of households' willingness-to-pay bids				11,800
(4) Estimated revenue based on tariff of Rs 12.5 per month, 75% households connected, and Rs 80 connection fee.	34,000	300	5,300	5,600
(5) Cost of piped water system to PHED for 75% households	1,125,000	10,000	2,800	12,800

Table J.8
Costs of Village-Level Water Supply Options (Rs)

Service option	Typical village with 5000 population[a] (Brackish-water zone) Total capital (Rs)	Monthly capital (Rs)	Monthly O & M (Rs)	Total monthly (Rs)
(1) Piped water system (100% of households connected)				
Cost to PHED	1,500,000[b]	13,500[c]	3,800[d]	17,300
Cost to households	281,000[e]	2,500[c]	—	2,500
Total				19,800
(2) Actual current water expenditures 62% - Handpump and electric motor 38% - Handpump only	1,084,000[f]	14,100[g]	9,800	23,900
(3) Summation of households' willingness-to-pay bids				22,500
(4) Estimated revenue based on tariff of Rs 25 per month, 78% households connected, and Rs 80 connection fee.	35,000	300[h]	11,000	11,300
(5) Cost of piped water system to PHED for 78% households	1,170,000	10,500[c]	2,900[d]	13,400

a 562 houses with 8.9 inhabitants per household.
b Based on tubewell at Rs 300 per capita capital costs.
c Assumes an economic life of 25 years, 10% real interest rate.
d Assumes annual operation and maintenance costs equal to 3% of total capital costs (based on cost data from PHED).
e Rs 500 connection costs per household.
f Cost of electric motor, Rs 1500; Cost of handpump, Rs 1000.
g Assumes an economic life of 10 years, 10% real interest rate.
h Computed over 25 years at 10% real interest rate.

Table J.9
Comparative Features of the Three Environmental Zones[a]

	Sweet water zone	Brackish water zone	Arid zone
Averge village size[b] (number of inhabitants)	5,778	10,229[c]	1,085
Monthly household income[d] (Rs)	1,995	1,679	1,409
Monthly household expenditure per capita (Rs)	—	216	227
Construction value of house (000 Rs)	86	134	103
Household size	9	9	7
Percentage of			
Adult women in household	26	28	30
Children in household	41	37	38
Age of head of household (years)	50	51	51
No. of years of education of most educated			
Member of household	8	9	8
Woman in household	4	4	3
Households involved in farming (%)	27	18	31
Households owning animals (%)	—	45	72
Households with land or other property (%)	63	52	75
Households with external exposure (%)	33	37	50

a Sample statistics except where indicated.
b Population of sample villages from population census, 1981.
c There is one very large village in the sample (Pop. 20,586). The average excluding this village is 8,157.
d Source: Household Income and Expenditure Survey, 1984-85. The values are the average rural household incomes for the three study districts. The comparative values for Punjab and Pakistan are Rs 1,533 and Rs 1,545, respectively.

Table J.10
Comparative Water-Related Characteristics in the Three Environmental Zones*

	Sweet water zone	Brackish-water zone	Arid zone
Monthly tariff for domestic connection to piped water system (Rs)**	10	12	20
Percentage of connected households in villages with piped water systems	55	75	96
Essential water consumption (Liters/person/day)			
Villages with piped water	19	31	23
Villages without piped water	24	32	23
Water consumption of animals (Liters/animal/day)			
Villages with piped water	—	48	36
Villages without piped water	—	58	43
Households that believe water should be supplied free (%)	44	52	88
Households that believe water can be supplied free (%)	38	27	67
Households that favor metering of house connections (%)	54	81	61
Households that believe water supply systems should be managed by PHED (%)	71	66	78

* Sample statistics except where indicated.
** Source: PHED

Table J.11
Mean Willingness-to-Pay Bids for Monthly Tariff of Piped Water Systems with House Connections in the Three Zones

