CHAPTER 3

DEMAND ANALYSIS AND FORECASTING

CONTENTS

Figures

Boxes

Tables

3.1 Effective Water Demand

3.1.1 Defining Effective Demand for Water

1. The "effective demand" for water is the quantity of water demanded of a given quality at a specified price. The analysis of demand for water, including realistically forecasting future levels of demand, is an important and critical step in the economic analysis of water supply projects. The results of demand analysis will enable the project team to:

(i) determine the service level(s) to be provided;
(ii) determine the size and timing of investments;
(iii) estimate the financial and economic benefits of the project; and
(iv) assess the ability and willingness to pay of the project beneficiaries. Furthermore, the surveys carried out during the demand assessment will provide data on cost savings, willingness to pay, income and other data needed for economic analysis.

2. It is useful to note the difference between "effective demand" for water and "actual consumption" of water. Water consumption is the actual quantity of water consumed whereas effective demand relates that quantity to the price of water. For example, a low level of water consumption may not represent effective demand but may instead indicate a constraint in the existing supply of water. This is illustrated in Box 3.1.

Box 3.1 Example of Constrained Water Demand

In Rawalpindi, Pakistan, the existing water supply system provided water for only an average of 3.8 hours per day and, on average, six days per week. Families connected to the public water supply system used an average 76 lcd. An additional 16 lcd was collected from secondary sources. From the household survey it appeared that during the (dry) summer, 86 percent of the population found the supply of water insufficient compared to 50 percent during the winter. Effective demand for water was higher than the quantity the utility was able to supply. This suggests that effective demand was constrained by existing supply levels.

Source: RETA 5608 - Case Study on the Water Supply and Sanitation Project, Rawalpindi, Pakistan

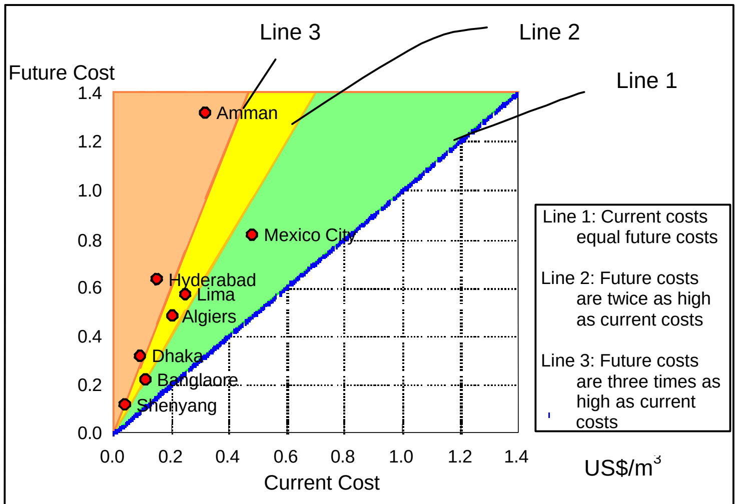
3.1.2 Increasing Cost of Water Supply

3. The demand for water is rising rapidly, resulting in water becoming increasingly scarce. At the same time, the unit cost of water is increasing, as water utilities shift to water sources farther away from the demand centers. Water from more distant sources may also be of lower quality. The costs of transporting water from the source to the consumer and that of water treatment necessary to meet potable water standards are becoming significant components of the unit cost of water.

4. The increase in the cost of water can be seen when the cost per cubic meter of water used by current water utilities is compared with the cost per cubic meter of water in new water supply projects (WSPs). This relation is shown in Box 3.2.

Box 3.2 **The Future Cost of Water**

For example, the current cost of water in Hyderabad is below \$0.2 per m^3 whereas in the figure below, the calculated cost of future water to be supplied through new schemes is more than \$0.6 per m^3. This means that future water is more than three times as expensive as water from the existing resources. Note that the points on line 1 indicate that future costs of water equal the current cost; the points on line 2 indicate that the future costs per unit are twice the current costs.



Source: Serageldin, Ismail. 1994. *The Financing Challenge*.

5. Box 3.2 reinforces the importance of making optimum use of scarce water resources by avoiding inefficiencies and wastage in existing supplies and designing efficient future investment projects. In designing new projects, it is becoming increasingly important to make optimum use of existing resources to be able to avoid or postpone costly investments in the future.

3.2 The Demand for Water: *Some Concepts*

3.2.1 Incremental vs. Nonincremental Demand for Water

6. A WSP usually increases the supply of water either by making more effective use of existing supply capacity or by adding additional supply capacity. To the consumer, the additional capacity supplied will either displace and/or add to already existing water sources. Every person uses water for drinking, cooking, bathing, washing of clothes, for sanitation purposes, etc. Sources of water include piped water supply systems, dugwells, hand pumps, canals, ponds, rivers, bottled water, water from vendors, rainwater, etc.

7. If the additional supply of water is used to displace already existing sources, it is called nonincremental demand. For example, a household which obtains a new connection to the piped water supply system may no longer make use of the existing dugwell.

8. If the additional supply of water generates an increase in existing consumption, it is called incremental demand. For example, a household obtaining its water from a well at a distance of 300 meters may increase its water consumption from 450 liters to 650 liters per day after a public tap is installed in closer proximity to the house.

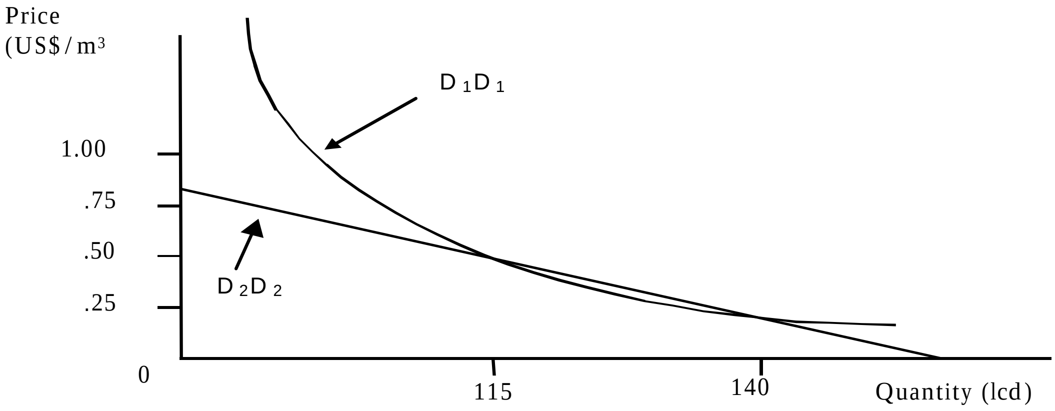
3.2.2 The Relation between Price and Quantity

9. From an economic perspective, the price of water is an important determinant of per capita water consumption. The relation between the quantity of water used and the price is illustrated by a demand or willingness-to-pay curve for water, an example of which is given in Figure 3.1.

10. The downward sloping demand curve indicates the “decreasing marginal value” of water. The first five liters of water per capita per day will be extremely valuable as they are necessary to sustain life. This is illustrated by curve D_1D_1 in Figure 3.1. The second five liters will also be valuable, (e.g. in their use for hygienic purposes). The next five liters are valuable for food preparation, cooking and washing of clothes. All other factors being equal, for each additional increment of water, the marginal value of water tends to decline as the individual is putting the water to less and less valuable uses. Consequently, the individual’s willingness to pay for each increment of water will gradually decrease.

11. D_1 D_1 in Figure 3.1. represents a non-linear curve for an average household and shows an example of an individual’s water demand or willingness-to-pay curve. If the water tariff is increased from \$0.25 to \$0.50, this individual would (all other factors remaining equal) reduce daily consumption from 140 liters to 115 liters.

Figure 3.1 An Individual’s Water Demand Curve: Linear and Non-linear Relationships



12. In this Handbook, a linear demand curve will often be used for illustrative purposes, as indicated by line D_2 D_2. However, the nonlinear relationship between quantity and price is probably a better approximation of the actual behavior of water users.

3.2.3 The Concept of Price Elasticity of Demand

13. One question which often arises when considering the demand curve is how much the quantity demanded by an individual will change when the price per unit of water changes. The price elasticity of demand is a measure that describes the degree of responsiveness of the quantity of water to a given price change and is defined as follows:

$$e_p = - \frac{\text{percentage change in the quantity of water demanded}}{\text{percentage change in the price per unit of water}}$$

$$e_p = - \frac{dQ/Q}{dP/P} = - \frac{dQ}{Q} \times \frac{P}{dP} = - \frac{dQ}{dP} \times \frac{P}{Q} = \text{slope} \times \frac{P}{Q}$$

14. The price elasticity of demand for water is normally negative because the demand curve is downward sloping, which means that an increase (decrease) in price is expected to lead to a reduction (increase) in demand.

