TAC BACKGROUND PAPERS **NO. 2**

Water as a Social and Economic Good: How to Put the Principle into Practice

By PETER ROGERS,
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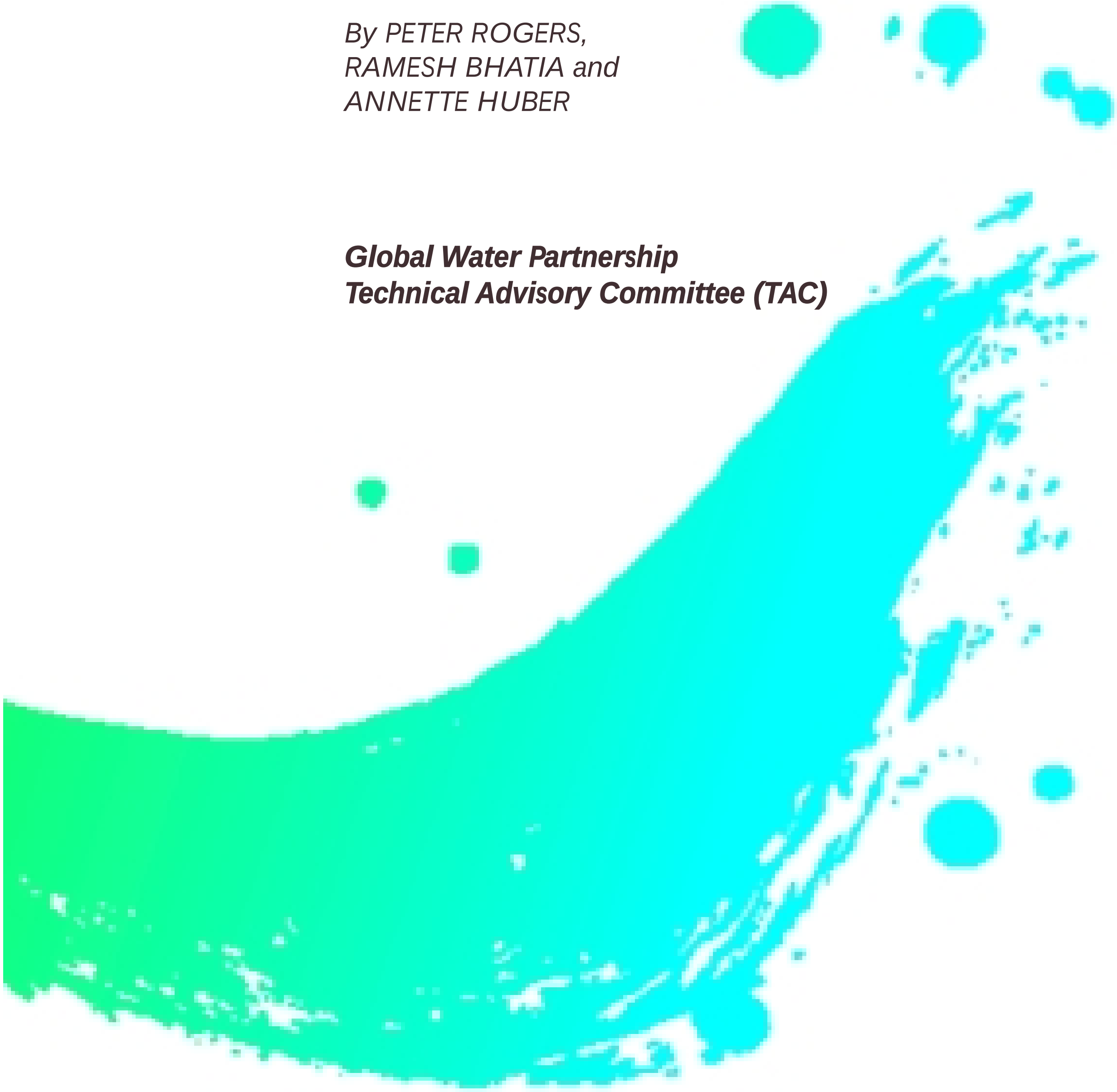
ANNETTE HUBER



Global Water Partnership
Technical Advisory Committee (TAC)

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GWP promotes IWRM by creating fora at global, regional, and national levels. The Partnership's governance includes the Technical Advisory Committee (TAC), a group of 12 internationally recognised professionals and scientists skilled in the different disciplines of water management. This committee, whose members come from different regions of the world, provides technical support and advice to the other governance arms and the Partnership as a whole. The TAC has been charged with developing an analytical framework of the water sector and proposing actions that will promote sustainable water resources management. The TAC maintains an open channel with its mirror bodies, the GWP regional TACs, currently being established around the world to facilitate application of IWRM regionally and nationally.

Worldwide adoption and application of IWRM requires changing the way business is conducted by the international water resources community, particularly the way investments are made. To effect changes of this nature and scope, a strategy that addresses the global, regional, and conceptual aspects and agendas of implementing actions is being employed. This series, published by GWP via its host institution – the Swedish International Development Cooperation Agency (Sida) – was created to disseminate the papers written and commissioned by the TAC to address the conceptual agenda. Issues and sub-issues within them, such as water for food security, privatisation, and the role of women in water management are addressed in the papers.

The findings, interpretations, and conclusions expressed within this series are entirely those of the authors and should not be attributed in any manner to GWP, Sida, nor as official expressions of the Global Water Partnership Technical Advisory Committee. This particular paper, Water as a Social and Economic Good: How to Put the Principle into Practice, *was prepared by TAC members Peter Rogers and Ramesh Bhatia, and by Annette Huber, for a November 1996 meeting of the TAC in Windhoek, Namibia.*

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Water as a Social and Economic Good: How to Put the Principle into Practice

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INTRODUCTION AND SCOPE

AGENDA 21 AND THE DUBLIN PRINCIPLES put the concept of water as an economic good on the global agenda, and they have received wide acceptance by the world's water professionals. However, there is substantial confusion about the exact meaning of some of the articulated principles. In particular, it is not clear to many non-economists what is implied by the statement that water is an "economic good" or an "economic and social good." This paper addresses this lack of understanding by formulating the concept of water as an economic good and explaining, in practical terms, the economic tools that can be used to effect the environmentally, socially, and economically efficient use of water.