	Sweet water zone (Current tariff= Rs 10 per month)	Brackish-water zone (Current tariff= Rs 12 per month)	Arid zone (Current tariff= Rs 20 per month)
Villages with piped supply			
Mean WTP bid for standard system[a]	—	16	39
Mean WTP bid for improved system[b]	15	33	51
Villages without piped supply			
1. (but which had a piped system in the past)[c]			
- Mean WTP bid for standard system	17	—	—
2. (and in which households know a piped system will be installed soon)			
- Mean WTP bid for standard system	—	41	42
- Mean WTP bid for improved system	—	58	59
3. (no piped system in the past, no piped system planned)			
- Mean WTP bid for standpipe system	—	—	35
- Mean WTP bid for standard system	21	37	55
- Mean WTP bid for improved system	—	51	—

a Standard system refers to the kind of piped water system with house connections which has been installed by the PHED in Punjab.

b In the sweet water zone the improvement consists of the supply of an extra 4 hours of water per day from the standard system. In the other two zones it consists of a continuous water supply with improved pressure and reliability.

c No systems are planned to be installed in the sweet water zone. One village has an inoperative system.

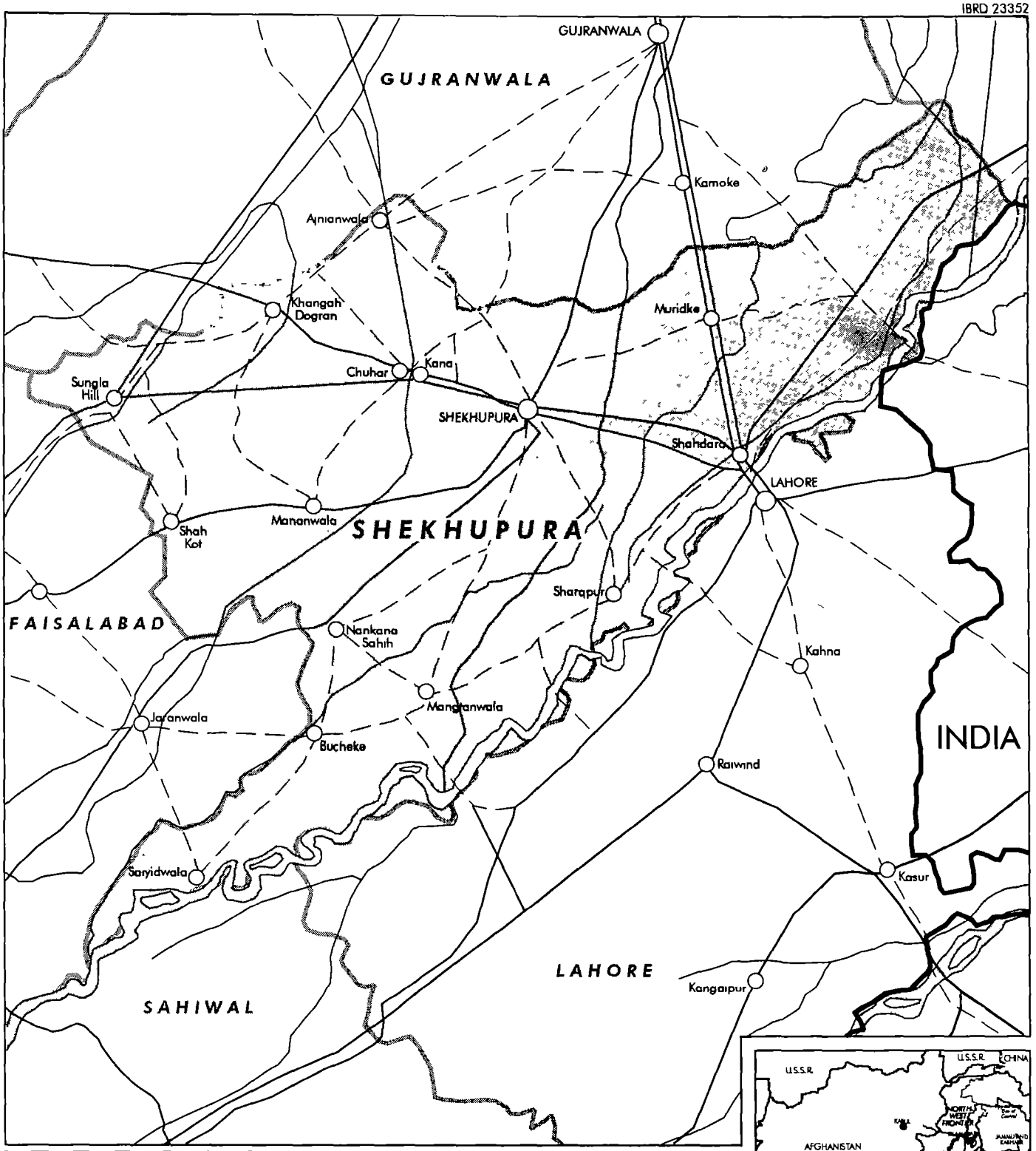
Table J.12
Actual and Hypothetical Frequency of Connection to Piped Water Systems with House Connections in the Three Zones