15. If $e_p < |1|$, demand is '**inelastic**'. For example, if an increase of 25 percent in water fees leads to a 10 percent reduction in the demand for water, this would result in a price elasticity of -0.40. The relative change in quantity demanded (dQ/Q) is, in this case, smaller than the relative change in price (dP/P).

16. If $e_p > |1|$, demand is **elastic**. For example, if a 25 percent increase in water fees leads to a 50 percent reduction in demand, this would result in a price elasticity of -2. The percentage change in quantity demanded is larger than the percentage change in price.

17. For a linear demand curve as can be verified through the formula for e_p, the higher the price, the higher the absolute value of price elasticity. Using a nonlinear demand curve (Figure 3.1), it can be seen that for the first few liters of water, demand will be very inelastic, meaning that the consumer is willing to pay a high price for the given volume of water. As the marginal value of the water gradually declines, the consumer's demand will become increasingly elastic, meaning that price fluctuations will result in larger changes in quantity demanded.

18. In studies carried out by the World Bank (Lovei, 1992), it has been found that the price elasticity for water typically ranges between -0.2 and -0.8, indicating

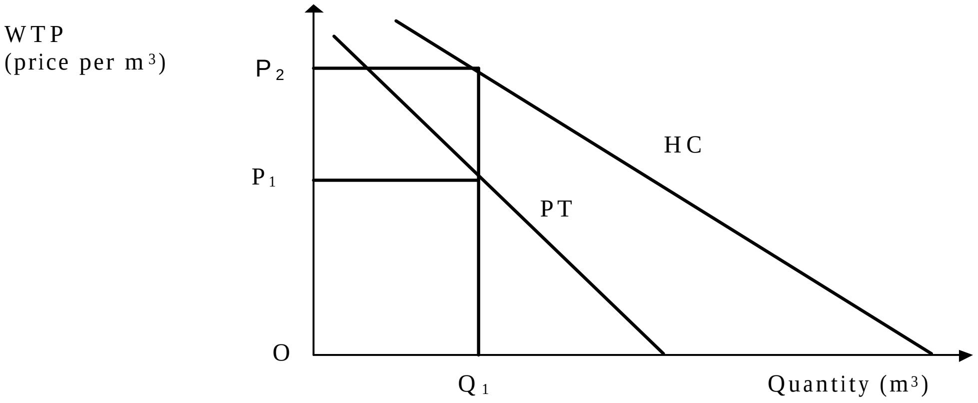
inelastic demand. For example, e = -0.2 means that a 10 percent increase in price would lead to a reduction in the quantity demanded by only 2 percent.

3.2.4 Different Demand Curves for Different Products

19. The definition of effective demand mentions " the demand for water of a certain quality". The quality of the product "water" is not easily explained and a number of characteristics are normally included in defining it, including chemical composition (e.g., WHO standards), taste and smell, water pressure, reliability of supply, accessibility and convenience. The first two characteristics determine the quality of water in the stricter sense. The other characteristics define water quality in its broader sense.

20. The combination of these characteristics will determine the "product" water or service level. Up to a certain point, an individual is prepared to pay a higher price for a product with a higher quality. For the same "quantity" of water, an individual will be willing to pay a higher price for a higher quality product. For example, consumers are normally willing to pay a higher price for water from a house connection than for water from a public tap. In this case, there are two different demand curves: one for house connections (HC) as shown in Figure 3.2, and one for public taps (PT) as shown in Figure 3.3.

Figure 3.2 Demand Curves for Water from Public Taps vs. House Connections

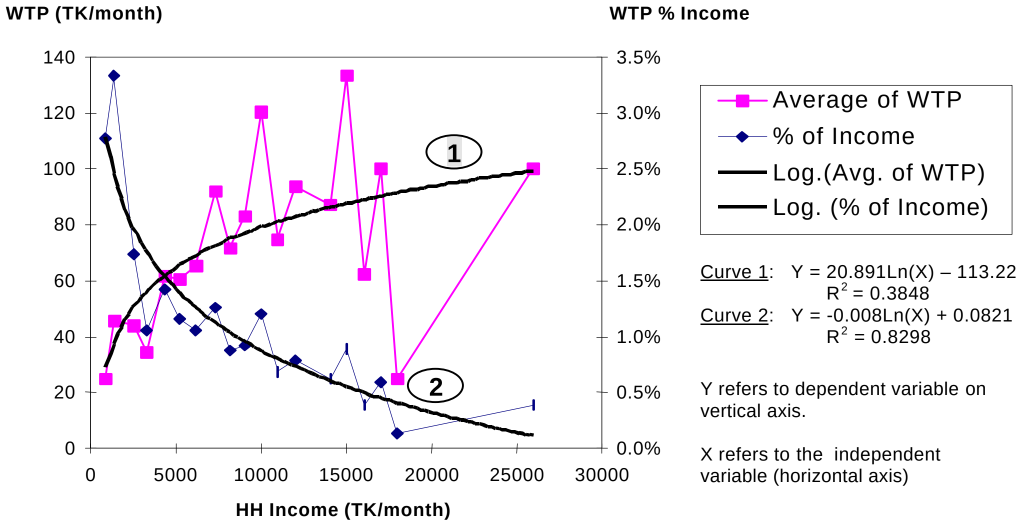


3.2.5 The Relation between Household Income and the Demand for Water

21. Households with high income are normally able and willing to pay more for a given quantity of water than households with lower incomes. In relative terms (as a percent of income) however, people with higher incomes are prepared to pay smaller percentages of their income for water than people with lower incomes. These statements were confirmed in the case studies and are illustrated in Box 3.3.

Box 3.3 Relationship Between WTP and Income

The relationship between willingness to pay and month income has been confirmed in the case studies. For example, in Jamalpur, Bangladesh, the relationship as illustrated below was found.

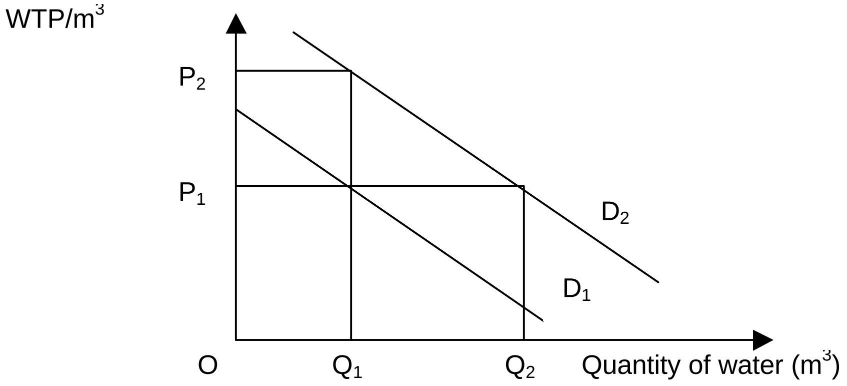


Curve 1 explains the relationship between income and WTP in absolute terms. Households with higher income are willing to pay more for the total quantity of water consumed. Curve 2 illustrates the relation between income and WTP as a percentage of income. When income increases, a smaller proportion of household income is set aside to pay for water.

Source: RETA 5608 Case Study on the Jamalpur Water Supply and Sanitation Project, Bangladesh

22. An increase in income will cause the demand curve for water to shift to the right (from D_1 to D_2), as illustrated in Figure 3.4. At price P_1 the quantity of water consumed increases from OQ_1 to OQ_2. The shift in the demand curve to the right also indicates a higher willingness to pay (from P_1 to P_2) for the same quantity of water OQ_1.

Figure 3.3 Relation between Demand and Income: Shift of Demand Curve



23. The relation between water consumption and income can be expressed in terms of "income elasticity". The formula for income elasticity is as follows:

$$e_i = \frac{\text{Percentage change in quantity of water consumed}}{\text{Percentage change in Income}}$$

$$e_i = + \frac{dQ/Q}{dI/I} = \frac{dQ}{dI} \times \frac{I}{Q}$$

24. The literature on the relation between income and water consumption is rather limited, but a value between 0.4 and 0.5 appears to be reasonable (see e.g. Katzman 1977, Hubbell 1977 and Meroz 1986). A positive income elasticity of 0.4 means that if an individual's household income increases by 10 percent, consumption is expected to increase by 4 percent. A value which is less than one shows that the demand for water is rather inelastic to changes in income.