The potential role of economic tools in providing socially acceptable public decisions is not widely appreciated, particularly in many highly regulated situations. Furthermore, this paper suggests, contrary to the public perception, that with the improvement of the use of economic tools, the role for government regulation in managing water as an economic good is increased, not decreased.

The paper is divided into three sections following this introduction: Section I presents the general principles and methodologies for estimating costs and values in the water sector. In section II, some illustrative estimates of costs and values in urban, industrial, and agricultural sectors are presented based on available data. Section III provides a summary of results and conclusions.

I. ESTIMATION OF THE COST AND VALUE OF WATER

General Principles

There are several general principles involved in assessing the economic value of water and the costs associated with its provision. First, an understanding of the costs involved with the provision of water, both direct and indirect, is key. Second, from the use of water, one can derive a value, which can be affected by the reliability of supply, and by the quality of water. These costs and values may be determined either individually, as described in the following sections, or by analysis of the whole system. Regardless of the method of estimation, the ideal for the sustainable use of water requires that the values and the costs should balance each other; full cost must equal the sustainable value in use.

It may be pointed out that the value in alternative uses and opportunity costs are determined simultaneously when water supplies match water demands for user sub-sectors over time and space. Water markets, if functioning, will perform these functions of matching water demands (both for quantity and quality) with supplies if appropriate policies (regulatory and economic incentives) are used to take care of externalities. In the absence of such well-functioning water markets, efficient water allocations (and resulting values and costs) can be obtained by using multi-period, multi-location systems analysis models (Sinha, Bhatia, and Lahiri 1986; Anandalingam, Bhatia and Cestti 1992; and, Harshadeep 1995). With the advent of high-speed computers and efficient software, it is now possible to obtain empirical estimates of values and costs using a systems analysis model on a personal computer.

However, where such systems analysis models are not available for the practical purposes of estimating values, costs and tariffs, a partial equilibrium approach should be followed. This requires estimating the opportunity cost of water when used in a particular sub-sector in order to reflect the cost to society of depriving other sectors of the use of this water. For example, while evaluating the full economic cost of water used in the industrial sector, it becomes necessary to estimate value in the best alternative foregone, which may be urban households or agriculture. Similarly, estimating the economic cost of water used in irrigation requires the estimation of the value of water used in the industrial and urban sectors. As illustrated below, there may be difficulties in estimating opportunity costs of irrigation water when irrigation accounts for 60 to 80 percent of the total water used.

Components of Full Cost

Figure 1 shows schematically the composition of the various components that add up to make the costs. There are three important concepts illustrated in this figure: the Full Supply Cost; the Full Economic Cost; and the Full Cost. Each of these is composed of separate elements that need further explanation.

Full Supply Cost

The Full Supply Cost includes the costs associated with the supply of water to a consumer without consideration of either the externalities imposed upon others nor of the alternate uses of the water.[1] Full Supply Costs are composed of two separate items: Operation and Maintenance (O&M) Cost, and Capital Charges, both of which should be evaluated at the full economic cost of inputs.

> O&M Cost: These costs are associated with the daily running of the supply system. Typical costs include purchased raw water, electricity for pumping, labor, repair materials, and input cost for managing and operating storage, distribution, and treatment plants. In practice, there is typically little dispute as to what are considered O&M Costs and how they are to be measured.
>
> Capital Charges: These should include capital consumption (depreciation charges) and interest costs associated with reservoirs, treatment plants, conveyance and distribution systems. There is some disagreement about the calculation of Capital Charges. Older methods use a backward accounting stance and look for the costs associated with repaying the historical stream of investments.

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[1] Water resources exhibit externalities in the sense that they have the property of "mutually interfering usage." Individuals take the valuable commodity of clean water from the same environment which they then use to dump wastes, thus interfering with the use of the no-longer-clean water by themselves and others. In economic parlance these aspects are referred to as "externalities."