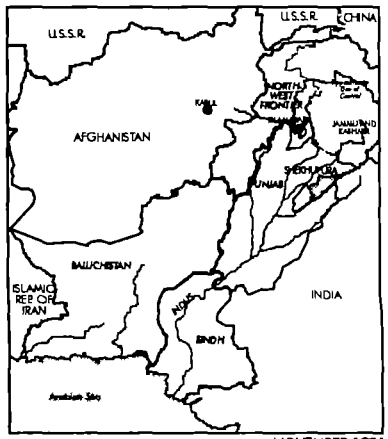
	Sweet water zone (Current tariff= Rs 10 per month)	Brackish-water zone (Current tariff= Rs 12 per month)	Arid zone (Current tariff= Rs 20 per month)
Villages with piped supply			
- Households actually connected at current tariff (%)	55	75	96
- Households who say they would connect at the current tariff if the piped system were improved[a]	60	95	94
Villages without piped supply			
1. (but which once had a piped system)[b]			
- Households who say they would connect to a piped system at current tariff (%)	84	—	—
2. (and in which households know that a piped system will be installed soon)			
- Households who say they would connect to a piped system at the current tariff (%)	—	97	87
3. (no piped system in the the past, none planned)			
- Households who say they would connect to a piped system at the current tariff (%)	85	90	94
- Households that would subscribe to a standpipe system at Rs 15 per month	—	—	84

a See footnote 2, Table J-10.
b When the system was operative, 69% of the households were connected.

Table J.13
Households' Willingness to Pay for Connection to Piped Water System by Socioeconomic Characteristics (Villages without Piped Water Supply)

	Sweet water zone		Brackish water zone		Arid zone	
	Percent of sample	Mean WTP bid (Rs per month)	Percent of sample	Mean WTP bid (Rs per month)	Percent of sample	Mean WTP bid (Rs per month)
Education of most educated member of household						
0 - 8 years	44	15	38	36	48	44
9 - 12 years	41	21	41	40	48	53
> 12 years	15	33	21	47	4	55
Construction value of house (Rs)						
0 - 49,000	38	14	9	33	25	44
50,000 - 99,000	40	20	22	36	31	41
100,000 - 149,000	10	21	19	38	21	56
≥ 150,000	12	35	50	44	23	56
Occupation						
Non-farming	75	21	79	40	58	53
Farming	25	17	21	41	42	43
Ownership of animals						
Yes	N.A.	N.A.	49	41	80	48
No			51	39	20	53
Overall mean		21		40		49





PAKISTAN

SHEKHUPURA DISTRICT

- SHEKHUPURA DISTRICT
- SELECTED CITIES
- DISRTICT BOUNDARIES
- INTERNATIONAL BOUNDARIES
- RIVERS
- MAJOR ROADS
- OTHER ROADS
- RAILROADS