25. For example: consider the case that income increases from Rp200,000 (I_1) to Rp300,000 (I_2), and water consumption increases from 15 m^3/month (Q_1) to 18 m^3/month (Q_2). In this case, income elasticity is calculated as follows:

$$\begin{aligned} e_i &= (dQ/DI \times I/Q) \\ &= ((Q_2-Q_1)/(I_2-I_1)) \times I_1/Q_1 \\ &= ((18-15)/(300{,}000-200{,}000)) \times 200{,}000/15 \\ &= 0.4 \end{aligned}$$

3.2.6 Other Determinants of the Demand for Water

26. In addition to price and income, other factors or determinants can also influence the demand for water. A checklist of possible water demand determinants is presented in Table 3.1. Each project may have its own set of water demand determinants and the importance of a given factor may differ from one project to another. The major determinants of water demand are briefly discussed below:

(i) Domestic Demand

(a) *Population*. Population (especially population growth) is a very important factor in determining future demand. Population growth may consist of natural growth or, in certain cases, migration (e.g. from rural to urban areas). Small differences in demographic trends have large effects on water consumption. For example, all other factors remaining constant, an annual population growth of 2 percent over a period of 20 years results in an increase in consumption of approximately 50 percent; whereas an annual growth of only 1.5 percent generates an additional consumption of about 35 percent over the same period.

(b) *Access to and Costs of Alternative Sources*. If water from other sources of good quality is readily available, people will generally be less interested to displace their current sources. For example, in areas where shallow ground water of good quality is available throughout the year and when households have their own dugwells, people may be less inclined to apply for a connection to a new piped system especially if the price of piped water is higher than the unit cost of water from the alternative source.

(c) *Availability and Quality of Service*. If existing water supply companies provide a fully satisfactory service to their customers, households not yet connected will usually be more interested in connecting to an expanded water supply system.

(ii) Nondomestic Demand

(a) *Size and Type of Industry*. Logically, size and the type of industry will, to a large extent, determine the quantity of future consumption of water.

(b) *Industrial growth*. Economic development and regional or urban development may strongly influence future demand for water.

(c) *Legal obligations*. In certain countries or industrial areas, industries must apply for a permit to make use of alternative sources (for example, ground water) or are obligated to connect to piped systems, if available.

27. The demand for water is often analyzed for relatively homogeneous groups of users. In many cases, a distinction is made between domestic and nondomestic users. Furthermore, demand from domestic users is often separately analyzed for :

(i) users currently connected to the system (existing connections) and

(ii) those to be connected to the system under the proposed project (new connections).

Table 3.1 Major Determinants of Water Demand

A. Domestic Demand
   1. Number and size of households
   2. Family income and income distribution
   3. Costs of water presently used
   4. Cost of future water used
   5. Connection charges
   6. Availability and quality of service
   7. Cost and availability of water using devices
   8. Availability of alternative water sources
   9. Present water consumption
   10. Legal requirements
   11. Population density
   12. Cultural influences

B. Commercial Demand
   1. Sales or value added of non-subsistence commercial sector
   2. Costs and volume of water presently used
   3. Price of future water used
   4. Connection charges
   5. Costs of water using appliances
   6. Quality and reliability of service
   7. Working hours of various types of commercial establishments
   8. Legal requirements

C. Industrial Demand
   1. Present and future costs of water
   2. Type of industry and water use intensity
   3. Relative price of alternative sources
   4. Quality and reliability of supply
   5. Costs of treatment and disposal of waste water
   6. Legal requirements

D. Agricultural Demand (for [non] piped water supply)
   1. Present and future costs of water
   2. Availability of other sources
   3. Quality and reliability of supply
   4. Supply cost of alternative water systems
   5. Number of cattle
   6. Legal requirements

E. Public Services Demand
   1. Present and future costs of water
   2. Per capita revenue of local governments
   3. Number and size of public schools, hospitals etc.
   4. Legal requirements

28. The factors which determine domestic demand may differ between the urban and the rural sector. In the rural sector, special attention needs to be given to such things as the availability of alternative water sources, the income and ability to pay for or contribute to the project facilities and their management, the choice of technology and the use of water for other purposes like agriculture (e.g. livestock or vegetable growing) and, the ability to operate and maintain facilities. In the rural context, the assessment of effective demand will have to be carried out in close consultation with the local population, and attention needs to be given to issues such as community participation and hygiene education.

29. The factors which determine demand will, to a large extent, define the need for information. The project analyst will have to determine the key factors which need to be considered into the analysis and design of the project.

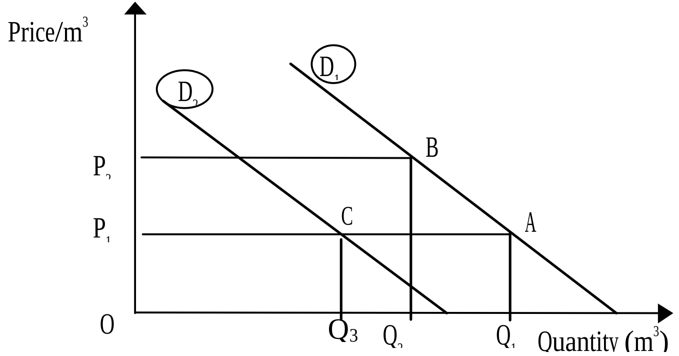
3.3 The Use of Water Pricing to "Manage" Demand

30. In Section 3.2 the relation between the price of water and the quantity of water was explained. This section deals with some applications of this concept.

3.3.1 Instruments of Demand Management

31. To understand how the quantity of water demanded can be influenced, let us look again at the demand curve for water, as illustrated in Figure 3.4.

Figure 3.4 Demand Management



32. Assume that present demand is Q_1 at price P_1. This refers to point A on demand curve D1. To reduce demand, one can try to:

(i) reduce the quantity demanded by increasing the price of (excessive) water use. This will result in a reduction of demand from, for example, point A to B (movement along the same demand curve). At a higher price (OP_2), a smaller quantity of water (OQ_2) is demanded. By introducing financial incentives, consumers (domestic and nondomestic) can be expected to reduce their water consumption. Often, the objectives and reasons for such a policy will have to be thoroughly explained to the users through public education programs. Examples of introducing financial measures include:

(a) increasing the average water tariff;

(b) introducing progressive water tariff structures, aiming at reduction of excessive water use;

(c) increasing tariffs for wastewater discharge: (industries will be particularly sensitive to this measure);

(d) introducing ground water abstraction fees;

(e) fiscal incentives (e.g. for investments in water saving devices or treatment plants);

(f) utilization of water markets: experience from water markets in the United States and Gujarat, India indicates that water markets create a framework which contributes to the efficient use of water.

An example of application of pricing effects is given in Box 3.4.

Box 3.4 Increased Water Tariff in Bogor, Indonesia

In 1988, after increases in average water tariffs for domestic users (about 115 percent) and nondomestic users (170 percent), the consumption of water per household dropped from an average of about 38 m^3 per household per month to an average of about 27 m^3 per month. This price increase was accompanied by an intensive public education program. This has resulted in consumption being maintained below previous levels, notwithstanding the fact that real water prices have since declined and incomes have continued to increase until mid-1997.

Source: IWACO-WASECO. 1989(October). *Bogor Water Supply Project: The Impact of the Price Increase in June 1988 on the Demand for Water in Bogor*.

Price increases may also have undesirable effects. In the case of a significant increase in the price of water by a utility, consumers may, whenever feasible, divert to other water sources. For example, in Jakarta, excessive use of ground water causes land levels to go down. If, in this situation water tariffs are significantly increased, many consumers would again divert to ground water as a main source of water. A tariff increase introduced by the utility would, therefore, have to be accompanied by other measures to control the use of ground water, such as: (higher) fees for the use of ground water to industries; taxes to domestic users of ground water; and educational programs.

(ii) move the demand curve to the left, resulting in a reduction in the quantity demanded from point A to point C. This means that at the same price level (P_1), the quantity of water demanded will be reduced from OQ_1 to OQ_3. This can be achieved through:

(a) introduction of water saving devices;

(b) changing consumer behavior through educational programs;

(c) legal measures (e.g. regulating the use of ground water);

(d) industrial “water-audit” programs. This entails a review of the use of water and waste water in industrial plants, with the purpose of reducing the use of water.

(iii) save the use of water or avoid waste of water resources on the supply side. Such measures could include:

(a) increase in efficiency at the utility level (reduction of production losses, UFW); and

(b) institutional changes (merger of utilities may create economies of scale).