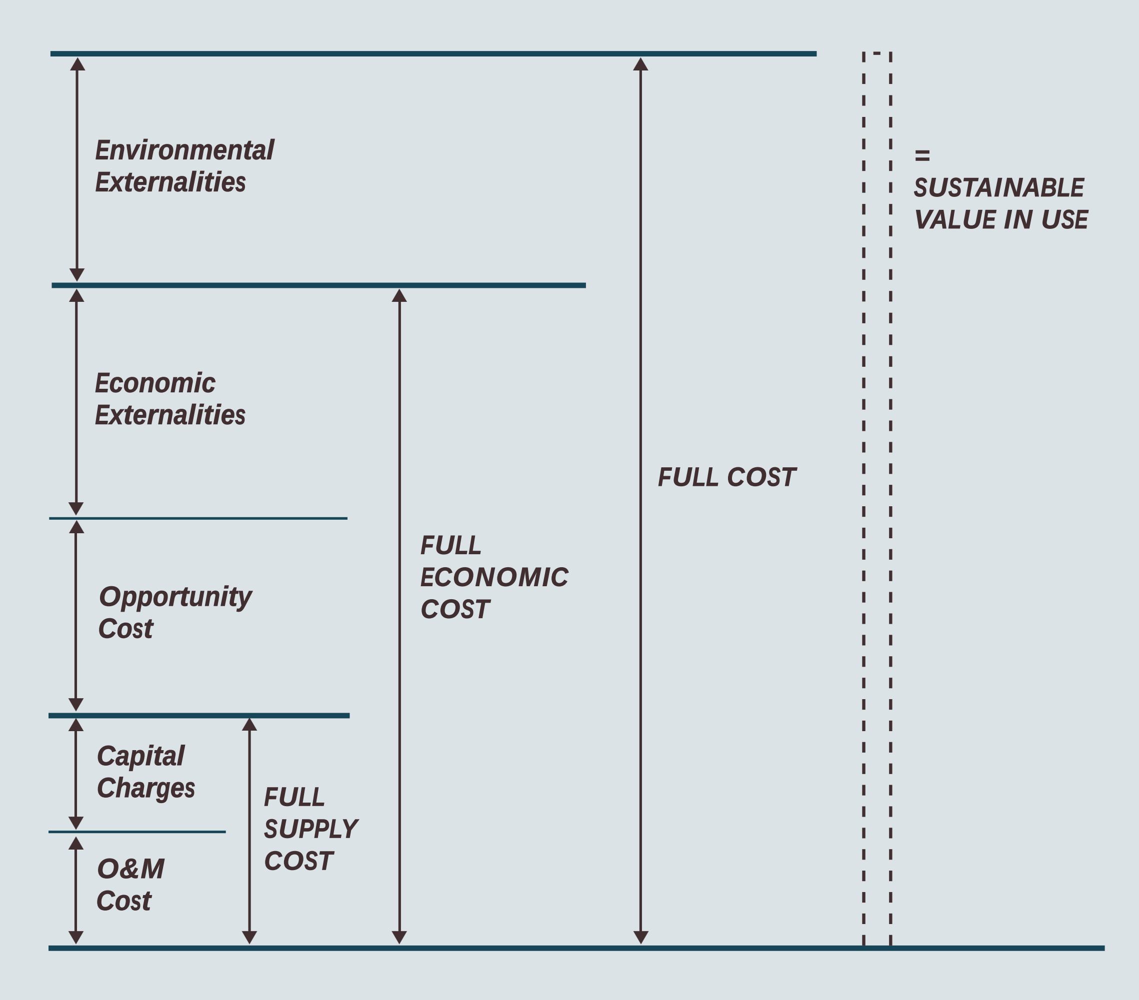

Figure 1. *General Principles for Cost of Water.*

Modern methods stress a forward-looking accounting stance and look for the costs associated with replacement of the capital stock with increasing marginal costs supplies. These coupled with the O&M Costs approximate the long-run marginal costs.

Full Economic Cost

The Full Economic Cost of water is the sum of the Full Supply Cost as described in the previous section, the Opportunity Cost associated with the alternate use of the same water resource, and the economic externalities imposed upon others due to the consumption of water by a specific actor.

OPPORTUNITY COST: This cost addresses the fact that by consuming water, the user is depriving another user of the water. If that other user has a higher value for the water, then there are some opportunity costs experienced by society due to this misallocation of resources. The Opportunity Cost of water is zero only when there is no alternative use – that is no shortage of water. Ignoring the Opportunity Cost undervalues water, leads to failures to invest, and causes serious mis-allocations of the resource between users. The Opportunity Cost concept also applies to issues of environmental quality, which are discussed further in the paper.

ECONOMIC EXTERNALITIES: As a fugitive resource, water results in pervasive externalities.[2] The most common externalities are those associated with the impact of an upstream diversion of water or with the release of pollution on downstream users. There are also externalities due to over-extraction from, or contamination of, common pool resources such as lakes and underground water.[3] There may also be production externalities due, for example, to the agricultural production in irrigated areas damaging the markets for upland non-irrigated agriculture, or forcing them to change their inputs. The standard economic approach to externalities is to define the system in such a way as to "internalize the externalities." In this paper we have chosen to separate the economic and environmental externalities, realizing that in some cases it will be difficult to distinguish exactly between them. The externalities may be positive or negative, and it is important to characterize the situation in a given context and estimate the positive or negative externalities and adjust the full cost by these impacts.

Positive Externalities occur, for example, when surface irrigation is both meeting the evapotranspiration needs of crops, and recharging a groundwater aquifer. Irrigation is then effectively providing a "recharge service." However, the net benefit of this "recharge service" will depend on the overall balance between total recharge (from rainfall and surface irrigation) and the rate of

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[2] By this we mean it literally moves from one place to another, and, unless it is abstracted and stored, it cannot be easily owned by any one user.

[3] Common pool resources, such as village commons, groundwater aquifers, and lakes are available for use to everyone, unless regulatory mechanisms exclude some persons or levy charges for their use.

withdrawal of groundwater. Under conditions where groundwater is being "mined," the recharge from a surface system provides a net benefit that will be equal to the value of net additional crop output attributable to this additional volume of water. When the total recharge is greater than total withdrawal (but still does not result in a high groundwater table), the net benefit from the "recharge service" will be equal to the reduction in the cost of water pumping. This saving in costs may be small (equal to the cost of fuel or electricity) if it does not result in significant savings in investment costs as a result of a higher groundwater table. Hence, the net benefit of the positive externalities would have to be carefully assessed against the additional capital costs of reservoirs and/or the costs of conveyance and distribution of the "leaky" surface irrigation systems.

Negative Externalities, as discussed in Briscoe (1996), may impose costs on downstream users if the irrigation return flows are saline, or where return flows from towns impose costs on downstream water users. One method used to account for these externalities is to impose a salinity levy on users, depending on their water use patterns. This is used in the Australian state of Victoria, and the surcharge is determined by the cost of restoring the saline water to its original condition (and is generally greater than the abstraction cost which users have to pay). Where return flows from towns impose costs on downstream users, one approach (in the German Ruhr and French systems, Briscoe 1995) is to levy a charge on urban consumers for restoring the wastewater to an acceptable condition. These negative externalities should result in additional costs to users who impose these externalities on others.

FULL COST

The Full Cost of consumption of water is the Full Economic Cost, given above, plus the Environmental Externalities. These costs have to be determined based upon the damages caused, where such data are available, or as additional costs of treatment to return the water to its original quality.