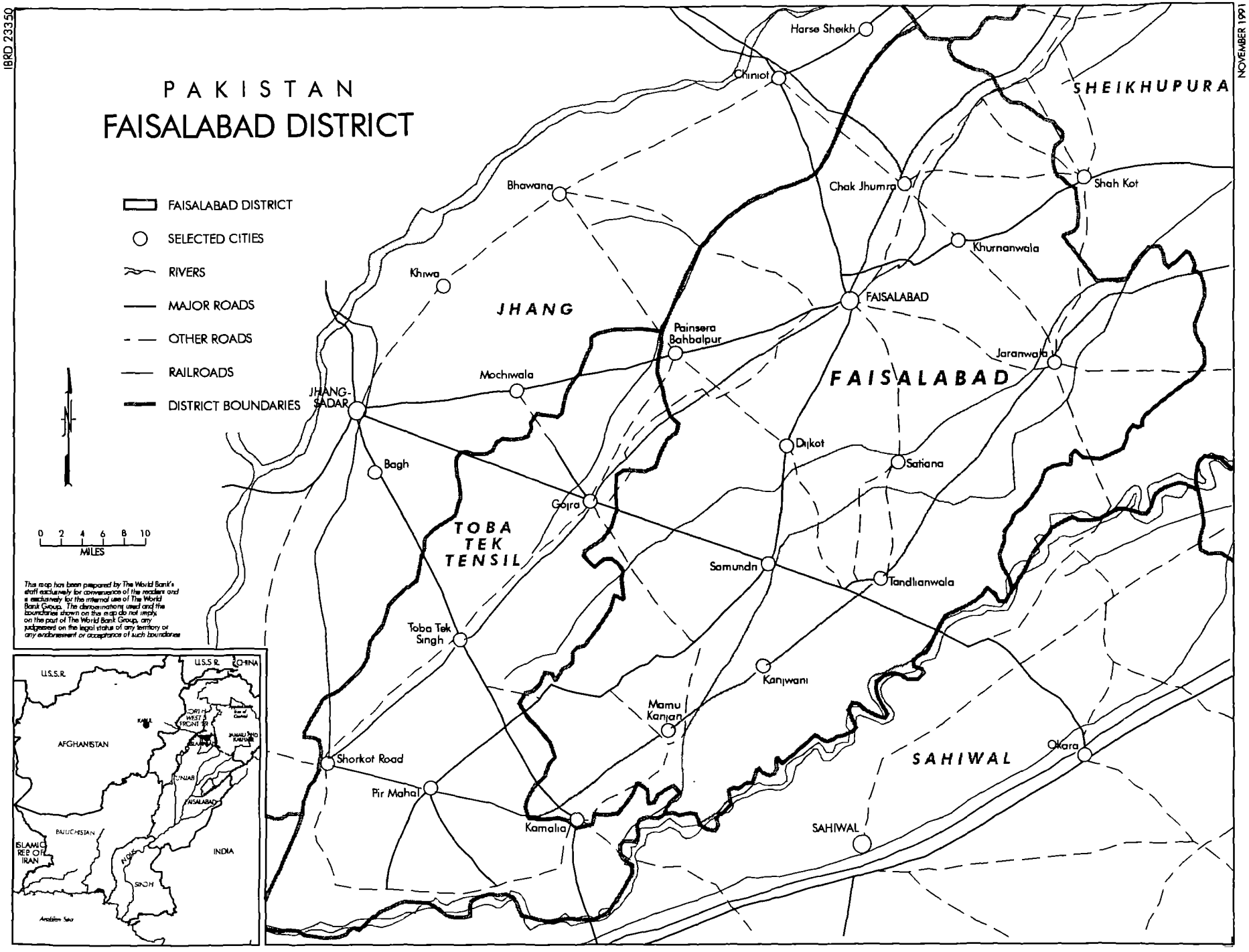
0 2 4 6 8 10
MILES

NOVEMBER 1991

IBRD 23350

NOVEMBER 1991

PAKISTAN
FAISALABAD DISTRICT



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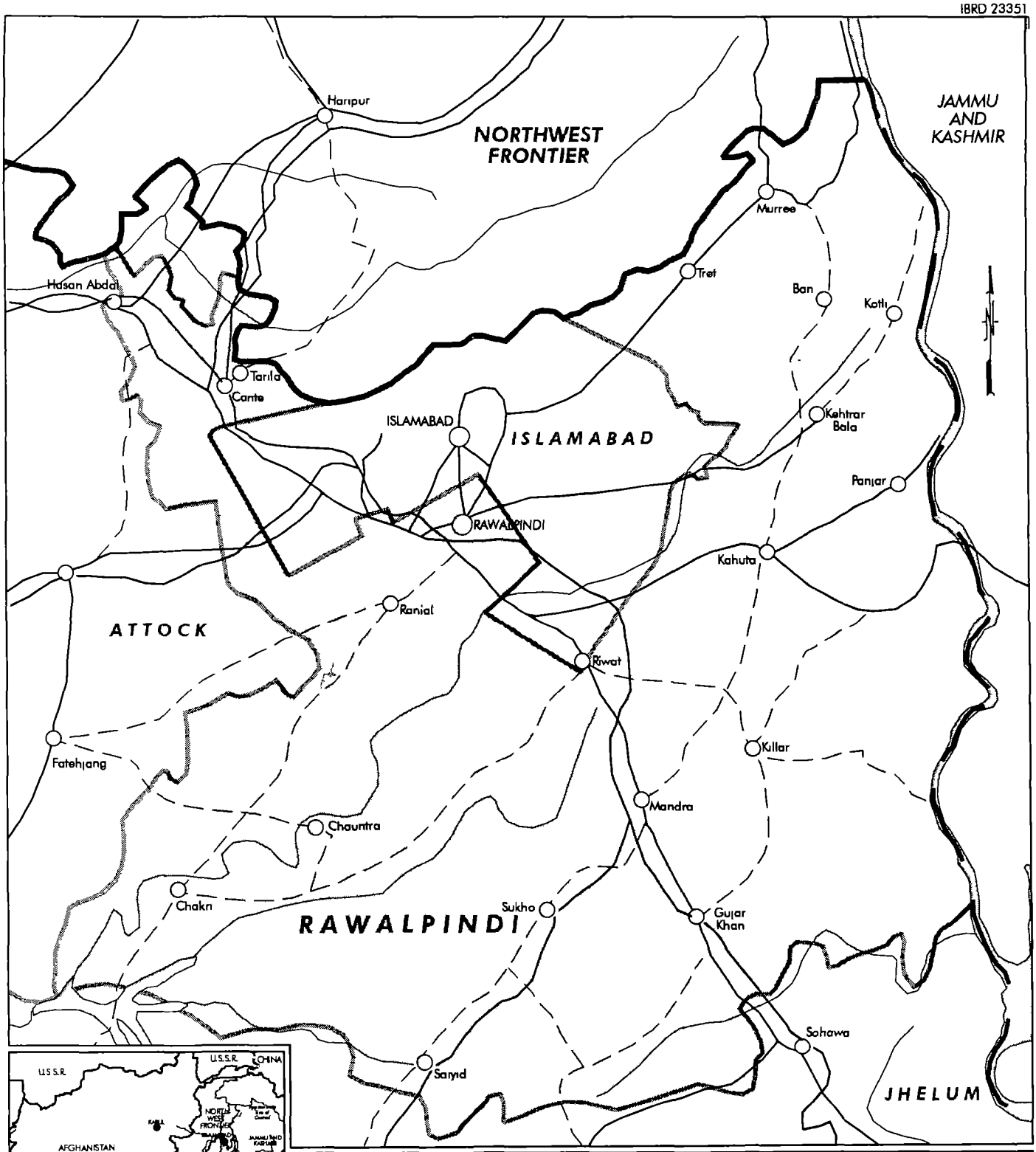

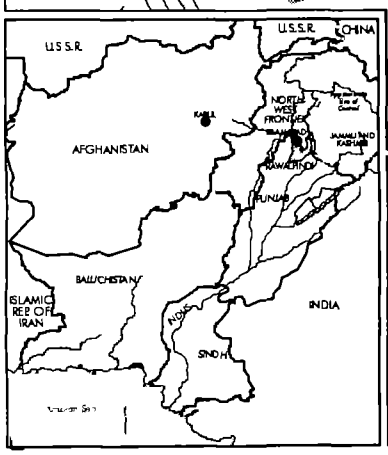

PAKISTAN
RAWALPINDI DISTRICT

RAWALPINDI DISTRICT
SELECTED CITIES
DISRTICT BOUNDARIES
PROVINCE BOUNDARIES
RIVERS
MAJOR ROADS
OTHER ROADS
RAILROADS

0 2 4 6 8 10
MILES

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NOVEMBER 1991

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