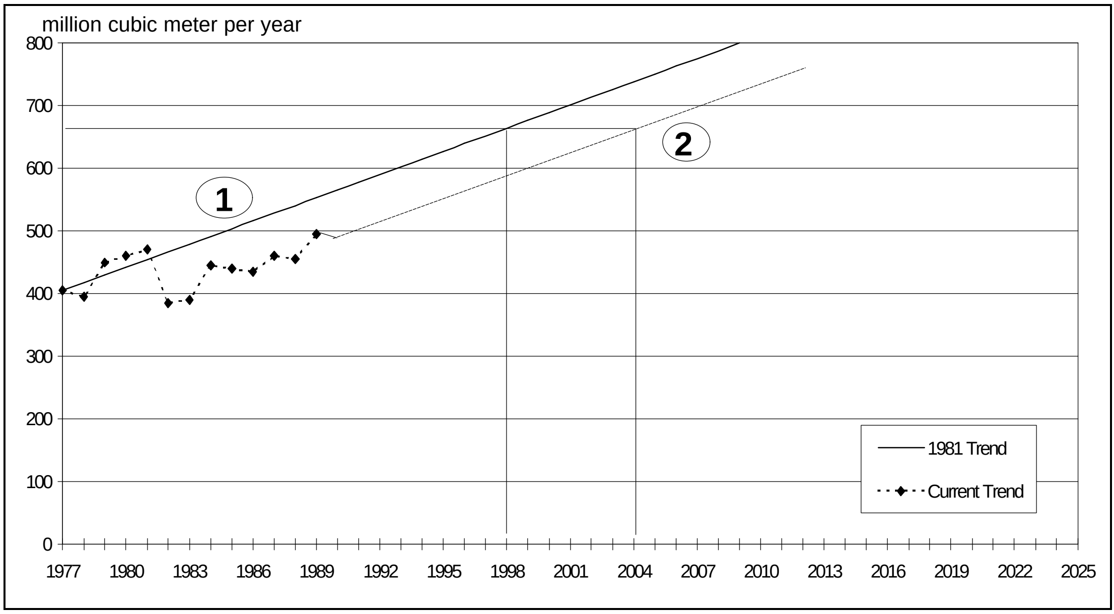
In most cases, water demand management and conservation policies will consist of a comprehensive set of measures to be carried out over a longer period of time to achieve the desired results.

3.3.2 Cumulative Effects of Water Demand Management and Conservation Programs

33. There is empirical evidence that domestic and nondomestic water consumption can be reduced by at least 20 to 30 percent by adopting appropriate demand management and conservation policies. Reduced water consumption will also result in reduced volumes of polluted water and will, in general, have positive environmental effects. Reductions in demand, in turn, will lead to substantial savings in needed investments as shown in Box 3.5. Finally, the water saved can be used for higher valued uses by other sectors in the economy.

Box 3.5 Demand Management and Investment Planning in Australia

In Melbourne, Australia, a combination of water demand management measures was used, such as: water pricing reforms, water saving devices, public education, etc. As a result, Melbourne's 1993 water demand projection (line 2) differs substantially from the 1981 trend (line 1). The shift to the right of the water trend curve has delayed the need to invest in additional supplies by about six years. The deferral in investment was valued at $25 million. This is illustrated in the figure below.



Source: Bhatia, Ramesh; Rita Cestti and James Winpenny. *Water Conservation and Reallocation: Best Practice Cases in Improving Economic Efficiency and Environmental Quality.* A World Bank-ODI Joint Study.

3.4 Data Collection

3.4.1 Cost Effectiveness of Data Collection

34. Data collection should be cost efficient and cost effective. The purpose of data collection is to improve the accuracy of the estimates and predictions made in designing and analyzing a WSP. It is therefore important to carefully consider which data are needed and where and how to obtain them.

35. The collection of data will require resources in terms of time and money. The benefit or value of additional data will gradually decrease. The project analyst will have to decide at which point the benefits of the additional data will no longer justify the cost made. At minimum, conducting a limited but representative household survey should provide essential information which could save large sums of money in terms of reduced investment.

3.4.2 Sources for Data Collection

36. Some methods of data collection, as they were used in the preparation of the case studies on which this Handbook is partly based, are presented in Appendix A. Section 1 of this appendix deals with:

(i) collection of secondary data from existing studies, water enterprises, government agencies, etc.;

(ii) conducting reconnaissance surveys in the area to observe the actual field situation; and

(iii) collection of primary data through field observations and household surveys.

37. Household surveys normally provide:

(i) data about family size, occupation, income etc.;

(ii) data about the quantity, quality and costs related to the current water supply (and sanitation) situation; and

(iii) data about the future use of water supply and sanitation: the preferences of respondents with regard to the future level of service, type of facility and what they are willing to pay for the preferred level of service.

3.4.3 Contingency Valuation Method

38. Using Contingency Valuation Method (CVM), the consumer is asked how much he or she is willing to pay for the preferred level of service. The data can be analyzed to provide the project analyst with an indication of the actual shape of the demand curve for water, thus helping to estimate the price elasticity of demand which is an important parameter in demand management. An example is given in Appendix A.

3.5 Demand Forecasting

39. Some of the initial steps in demand forecasting is defining the different service levels and preparing a rough estimate of the price of supplying these service levels in a specific village or town. Subsequently, water quantity demanded is estimated for the different combinations of service level and price.

40. Estimating a demand curve for a new WSP is difficult in practice and will, in most cases, require adequate resources and extensive field research. The Handbook emphasizes the need to undertake a comprehensive analysis of water demand for without-project and with-project situations for reasons explained earlier. Data on the factors which determine the demand for water will provide the project analyst with a better understanding of what is required and will enable him/her to formulate a better project.

3.5.1 Forecasting Urban Water Supply: *the Case of Thai Nguyen*

41. The techniques and methods used in water demand forecasting will be explained in this section by making use of a case study. The case study describes the steps in demand forecasting as it was carried out for Thai Nguyen, Viet Nam, one of the case studies developed in preparing this Handbook. Some of the data have been slightly adapted for illustration purposes.

42. The general process and specific considerations in forecasting water demand are explained in the text. The application of these principles to demand

forecasting in Thai Nguyen is described in the boxes. The data needed to carry out the demand analysis are presented in Table 3.2. A short description of Thai Nguyen is presented in Box 3.6.

Box 3.6 Thai Nguyen Case Study: Description of the Project Area

Thai Nguyen is located 80 km to the north of Hanoi on the Cau River. At the end of 1995, the population was 191,600 persons. The existing water supply system had 5,114 metered connections, which provided approximately 24 percent of the population with water.

The economy of Thai Nguyen is based on state enterprises, mainly heavy industry. There are also universities in the town. The main source of non-piped water supply is shallow groundwater, obtained through open wells or with electric pumps. A very small part of the population uses water from the river.

Source: RETA 5608 Case Study on the Provincial Towns Water Supply and Sanitation Project, Thai Nguyen, Viet Nam

Step 1: Estimating present and future population

43. A starting point in demand forecasting is determining the size and future growth of the population in the project area. This step is explained below, whereas the application of this step in Thai Nguyen is given in Box 3.7.

(i) The first step is to estimate the size of the existing population. In most cases, different estimates are available from different secondary sources. Often, the survey team will have to make its own estimate based on the different figures obtained.

(ii) The second step is to determine the service or project area (the area which will be covered by the project) and the number of people living there. The most important consideration in this respect is the expressed interest from potential customers. Furthermore, the service area will have to be determined in consultation with the project engineer, the municipal authorities and/or the water enterprise. Technical, economic and political considerations will play a role.

(iii) The third step is to estimate future population growth in the project area. This estimate will be based on available data about national, provincial or local population growth. It should also take into account the effects of urban and/or regional development plans and the effects of migration from rural to urban areas.

Box 3.7 Thai Nguyen Case Study: Assumptions Used, Ability to Pay and Willingness to Pay

Assumptions:

In the case of Thai Nguyen, these figures and assumptions have been applied (Table 3.2, lines 1-10):

(i) The annual population growth for Thai Nguyen has been estimated at 3% up to the year 1999 and 2.5% after that (line 1). These figures are lower compared to other Vietnamese towns because of its location in the mountainous northern part of Viet Nam; this percentage is applied to the population figures (line 2).

(ii) At present, the service area in Thai Nguyen covers only part of the town area with a 1995 population of 140,442 (line 4). The service area will remain the same in the new project. The population in the service area is assumed to grow faster compared to the general population growth because of better infrastructure facilities (line 3). The major expansion in the number of connections is assumed to take place between 1996 and 2000, then gradually after that,until 75% coverage is achieved (line 5).

(iii) One of the targets of the project was to achieve 75% coverage in the year 2020 (line 10). This figure was checked with the findings of a household survey, as follows:

First, 93% of the population expressed an **interest in connecting to the system** by means of a house connection. Interest for other service levels (public tap) was very low.