ENVIRONMENTAL EXTERNALITIES: We make a distinction between Economic and Environmental Externalities. The Environmental

Externalities are those associated with public health and ecosystem maintenance. Hence, if pollution causes increased production or consumption costs to downstream users, it is an Economic Externality, but if it causes public health or ecosystem impacts, then we define it as an Environmental Externality. Environmental Externalities are usually inherently more difficult to assess economically than the Economic Externalities, but we argue that it is possible, in most cases, to estimate some remediation costs that will give a lower bound estimate of the economic value of damages. Methods of estimating these externalities are not explored in this paper, but are discussed thoroughly in Dixon et. al (1994), Pearce (1976) and Winpenny (1991). We are now ready to assess the other side of the question; the value of water.

Components of the Value of Water

For economic equilibrium, the value of water, which we estimate from the Value in Use should just equal the full cost of water. At that point, the classical economic model indicates that social welfare is maximized. In practical cases, however, the Value in Use is typically expected to be higher than the estimated full cost. This is often because of difficulties in estimating the environmental externalities in the full-cost calculations. However, in many cases it may be lower than Full Cost, Full Economic Cost, and even below Full Supply Cost. This is often because social and political goals override the economic criteria.

The value of water depends both upon the user and to the use to which it is put. Figure 2 (p. 13) shows schematically the components of the Value in Use of water, which are the sum of the Economic and Intrinsic Values. As shown in the figure, the components of Economic Value are:

- Value to Users of Water
- Net Benefits from Return Flows
- Net Benefits from Indirect Use
- Adjustments for Societal Objectives

Economic Value

VALUE TO USERS OF WATER: For industrial and agricultural uses, the value to users is at least as large as the marginal value of product.[4] For domestic use, the willingness to pay for water represents a lower bound on its value, as there is additional value to the water as described below.[5] There are numerous studies that attempt to compute the marginal value of water use by industry and agriculture, and willingness to pay by domestic consumers (see, for example, Briscoe 1996; Gibbons 1986; Desvouges and Smith 1983, Griffin et al. 1995; Singh et al. 1992; Whittington et al. 1987; World Bank 1995).

NET BENEFITS FROM RETURN FLOWS: Return flows from water diverted for urban, industrial, and agricultural uses constitute a vital element of many hydrological systems, thus the effects of these flows must be taken into account while estimating the value and cost of water (Briscoe 1996; Seckler 1996; Sinha, Bhatia and Lahiri 1986). For example, a part of the water diverted for irrigation may recharge the groundwater table in the region and/or increase the returns to the river/canal downstream. However, the benefits from the return flows will critically depend on the proportion of water that is "lost" to evaporation (due to open drains and canals) or to other "sinks."

NET BENEFITS FROM INDIRECT USE: The typical example of these benefits occurs with irrigation schemes that provide water for domestic use (drinking and personal hygiene) and livestock purposes, which can result in improved health and/or higher incomes for the rural poor. For example, in areas of northwest India (Haryana and western Uttar Pradesh) where groundwater is saline, irrigation canals not only provide water for domestic and livestock uses, water in these canals recharge the groundwater table, thus enabling the pumping of water from handpumps and shallow tubewells. In the absence of this sweet water, use of saline groundwater by animals is reported to result in about a 50 percent

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[4] This reflects the additional value to the consumer (or society) of an additional unit of water.

[5] For example, the willingness to pay may be estimated by using "bidding games" where consumers indicate their monthly payments for a given service.

reduction in the output of milk (Bhatia and Raheja 1986). In many arid regions of Haryana, the Indian Punjab and the Pakistani Punjab, income from livestock accounts for a significant proportion of the income of poor households, particularly in the drought season. In addition to livestock, irrigation canals provide water for wildlife, flora and fauna and provide in-stream benefits. In some canals in southern India, canal drops are known to be used for installation of small and mini hydro plants. These indirect benefits have to be included while estimating the Value in Use of water that is diverted for agricultural purposes. Ignoring these benefits could result in a serious underestimation of societal benefits available from the volume of water that is diverted for irrigation. Irrigation is also known to have some adverse environmental and social impacts which result in hardships for poorer households. Such adverse consequences include, *inter alia*, waterlogging and salinization of soils, declining groundwater tables (which result in dry handpumps and shallow tubewells), and pollution of water from agrochemicals and waterborne diseases (Vaidyanathan 1993). *These environmental impacts can be considered in terms of the negative benefits in estimating the value of water in agriculture. Alternatively, they can be added to the Environmental Externalities component of the Full Cost of water.*

ADJUSTMENT FOR SOCIETAL OBJECTIVES: For water use in the household and agricultural sectors, there may be an adjustment made for societal objectives such as: poverty alleviation, employment and food security (particularly in rural areas, where foodgrain prices tend to be high in the absence of the additional food output gained from irrigated agriculture, and where it may be difficult to supply imported foodgrains). Such adjustments are over and above the value of water to the user and should be added to reflect various societal objectives, as described in the section on irrigated agriculture. Extreme care must be taken in the use of these adjustments, with full consideration of the alternatives to meet these goals. *The estimates of these values are not to be arbitrarily set, but should be determined on the basis of the best available methods that give the real gains to the society from price differentials among sectors.*