Second, **willingness to pay for water** in Thai Nguyen amounted to an average of VND3,005 per m^3 (VND2,317 per m^3 for connected households and VND3,119 per m^3 for non-connected households). WTP for connected households is lower than WTP for non-connected households. This might be explained by the fact that connected households are most likely influenced by the current average water tariff of VND900 per month. It can be assumed that willingness to pay will increase when income and service levels increase. For these reasons, it was concluded that the set target of 75% coverage was realistic.

Third, with regard to **ability to pay for water,** a so-called "affordability tariff" was calculated. The affordability tariff indicates the average tariff at which a certain percentage of the population can afford to use a minimum amount of water and not spend more than a given percentage of his/her income. An example of this calculation is given below:

Items	Unit	1996	2000
Average Monthly Income	VND'000	1,052	1,184
Lowest Income at 75% Coverage	VND'000	600	675
Min. expenditure on water (5% of income)	VND'000	30	33.8
Minimum consumption	Lcd	60	60
Average HH size	persons	4.26	4.26
Average monthly consumption	m^3	7.78	7.78
Affordability tariff	VND/m^3	3,856	4,344
Estimated costs of water	VND/m^3	4,000	4,000

In Thai Nguyen, average monthly income in 1996 was VND1,052,000. 75%of the population had an income higher than VND600.000. Taking 5% as an indicator of the maximum ability to pay, this means a maximum amount of VND30,000 per month. Assuming a minimum consumption of 60 lcd and an average household size of 4.26 results in a minimum required monthly consumption of 7.78 m^3 per month. The affordability tariff is calculated as VND30,000/ 7.78 m^3 = VND3,856/m^3.

This indicates that in the year 1996, 75% of the population can afford to pay an average tariff of VND3,856 per m^3 (based on a minimum consumption of 60 lcd) and not spend more than 5% of his/her income. Comparing the affordability tariff with the estimated average costs of water to be provided by the project, indicated that the target of 75% was realistic.

Source: RETA 5608 Case Study on the Provincial Towns Water Supply and Sanitation Project, Thai Nguyen, Viet Nam

(iv) Finally the project has to determine which level of coverage it intends to achieve. Often, project objectives contain statements such as:

> "provide safe water supply to 75 percent of the population of town x".

In this statement, it is assumed that the town area and service or project area are the same.

44. It is strongly recommended that such statements are verified in the field by asking potential customers:

(i) whether or not they are willing to connect to a new or expanded water supply system;

(ii) which service level they prefer;

(iii) whether or not they are willing and able to pay for the related costs; and

(iv) how much they are willing to pay.

Step 2: Estimating the number of persons to be connected

45. The number of persons making use of one connection needs to be determined.

(i) One figure which is often available is the average size of the household. This figure may, however, differ from the number of persons making use of one connection. Other persons may live in or near the house, making use of the same connection. Sometimes this information is available from the water enterprise; otherwise, it should be checked in the survey. An assumption will have to be made whether or not this number will remain the same over the project period. With increasing coverage in the service area and decreasing family size over the years, it may be assumed that the number of persons making use of one connection will gradually decrease.

(ii) Depending on the coverage figures assumed in step 1(iv) and the data found under step 2(i), the annual increase in the population served and the annual increase in the number of connection can be calculated.

Box 3.8 Thai Nguyen Case Study: Number of Persons per Connection

In Thai Nguyen, the number of connections in 1995 was 5,114 (Table 3.2, line 6). The average household size was 4.26. In the household survey it was found that the average number of persons making use of one connection is 6.5. In many cases, private connections were in fact used as a kind of yard connection. It was assumed that with the increasing number of connections in town, the number of persons making use of one connection would gradually decrease from 6.5 in 1995 to the level of 4.26 in year 2010 (line 8). By multiplying the end of year number of connections by the number of persons per connection and comparing this to the total population in the service area, the end of year coverage in the service area is calculated (line 9 and 10).

Source: RETA 5608 Case Study on the Provincial Towns Water Supply & Sanitation,Thai Nguyen, Viet Nam

Step 3: Estimating water consumption from the piped system[1] before-project

46. The starting point for estimating demand for water in the with-project situation is to estimate demand or consumption before-project. In piped water supply systems with working watermeters, estimating existing consumption is straightforward. In some cases, consumption before the project will provide a reasonable indicator of demand for water at a certain price level. In cases where the current system capacity is insufficient, consumption may be lower than actual demand. In those cases, data from other utilities may provide indications of normal consumption patterns.

47. In the case of piped water supply systems without installed watermeters, it is often difficult to estimate water consumption before-project. In general, households do not have a clear idea of how much water they consume per day; therefore, directly asking these households does not provide reliable answers. In the case studies, the following methods were suggested to address this problem:

(i) measuring the volume of water storage facilities available in the house and estimating how much of the storage capacity is used on a day-to-day basis;

(ii) carrying out a small in-depth survey among a selected number of users;

(iii) installation of temporary water meters at a selected number of connections, including consideration of seasonal variations;

---

[1] Existing consumption from nonconnected households will be estimated later as part of step nine (estimating incremental and nonincremental demand). Refer to Box 3.16.

(iv) estimating the number of buckets of water which are carried/hauled by a household on a day-to-day basis from each supply source, and

(v) if data on total production and/or distribution of water are available, an estimate can be made about consumption per household, after deducting the estimated UFW.

Step 4: Estimating Demand for Water Without-Project

48. The without-project situation is not necessarily the same as the before-project situation

(i) The water company may be under pressure to connect additional customers to the system even though the system capacity is not sufficient. This, in turn, may reduce average consumption per capita and service levels and people would have to start looking for alternative sources. In case the project includes a rehabilitation component, it is reasonable to assume that the current level of water service will gradually deteriorate in the without-project scenario.

The application of steps 3 and 4 in Thai Nguyen is given in Box 3.9.

Box 3.9 Thai Nguyen : Demand before-project and without-project

In the case of Thai Nguyen, existing consumption was found to be 103 lcd. Because the water pressure was considered sufficient by the large majority of customers and an average supply of about 23 hours per day could be maintained throughout the year, it was therefore assumed that the consumption before-project of 103 lcd equals demand at the current price level.

Furthermore, because the project basically aims at an expansion of supply to achieve a higher coverage, it has been assumed that demand without-project will remain equal to demand “just before the project”.

Source: RETA 5608 Case Study on the Provincial Towns Water Supply and Sanitation Project, Thai Nguyen, Viet Nam

Step 5: Estimating Demand for Water With-Project

49. Future demand for water at the household level will depend on a number of factors. The most important factors are changes in service level, water tariffs and income. When extrapolating demand to cover new supply areas, other factors such as

differences in income, housing, alternative sources, etc. will have to be taken into account.

(i) *Service Level.* Improvements in service level include for example:

  (a) increased number of supply hours;

  (b) improved water quality;

  (c) higher water pressure;

  (d) a shift from public tap to piped house connection; and

  (e) a shift from own facilities to a connection to a piped system.

  In general, it is difficult to assess the effect of these physical improvements on individual water consumption. Households will, in most cases, not be able to provide accurate estimates. In case the project will result in considerable improvements in existing supply conditions, the best source of information is data from other water enterprises that supply water in comparable conditions.

  In case the present water supply system functions satisfactorily and demand is not constrained, existing consumption data may be taken as the basis for future water demand estimates.

(ii) *Water Tariffs.* An increase in water charges will generally result in a decrease in the demand for water. In case the household remains on the same demand curve, the extent of the decrease will be determined, among others, by the numerical value of the price elasticity of the demand for water . Difficulties in estimating the price elasticity include:

  (a) new WSPs often generate a better level of service and may, therefore, cause a shift from one demand curve to a new demand curve as another product is offered. In this case, price elasticities pertaining to the old demand curve could only be used as a proxy for the true price elasticity which is very difficult to determine.

  (b) a situation of constrained supply exists and therefore, existing demand is not known;

(c) it is very difficult to estimate how much individual households will reduce water consumption when prices are increased because individual households will have great difficulty in providing reliable estimates.

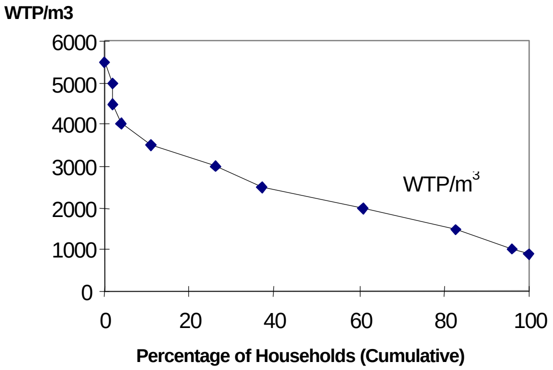
If available, data on earlier price increases and subsequent reduction in water consumption can be examined. If such data are not available, it is recommended to use conservative estimates based on experiences described in the literature.