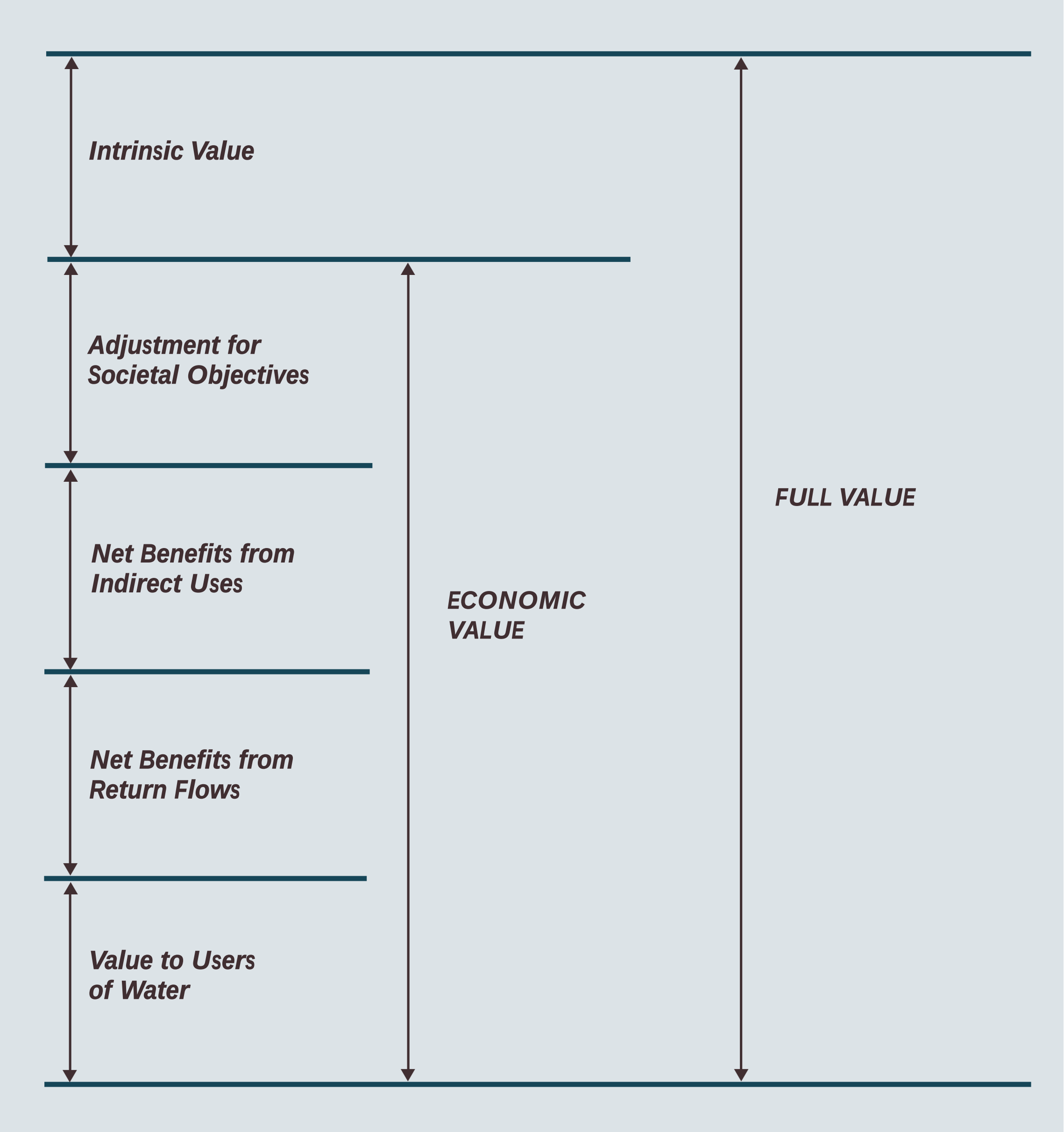


Figure 2. General Principles for Value in Use.

Intrinsic Value

The concept of economic value, it should be noted, does not assign any value to concerns such as stewardship, bequest values, and pure existence values. While these are difficult to measure they are, nevertheless, valid concepts and do reflect real value associated with water use (or non-use).

A comprehensive review of the different types of benefits occasioned by environmental management is given in Desvouges and Smith (1983). The benefits are split into the two major categories of "current user values" and "intrinsic values." The current user values themselves are split into two major categories of "direct" use and "indirect" use. In terms of figure 2 these intrinsic values are generally difficult to define and estimate, but in some cases they could be considered as externalities of use of the resource, and hence, are relatively easy to incorporate. In other cases, for example with bequest value, they may always be difficult to locate in the conceptual scheme. One way to approximate intrinsic values is to estimate "hedonic price indices" associated with the consumption of goods and services. For example, Harrison (1973) estimated the price of housing based upon a regression of price on several economic, location, social, and environmental variables. In this way it is possible to relate the actual behavior to the desirability of various intrinsic values, such as a "water view," and "green vistas" associated with irrigation works, or instream flow and quality requirements.

Other Issues to be Considered

THE EFFECTS OF RELIABILITY OF WATER SUPPLY ON COST AND VALUE: The value of water depends crucially on the timing and reliability of the water supplies. Timeliness is most critical in irrigated agriculture where water shortages during critical stages of plant growth result in reduced crop yields. Lack of reliable irrigation supplies in public irrigation systems, particularly in South Asia, are responsible for low crop yields and farmers' lack of willingness to pay the full cost of water. Pumping of groundwater (e.g. in northwest India and Pakistani Punjab) improves timeliness and reliability of water input, and, hence, has resulted in relatively higher crop yields. For example, in four Indian states (Punjab, Haryana, Andhra Pradesh and Tamil Nadu), land-receiving groundwater irrigation produced roughly twice as many additional foodgrains per hectare as land receiving canal irrigation (Repetto 1994; Chambers 1988; Dhawan 1988).

However, improving reliability and timeliness in water supplies entails higher costs in terms of additional storage capacity and/or pumping. For example, in the northwestern state of Haryana, where the irrigation charges for surface water supplies are less than \$10 per hectare per year (\$/ha/yr), farmers are known to spend as much as \$90/ha/yr in irrigation costs. These irrigation costs account for as much as 20 percent of the net value of output from these crops and indicate that farmers' willingness-to-pay (as well as actual payments) are quite high for timely and reliable water supplies for irrigation. Hence, those institutional and financing arrangements that ensure reliable water supplies are likely to be more sustainable for improving water use efficiency than those that concentrate only on cost-recovery.