An indication of changes in demand as a result of price increases can also be obtained from willingness-to-pay surveys. An example is provided in Box 3.10. However, it should be noticed that the percentage of households is only a rough proxy for the true dependent variable which is the quantity of water consumed expressed in m^3.

Box 3.10 Thai Nguyen: Relation between WTP and Number of Households

In Thai Nguyen, the willingness-to-pay survey for already connected households provided the results as given in the Table below. The 1996 tariff is VND900/m^3 and therefore, all households are apparently willing to pay that amount. Subsequently, 83 percent of households is willing to pay a tariff of VND1,500/m^3, 61 percent is willing to pay VND2,000/m^3, etc. These figures can be depicted in a graph shown in the Box. The line connecting the dots could be considered as a “surrogate demand curve”.

WTP (VND/m^3)	Percentage of Households (Cumulative)
5,500	0
5,000	2
4,500	2
4,000	4
3,500	11
3,000	26
2,500	37
2,000	61
1,500	83
1,000	96
900	100



Assume that in this case, the new tariff has been fixed at VND1,500/m^3. An indication of the relative change in the number of HH (q) to relative changes in tariff (p) for these values is as follows:

$$\frac{(q2-q1)/q1}{(p2-p1)/p1} = \frac{(83-100)/100}{(1{,}500-900/900)} = -0.26$$

Assuming a constant average consumption per HH, this figure provides an indication of the value of the point price elasticity for connected households.

(iii) *Income Levels.* In most cases, it is expected that the real income level of households will increase over the lifetime of a WSP, which is normally 20 to 30 years. When real income increases, the demand for water is also expected to increase, depending on the value of income elasticity. A generally accepted level of income elasticity is between 0.4 and 0.5. An application of the issues raised above for Thai Nguyen is presented in Box 3.11.

Box 3.11 Thai Nguyen Case Study: Estimating Future Demand

In Thai Nguyen, the following assumptions were made to estimate future demand:

- Existing per capita consumption equals existing demand: Q = 103 lcd (Table 3.2, line 12);
- The proposed tariff for the year 2010 is VND2,000/m^3 and for the year 2020, it is VND2,500/m^3. This results in required annual real price increases (dP/P) of 5.87 percent during the period 1997-2010 and 2.26 percent in the period 2011-2020 (line 38).
- A price elasticity was estimated at – 0.3 (line 37);
- increases in real income of 4 percent per annum (based on national forecasts) (line 42);
- an income elasticity of + 0.50 was assumed based on literature (line 41).

A sample calculation of the above estimate for the first year (1997) is given below:

Price Elasticity = [dQ/Q] / [dP/P];
dP/P = + 5.87%.
Therefore, - 0.3 = dQ/Q/ 0.0587; or:
dQ /Q = - 0.01761 = - 1.76% (when prices increase with 5.87 percent, demand for water will decrease with 1.76 percent: line 40). The decreased demand for water indicates the price effects.

Income Elasticity = dQ/Q / dI/I;
dI/I = + 4%.
Therefore, 0.5 = dQ/Q/0.04, or:
dQ/Q = 0.02 = 2 % (an increase in income of 4 percent will result in an increase in water demand with 2 percent, line 43). This increased water demand represents the income effects.

The combined effect of changes in price and income on quantity demanded shows a net result of: 2% - 1.76 % = 0.24% (see line 44 and line 11).
The positive effect of the income increase is slightly larger than the negative effect of the price increase. Per capita consumption in this case will increase from 1996 to 1997 by 103 x 0.0024 = 0.24 liter.

Source: RETA 5608 Case Study on the Provincial Towns Water Supply and Sanitation Project, Thai Nguyen, Viet Nam.

Step 6: Calculating Total Domestic Demand With-Project

50. Based on the projections for population and per capita water consumption, the domestic demand for water can be calculated by multiplying the number of persons served with the daily consumption as shown in Box 3.12.

Box 3.12 Thai Nguyen Total Domestic Demand

The total domestic demand for Thai Nguyen for the year 1995 is calculated as follows:

Basic calculations for estimating Total Domestic Demand[a]

Table3.2 Line no.	Item	Unit	Value	Explanation
9	Persons served	No.	33,241	
12	Per capita consumption	Lcd	103	
13	Total Consumption per day	m^3/day	3,424	(33,241 x 103)/1000
14	Total Consumption per year	‘000 m^3/year	1,250	(3,424 x 365)/1000
15	Household consumption	m^3/month	20.4	1,250,000/ (12 x 5,114)

a/ - Calculations may slightly differ due to rounding off of original figures.

Step 7: Nondomestic consumers

51. In general, future demand for water from the nondomestic sector is difficult to estimate. Future demand will depend, among others, on the price of water, reliability of supply, type and size of industries, regional and urban development plans, legal requirements, etc.

52. In the short run, the nondomestic sector is less likely to quickly increase/decrease the use of water as a result of changes in prices, meaning that nondomestic demand for water is more inelastic than domestic water demand. Reasons for this include:

(i) the users of water are often not the persons who have to pay for it (for example, in offices, hotels);

(ii) for industries, the costs of water are, in general, very small as compared to other production costs; and,

(iii) any increase in the price of water is likely to be incorporated in the cost-price of the product produced and be charged to the consumer.

53. In the medium to long run, however, large nondomestic consumers will often compare the costs of water from other sources with the costs of water from the piped system. If they can obtain cheaper water from other sources, they may not be willing to connect to the piped system, unless there is a legal obligation.

54. In some cases, the government may wish to encourage industries to apply water saving technologies and the application of such technologies will be encouraged by higher water tariffs such as discussed in Box 3.13.

Box 3.13 **Example of Estimating Industrial Consumption**

When projecting industrial demand for three cities in China, industrial water consumption was expected to grow at a rate of 8.7 percent per annum, based on expected industrial growth rates for the next ten years. At the same time, a survey conducted by the municipal authorities revealed that water consumption of industries in the cities was two to five times higher than water use in comparable industries in many other countries. In an effort to conserve water, the cities now require industries to improve water consumption efficiency by imposing penalties for excessive use. At the same time, water allocations to new industries are now based on prudent water use for the concerned industrial sector. Based on these new policies and their strict enforcement, it is expected that water consumption levels will be reduced to about 70 percent of existing levels. This would result in an industrial water consumption growth of 4.7 percent per annum, compared with the initially much higher growth rate of 8.7 percent.

Source: WB-SAR. 1991. *Liaoning Urban Infrastructure Project*. China.

55. Depending on available information about existing nondomestic consumption, estimates of economic and industrial growth, regional and urban development plans, employment figures, (expected) legislation, the application of water saving technologies, etc., approaches in estimating nondomestic water demand include:

(i) the application of past growth rates for nondomestic water consumption;

(ii) the application of population growth rates to existing water consumption of, for instance, government institutions;

(iii) the application of industrial- or economic growth rates to existing nondomestic consumption;

(iv) estimate nondomestic consumption as a (changing) percentage of estimated domestic consumption; and

(v) estimate the effects of water conservation technologies on nondomestic consumption;

The estimates for nondomestic consumption in Thai Nguyen are given in Table 3.2 and illustrated in Box 3.14.

Box 3.14 Example of Estimating Nondomestic Consumption

In Thai Nguyen, a small survey was conducted among nondomestic users. It appeared that enterprises were willing to pay up to VND3,500/m^3. At higher tariffs, however, they would start developing alternative water sources.

Based on secondary data analysis, the following assumptions were developed:

- government/social sector at 2.5 percent per year based on forecasts for population growth (Table 3.2, line 16)
- commercial sector growth at 3.0 percent per year (line 21);
- industrial sector growth at 4 percent per year, based on forecasted industrial growth (line 26);

The calculations are presented in Table 3.2 lines 16 - 29. Calculations for the different sectors are basically the same. The number of connections is first multiplied with the annual growth figure for the sector. This figure is then multiplied by the average consumption per connection per day and subsequently with 365 to find the annual figures.

Example: Commercial consumption in 1996 amounts to 20 x 1.03 x 5,147 x 365/1000 = 38,700 m^3/year (figures in Table 3.2 may slightly differ due to rounding).

Source: RETA 5608 Case Study on the Provincial Towns Water Supply and Sanitation Project, Thai Nguyen, Viet Nam

Step 8: Application of Technical Parameters

56. After having added domestic and nondomestic demand (see lines 31/32 in Table 3.2), certain technical parameters need to be incorporated in order to determine the total demand for water.