Reliable and adequate water supplies are also critical for households and industrial users. High investment costs are incurred and high prices are paid by households as part of the coping strategies adopted in the face of uncertain water supplies (World Bank Water Demand Research Team 1993; World Bank 1995). For example, poor people, especially in urban areas, often must pay very high prices for obtaining adequate water supplies of acceptable quality (Bhatia and Falkenmark 1993).

Reliable water supplies for industry and thermal power plants are critical for maintaining desired production levels. Because water for industrial and power purposes is also required during the dry season, provision of water for these users entails high opportunity costs as well as high supply costs. Providing reliable water supplies during the dry season results in higher storage costs and higher evaporation losses in reservoirs and canals. These costs must be considered while evaluating the benefits and costs of industrial water supplies. Further, the need to provide a given quantity to industry in a dry season may result in lower area under irrigation when their peak water requirements coincide during a particular fortnight. This has to be factored in when calculating the opportunity costs of water in the industrial and urban sectors.

WATER QUALITY CONCERNS IN COST AND VALUE: As in the case of reliability, water quality influences both values and costs. The first three to four liters of water used for drinking purposes must be of the best quality and provide high value to the consumer as well as to society. Water for bathing, washing and personal hygiene need not be of the same quality as that used for drinking and cooking purposes. Flushing of toilets, cleaning, and gardening require varying qualities of water, resulting in differing levels of value, and hence willingness to pay. Industrial processes can use recycled water for process, cooling, and for transporting waste materials. Similarly agriculture needs differing water qualities, resulting in differing values and costs of provisioning the water. In particular, the demand for various water qualities for different uses provides incentives for recycling and re-use of water, with a view to matching demands with supplies.

II. VALUES AND COSTS IN USER SECTORS: SOME ILLUSTRATIVE ESTIMATES

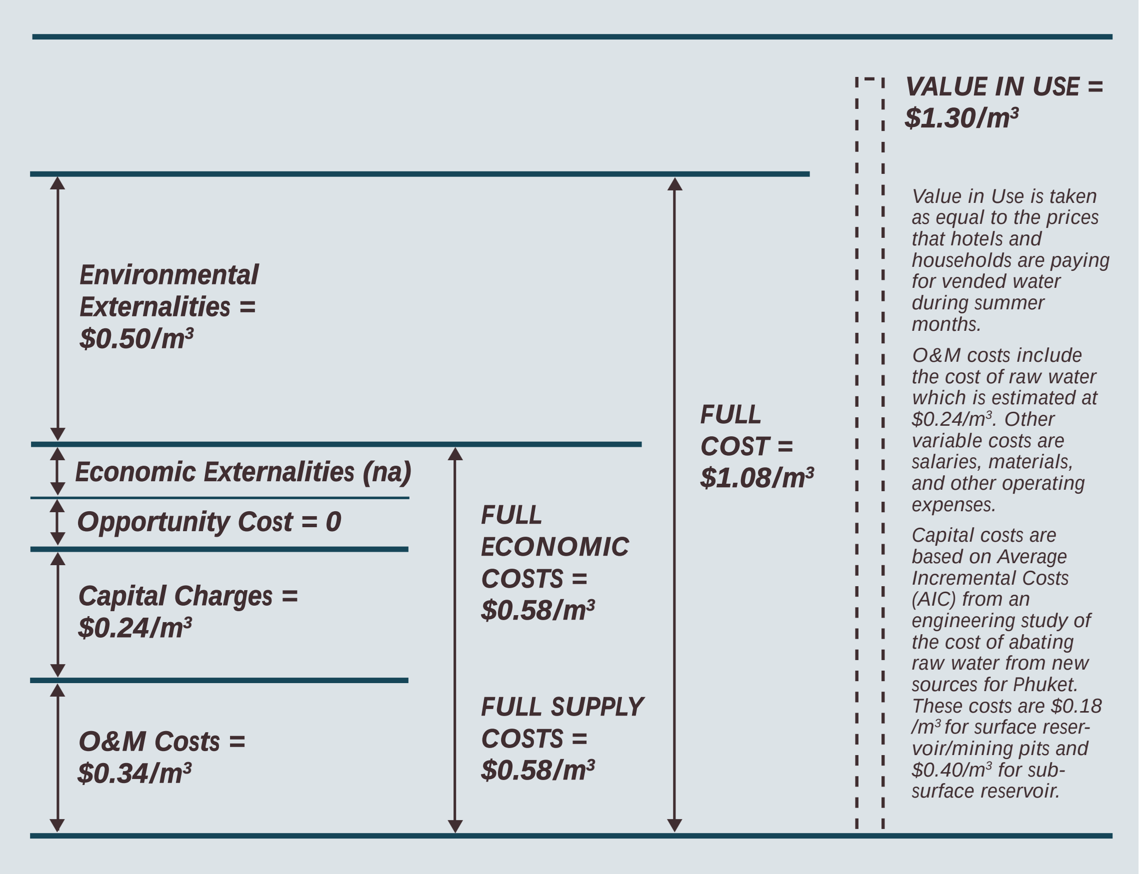
In this section we present some illustrative estimates for three primary water user sectors: urban households, industry, and irrigated agriculture. These estimates are based on the best available data and are specific to the conditions and situations for which these estimates have been made. As stated in the introduction, ideally these estimates would be generated on the basis of systems analysis, but in the absence of the resources necessary to do this, which is typical for most developing countries, we present here the next best alternative calculations. These empirical estimates are presented here with a view to raising methodological issues that will help in the operationalizing of the principle that water is a social and economic good. Estimates for ecological uses have not been presented in view of the methodological difficulties of quantifying these benefits and costs (Briscoe 1996; Goodland 1996; Gibbons 1986).