Unaccounted for Water

57. Normally a certain percentage of the water supplied to consumers is lost due to technical losses (physical leakages) and/or nontechnical losses (unmetered consumption, illegal connections). This so-called Unaccounted For Water (UFW) is normally expressed as a percentage of the volume of distributed water. In 1995, the average percentage of UFW in 50 Asian cities was 35 percent of water distributed (*Water Utilities Data Book for the Asian and Pacific Region*, 1997). This high level of UFW illustrates the inefficient use of existing water resources and is of great concern to the management of water utilities. A reduction of the UFW rate is therefore normally a specific objective in the formulation of new WSPs.

58. It will be necessary to include a realistic estimate of UFW in a demand estimate for a WSP. This percentage will naturally relate to the existing UFW rate and should be based on realistic targets for UFW reduction.

59. It is also necessary to estimate the proportion of technical and nontechnical losses in UFW because, in economic analysis, nontechnical losses (which add to the welfare of the population served) are included in the assessment of economic benefits. This assessment is often difficult and the project analyst will have to make a reasonable estimate in consultation with water enterprise staff. The percentage reduction in UFW should be set realistically in consultation with the project engineers (for technical losses) and utility managers (for nontechnical losses). A reduction in UFW will normally require a sizable portion of the project investment cost.

Peak Factor

60. The demand for water will very seldom be a constant flow. Demand for water may vary from one season to another and throughout the day. Daily demand will show variations and there will be peak hours during the day, depending on local conditions. These seasonal and daily peak factors will influence the size of the total installed capacity. These are technical parameters and will be determined by project engineers.

61. The demand for water is seldom constant. Rather it varies, albeit seasonally, daily and/or based on other predictable demand characteristics. At different times of the year the demand for water may be higher than others due to factors such as heat which may increase the demand for water for hygiene, drinking and other purposes. At different times of the day the demand for water may be higher than others, based on people’s and industries needs and patterns of consumption. At other periods, the stock and flow requirements of the system may be impacted by other predictable events, such as an industrial activity. These seasonal, daily and other predictable demand factors are known as peak factors.

62. In determining the total installed capacity of a planned project, the technical staff needs to consider both these peak demand factors and the projected growth in demand. Failure to do so could result in the project becoming supply constrained and unable to fully meet the demand requirements of its targeted beneficiaries from its outset.

63. Data about daily and seasonal water consumption patterns will normally be available from secondary data or may be collected in the household survey. The application of technical parameters in Thai Nguyen is given in Box 3.15.

Box 3.15 Application of Technical Parameters

In the case of Thai Nguyen, the objective was to reduce UFW from its existing level of 39 percent in year 1995 to 25 percent in year 2015 (Table 3.2, line 33). The Peak Factor has been estimated at 1.1.

The calculation, for example, in the year 1996 is as follows:

‘000 m^3/year
Water Demand (domestic + nondomestic; line 32) = 2,665
UFW = (2,665,000/(1-0.38)) x 0.38 (line 34) = 1,633
Peak factor 10% x (2,665,000+1,633,000) = 430
Total Production Capacity required (line 36) = 4,728

(Please note that the figures resulting from the above calculations slightly differ from the figures in Table 3.2, due to rounding off.)

Table 3.2 Demand Forecast and Required Production Capacity

	Financial Analysis Stages 1& 2	Unit	1995	1996	1997	1998	1999	2000	2005	2010	2015	2020
	1. POPULATION											
1	Population Growth	%	3.0%	3.0%	3.0%	3.0%	3.0%	2.5%	2.5%	2.5%	2.5%	2.5%
2	Total Population Thai Nguyen	Number	191,615	197,363	203,284	209,383	215,664	221,056	250,105	282,970	320,155	362,226
3	Growth (in service area)	%	3.0%	3.0%	4.5%	4.5%	4.5%	3.0%	3.0%	3.0%	3.0%	3.0%
4	Total Population in Service Area	Number	140,442	144,655	151,165	157,967	165,076	170,028	197,109	228,503	264,898	307,089
5	Increase in No of Connections	%		10%	37%	37%	37%	37%	7%	7%	3%	3%
6	No of Connections (end of year)	Number	5,114	5,625	7,683	10,494	14,332	19,574	27,495	38,620	45,695	54,065
7	Increase Person/Connection	%	0.0%	-2.8%	-2.8%	-2.8%	-2.8%	-2.8%	-2.8%	0.0%	0.0%	0.0%
8	Person per Water Connection	Number	6.5	6.3	6.1	6.0	5.8	5.6	4.9	4.26	4.26	4.26
9	Population Served	Number	33,241	35,549	47,204	62,681	83,231	110,518	134,843	164,522	194,659	230,317
10	Coverage	%	24%	25%	31%	40%	50%	65%	68%	72%	73%	75%
	2. DEMAND											
	A. HOUSEHOLDS											
11	Increase per capita consumption	%		0.22%	0.24%	0.24%	0.24%	0.24%	0.24%	0.24%	1.32%	1.32%
12	Per capita consumption	l/con/d	103	103	103	104	104	104	105	107	114	122
13	Total consumption/day	m³/d	3,424	3,670	4,884	6,501	8,653	11,518	14,222	17,561	22,189	28,036
14	Total consumption	000m³/yr	1,250	1,339	1,783	2,373	3,158	4,204	5,191	6,410	8,099	10,233
15	Total Consumption	m³/mo/ conn	20.4	19.8	19.3	18.8	18.4	17.9	15.7	13.8	14.8	15.8
	B. GOVERNMENT											
16	Increase in No of Connections	%		2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%	2.5%
17	No of Connections (end of year)	Number	221	227	232	238	244	250	283	320	362	410
18	Consumption	l/con/d	8,895	8,984	8,826	8,670	8,518	8,368	7,656	7,006	6,772	6,546
20	Total Consumption	000m³/yr	718	745	748	753	758	766	791	818	895	982
	C. COMMERCIAL											
21	Increase in No of Connections	%		3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%	3.0%
22	No of Connections (end of year)	Number	20	21	21	22	23	23	27	31	36	42
24	Total consumption	m³/d	102	107	108	109	110	112	119	126	141	158
25	Total	000m³/yr	37	39	39	40	40	41	43	46	51	58
	D. INDUSTRIAL											
26	Increase in No of Connections	%		4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%	4.0%
27	No of Connections (end of year)	Number	17	18	18	19	20	21	25	31	37	45

28	Consumption	l/con/d	82,848	83,676	82,203	80,756	79,334	77,937	71,313	65,251	63,072	60,966
29	Total consumption	m^3/d	1,408	1,479	1,511	1,544	1,578	1,612	1,795	1,998	2,349	2,763
30	Total	000m^3/yr	514	541	552	564	576	590	655	729	858	1,011
	TOTAL DEMAND											
31	No of Connections (end of year)	Number	5,372	5,890	7,955	10,772	14,618	19,868	27,830	39,002	46,130	54,562
32	Total Water Demand	000m^3/yr	2,519	2,665	3,122	3,730	4,533	5,601	6,680	8,003	9,903	12,284
	3. PRODUCTION											
33	UFW (%)	%	39%	38%	38%	37%	36%	33%	30%	27%	25%	25%
34	UFW	000m^3/yr	1,626	1,666	1,890	2,185	2,569	2,759	2,863	2,960	3,301	4,095
35	Peak factor (10%)	000m^3/yr	414	433	501	591	710	836	954	1,096	1,320	1,638
36	Required Production('000m^3/Year)	000m^3/yr	4,559	4,764	5,513	6,506	7,813	9,195	10,497	12,059	14,524	18,016
	PER CAPITA DEMAND (HOUSEHOLDS)			1996	1997	1998	1999	2000	2005	2010	2015	2020
37	Price Elasticity			-0.300	-0.300	-0.300	-0.300	-0.300	-0.300	-0.300	-0.300	-0.300
38	Price Increase				5.87%	5.87%	5.87%	5.87%	5.87%	5.87%	2.26%	2.26%
39	Tariff			900	953	1,009	1,068	1,131	1,504	2,000	2,236	2,500
40	Price Effect		0	0	-1.76%	-1.76%	-1.76%	-1.76%	-1.76%	-1.76%	-0.68%	-0.68%
41	Income Elasticity			0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500	0.500
42	Income Increase			4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%	4.00%
43	Income Effect				2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%	2.00%
44	Combined Effect (Increase lcd)				0.24%	0.24%	0.24%	0.24%	0.24%	0.24%	1.32%	1.32%
45	Liters/Capita/Day			103	103	104	104	104	105	107	114	122

No - number; l/con/d - liters per connection per day; m^3/d - cubic meter per day; '000m^3/yr - thousand cubic meter per year; m^3/mo/conn - cubic meter per month per connection

Step 9: Calculating Incremental and Nonincremental Demand

64. In demand forecasting, it is necessary to prepare separate estimates for incremental and nonincremental demand with-project. When estimating the project's economic benefits, both categories of demand are valued in different ways as will be further explained in Chapter 6. Because the average volume of nonincremental water generally differs between connected and nonconnected users, and because other variables such as income and price may also differ, it is useful to do a separate analysis for these two groups of users.