Value and Cost of Water for Urban Households in Phuket, Thailand

Using the approach suggested in section I, figure 3 (p. 18) presents estimates of costs and values for urban water supplies in the tourist resort of Phuket in Thailand. Using the data provided in Patmasiriwat et al. (1995), the O&M Costs have been estimated as \$0.34 per cubic meter (m^3), which includes the cost of raw water (\$0.24/m^3). Capital Charges for the distribution system have been estimated as \$0.24/m^3, giving a Full Supply Cost of \$0.58/m^3. Because there are no alternative uses of this water in agriculture or industry, (the island is almost exclusively a tourist area) the Opportunity Cost is taken as zero and the Full Economic Cost is equal to the Full Supply Cost.

Environmental Externalities are taken into account by estimating the costs of wastewater treatment at \$0.50/m^3. Thus, the Full Cost is estimated at \$1.08 (\$0.58 plus \$0.50)/m^3.

The Value in Use (\$1.30/m^3) has been estimated from data on the willingness to pay of urban consumers and hotels for vended water



Value in Use is taken as equal to the prices that hotels and households are paying for vended water during summer months.

O&M costs include the cost of raw water which is estimated at $0.24/m^3$. Other variable costs are salaries, materials, and other operating expenses.

Capital costs are based on Average Incremental Costs (AIC) from an engineering study of the cost of abating raw water from new sources for Phuket. These costs are $0.18 /m^3$ for surface reservoir/mining pits and $0.40/m^3$ for subsurface reservoir.

Figure 3. Costs and Values for Urban Water Supply in Phuket, Thailand.

Source: D. Patmasiriwat et al.: Full Cost Water and Wastewater Pricing: A Case Study of Phuket, Thailand; Thailand Development Research Institute, August 1995.

during the summer months. This value is relevant for three summer months when there are extreme shortages of water. It may be mentioned that this estimate of the Value in Use is much higher than what the urban consumers indicated in a willingness-to-pay survey carried out in Phuket.

The gap between the value and costs implies a problem with sustainability in Phuket, or the need for more evaluation of the estimates given above. Some of the problems may arise because of the relative inaccessibility of the resource to alternate uses. The gap may also indicate a need for storage.

Value and Cost for Irrigated Agriculture in an Arid Zone: Haryana, India

Estimation of the Economic Value of water in irrigated agriculture involves computing the three components as illustrated in figure 4, p. 20. The monetary returns from water in irrigated agriculture vary tremendously across crops and agro-climatic regions, and they depend critically on the timing of application of water and the level and efficiency of use of inputs other than water. Positive Economic Externalities include health and income benefits from the use of irrigation water for the purposes of drinking, personal hygiene and for livestock. Net benefits should also be estimated from the return flows from irrigation. The detailed methodology of estimating these components along with an illustrative exercise is discussed below.

> THE NET VALUE OF OUTPUT IN IRRIGATED AGRICULTURE: If water markets were functioning, the value of water in irrigated agriculture could be obtained from the prices paid by farmers in the market. In the absence of water markets (particularly in surface irrigation), the value of water in irrigated agriculture can be derived as the Net Value of Output attributed to the use of water diverted for irrigating crops. It is defined from the Value of Water in Agriculture, as follows:

$$\text{Value of Water in Agriculture (VWA)} = \frac{\text{Net Value of Output with Irrigation} - \text{Net Value of Output without Irrigation}}{\text{Volume of Water Diverted for Irrigation}}$$