(i) Users already connected to a piped system. The calculation of nonincremental demand is best explained by a simple example as shown in Table 3.3.

Table 3.3 Nonincremental Water from connected users *(in lcd)*

	Without Project	With Project	Incremental Piped Water Supplied	Non Incremental demand piped water	Incremental demand for piped water
Average water use from piped system	75	100	25		
Average water used from other sources	15	0		15	
Average total Water Used	90	100			10

Before-project and without-project, already connected households use, on average, 90 lcd (75 lcd from the piped system and 15 lcd from other sources such as vendors or wells). With-project, production capacity will be increased, and the already connected users are expected to increase their consumption to 100 lcd. The additional supply of piped water in this case is an average of 25 lcd, consisting of 15 lcd which displaces water from other sources (nonincremental demand) and 10 lcd of incremental consumption.

There is also a need to consider the question whether or not the current demand figures with-project and without-project will change over time. Estimates of future water consumption with-project have been made in Box 3.11. In the without-project situation, current consumption figures may change over time as a result in changes in income, prices or changes in service levels. The project analyst will have to develop reasonable assumptions about taking these factors into account.

(ii) Users not yet connected to a piped system. Again, two questions need to be answered. The first question is: what will be the nonincremental use of water in the with-project situation? An example is given in Table 3.4.

Table 3.4 Average Nonincremental Water of nonconnected users *(in lcd)*

	Without Project	With Project	Additional Piped Water Supplied	Nonincremental piped water demand	Incremental piped water demand
Average water use from piped system	0	100	100		
Average water used from other sources	65	0		65	
Average total Water Used	65	100			35

In this example, the average user will:

(i) displace all the water currently used from other sources (non incremental demand = 65 lcd); and

(ii) increase consumption from 65 lcd to 100 lcd (incremental demand = 35 lcd). The additional supply of piped water will be 100 lcd on average.

The second question is: whether or not these figures will change over time. Box 3.16 provides an example which explains how the quantity of nonincremental water can be determined. A summary of step 9 is presented in Table 3.5 showing incremental demand for both connected and nonconnected households as well as nonincremental demand for water.

The above is applied to the case of Thai Nguyen in Box 3.16.

Box 3.16 Determination of Incremental and Nonincremental Water

In Thai Nguyen the existing supply capacity of about 10,000 m^3 per day is fully used. Increases in demand can only be met if the UFW is reduced, but this will require considerable investments.

Domestic demand:

Demand from presently connected households before-project is, on average, 103 lcd; and because the system is operating at full capacity, it is assumed that this figure will remain the same without-project. The household survey showed that the use of other sources by households, which are currently connected to the system, is negligible. It is assumed that this figure also will not change in the future. Furthermore, with-project, the average water use from the piped system will gradually increase (see Table 3.2, line 12). Therefore, the increased consumption of presently connected households can be considered as incremental water demand. The calculation for 1998 is as follows:

With the Project: (lines refer to table 3.5)

1998 Demand without the project	103 lcd	(line 8)
1998 Demand with the project	104 lcd	(line 9)
1995-98 Increase in per capita consumption:		
(1.0022 x 1.0024 x 1.0024 = 1.007 =)	0.70 %	(line 2)
1998 Demand without the project:	1,250,000 m^3/year	(line 1)
1998 Demand with the project:	1,258,750 m^3/year	(line 3)
1998 Incremental Demand	8,750 m^3/year	(line 4)

The average water use of non-connected households in Thai Nguyen before the project was estimated at 564 liters per day. With an average number of 5.5 persons per house, this means an average use of about 102 lcd (which is very close to the average consumption of users of the piped system). It is assumed that in without-project situation, this figure will not change in future. Furthermore, it is assumed that the average use of these households with-project and when they will be connected will increase in a similar way as the presently connected households.[1] The increase in average consumption is considered as Incremental demand. Nonconnected households which will obtain a new connection are assumed to displace all their present sources with water from the piped system. Therefore, this is considered as nonincremental demand.

<u>The calculation is as follows:</u>

Line	6	1998 number of connections	10494
	5	1995 number of connections	5114
		Incremental number of connections	5380
	7	1998 persons per connection	5.97
	9	1998 average water use	103.7 lcd
	8	1995 average water use	103 lcd
	10	1998 Incremental demand	8,206 m^3/ year (= 5380 x 5.97 x (103.7-103) x 365/1000)
	-	1998 additional supply nonconnected HH	1,215,705 m^3/year (= 5380 x 5.97 x 103.7 x 365/1000)
	-	1998 nonincremental demand nonconnected HH	1,207,499 m^3/year (= 1,215,705 - 8,206)

(Please note that the figures resulting from the above calculations slightly differ from the figures in Table 3.5, due to rounding off).

[1] It should be noticed, however, that this simplifying assumption may not hold in practice. As a result of the lower water price (with the project), the average water consumption of previously nonconnected households may actually increase more than the average water use of connected households. If empirical evidence is available, this should then be taken into account in the demand forecast.

Non Domestic Demand:

Without any further data available, it has been assumed that existing nondomestic consumers will continue to consume the same average volume of water with-project and without-project. Therefore, all additional nondomestic demand will come from industries not presently connected to the system which will fully displace existing sources. Therefore, all nondomestic water can be considered as nonincremental.

From the above it can be seen that except for the incremental demands from existing and future connections, all other demand can be considered nonincremental. It has been assumed that without-project demand from existing users will remain constant at 2,519,000 m^3 per year (Table 3.5,line 11) . The calculations for (non) incremental demand for the year 1998 are as follows:

1998 Total Demand without the project	2,519,000 m^3/year	(line 11)
1998 Total Demand with the project (refer to Table 3.2, line 32)	3,730,000 m^3/year	(line 12)
1998 Supply by the Project:	1,211,000 m^3/year	(line 13)
1998 Incr. demand connected HH	8,750 m^3/year	(line 14)
1998 Incr. demand non-conn. HH	8,447 m^3/year	(line 15)
1998 Nonincremental demand	1,193,803 m^3/year	(line 16)

As can be seen in the case of Thai Nguyen, the incremental water demand with-project is rather small, which is caused by the fact that the current use of water from other sources by non-connected households is relatively high and therefore, these households will only marginally increase their water consumption.

Table 3.5 Calculation of Nonincremental Demand

		Unit	1995	1996	1997	1998	1999	2000	2005	2010	2015	2020
	Connected Households											
1	Current conn HH consumption	‘000m³/yr	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250	1,250
2	Increase per capita consumption	%		0.22%	0.24%	0.24%	0.24%	0.24%	0.24%	0.24%	1.32%	1.32%
3	Future conn HH consumption	‘000m³/yr	1,250	1,252	1,255	1,258	1,261	1,264	1,280	1,295	1,383	1,477
4	Incremental Demand ConnHH	‘000m³/yr	0	2	5	8	11	14	30	45	133	227
	Nonconnected Households											
5	Current no. of connections		5,114	5,114	5,114	5,114	5,114	5,114	5,114	5,114	5,114	5,114
6	Future no. of connections		5,114	5,625	7,683	10,494	14,332	19,574	27,495	38,620	45,695	54,065
7	No. of persons per connection		6.50	6.32	6.14	5.97	5.81	5.65	4.90	4.26	4.26	4.26
8	Current Avg. water use	lcd	103	103	103	103	103	103	103	103	103	103
9	Future Avg. Water use	lcd	103	103	103	104	104	104	105	107	114	122
10	Incr demand		0	0	3	8	19	36	99	195	693	1,426
	Connected+Nonconn HH											
11	Total Existing Demand	‘000m³/yr	2,519	2,519	2,519	2,519	2,519	2,519	2,519	2,519	2,519	2,519
12	Total Future Demand	‘000m³/yr	2,519	2,665	3,122	3,730	4,533	5,601	6,680	8,003	9,903	12,284
13	Additional Supply by Project	‘000m³/yr	0	146	603	1,211	2,014	3,082	4,161	5,484	7,384	9,765
14	Incr Demand Conn HH	‘000m³/yr	0	2	5	8	11	14	30	45	133	227
15	Incr Demand Nonconn HH	‘000m³/yr	0	0	3	8	19	36	99	195	693	1,426
16	Nonincr Demand		0	143	595	1,194	1,984	3,031	4,033	5,245	6,558	