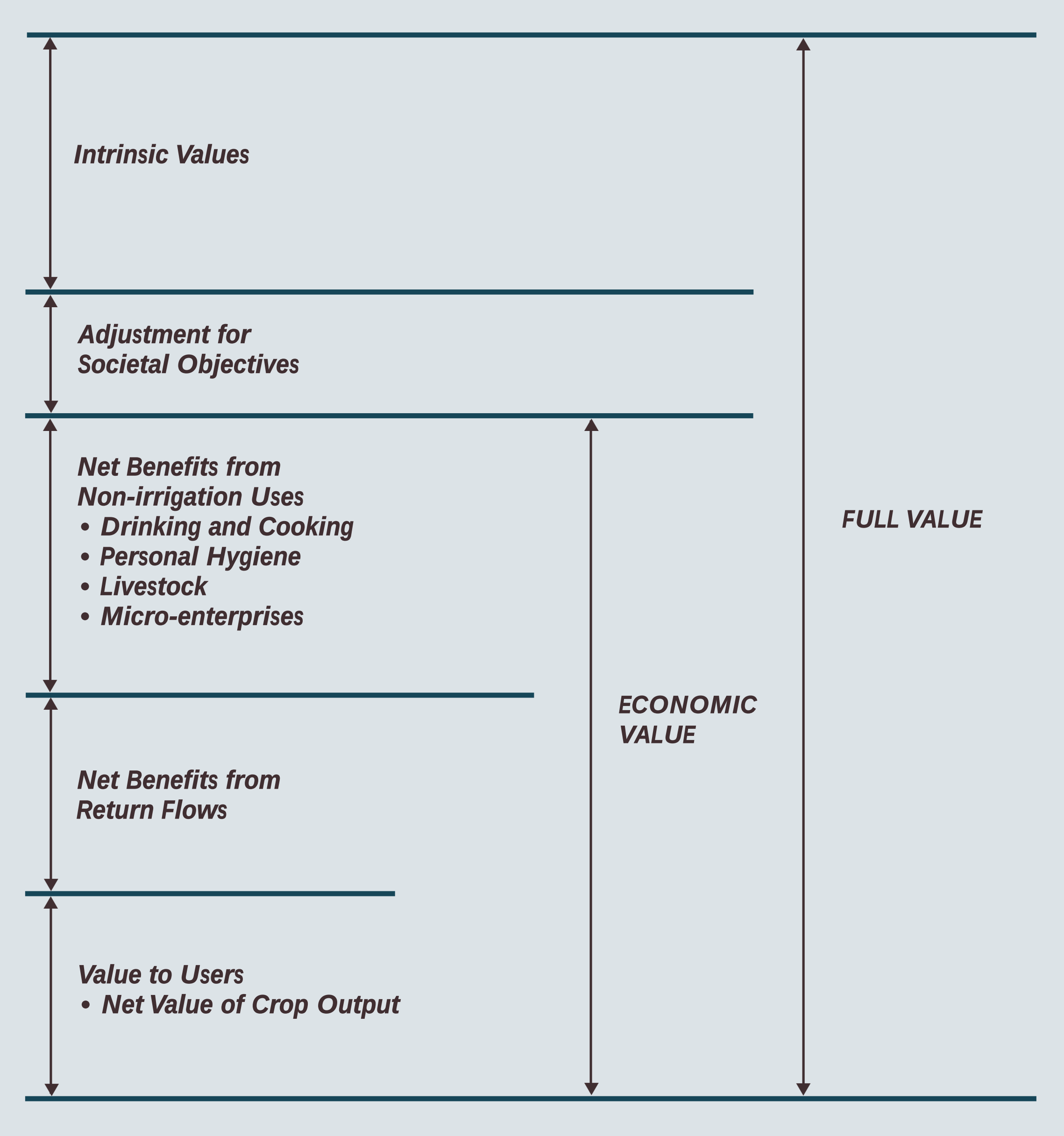


Figure 4. *Estimation of Value of Water in Irrigated Agriculture.*

The Net Value of Output is estimated as the gross value of output minus the cost of cultivation. The volume of water in the denominator refers to the quantities diverted for irrigation and not to the volume of water used by the crops or the evapotranspiration needs of the crops. This is because the costs of supply of water are determined by the volumes of water stored and/or diverted by irrigation structures, and not by the volume of water used by crops. To the extent these are positive return flows from water diverted from irrigation, these should be explicitly accounted for in termsof externalities as discussed later in this section. Similarly, rainfall is not included in the volume of water in the denominator, but it is accounted for when net value of output without irrigation is quantified.

Table 1 provides some data at the farm level which can be used to estimate the value of water in agriculture. The data are for a one-year rotation of wheat and paddy in Haryana in northwestern India. The gross value of output with irrigation is estimated to be $1290 per hectare (ha), while the gross value of output without irrigation is estimated to be only $220/ha. Thus, irrigation enables the farmer to increase the gross value of output by a little over $1070 when two water-intensive foodgrain crops are grown per year.

Table 1. *Estimates of Additional Net Value[6] of Output in Agriculture[7] in Haryana, India.*

	Value of Output with Irrigation	Value of Output without Irrigation	Additional Value/Costs
Gross Value of Output (US$/ha/yr)	1290	220	1070
Cost of Cultivation[8] (US$/ha/yr)	870	190	680
Net Value of Output (US$/ha/yr)	420	30	390
Estimated Water Input (m^3/ha/yr of water diverted)	20,600	0	20,600
Net Value of Output per Unit of Water Input (US$/$m^3$)			0.019

Source: Government of India: Cost of Cultivation of Major Crops, Ministry of Agriculture, 1993.

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[6] Conversion Factor: Rupees (Rs) 24 per US dollar ($).

[7] Under irrigated conditions, two crops have been assumed with the following yields: Paddy 4215 kg/ha and Wheat 3600 kg/ha. Data are for 1991-92.

[8] Cost of cultivation includes cash expenses, land rent, and family labor valued at market wage rate. Labor costs account for 17 percent of cost of cultivation with irrigation.

However, in the intensive farming adopted in the arid region, the cost of inputs, including the cost of irrigation, fertilizers, and labor, account for \$870/ha (table 1). This leaves only \$390/ha as the Net Value of crop output.

In view of the low rainfall in this arid region, and of the high evapotranspiration needs of crops, the irrigation water diverted from surface irrigation and pumped from the ground is very high. The estimates of irrigation requirements for Haryana are: 1640 millimeters (mm) for paddy and 420 mm for wheat (Dhawan 1988). This is equivalent to 16,400 m^3 of water diverted for paddy and 4200 m^3 of water diverted for wheat – i.e. a total of 20,600 m^3 of water per year. Given the crop output of 2900 kilograms (kg) of rice and 3600 kg of wheat, these figures show that 20,600 m^3 of water diverted for irrigation in a year resulted in a foodgrain output of 6500 kg – i.e. a ratio of 3.2 m^3 of water (diverted) per kg of foodgrain produced. However, this figure will be lower when return flows from water diverted for irrigation are taken into account (as discussed below).

NET VALUE OF CROP OUTPUT: The above estimates give a figure of Net Value of Crop Output to the farmer as \$0.019 m^3 of water diverted for irrigated agriculture (\$3,900/20,600 m^3).

ADJUSTMENT FOR SOCIETAL OBJECTIVES: As mentioned above, the societal benefits of food availability (particularly in rural areas) and of low foodgrain prices resulting from additional output from irrigated agriculture suggest that a premium may be attached to the benefits from crop output. To reflect this, the price of foodgrains has been increased by 50 percent. To reflect the objective of employment creation, a shadow wage rate equal to one half of the market wage rate has been used in view of the prevalence of unemployment in areas from where labor migrates to Haryana. Because the gross value of output is higher and the costs of cultivation are marginally lower, this adjustment increases the economic value of irrigation water by \$0.028 m^3.

NET BENEFITS FROM NON-IRRIGATION USES: As discussed earlier, irrigation supplies provide significant additional benefits for drinking, cooking, bathing, personal hygiene, and for livestock.

There are no empirical studies in which the additional value of these benefits have been quantified. In the absence of such data for Haryana, an estimate of $\$0.01/\text{m}^3$ is used for additional benefits to the value of water diverted for irrigation.

NET BENEFITS FROM RETURN FLOWS: It is known that a part of the return flows in Haryana go to the sink of saline groundwater, while the rest charge the groundwater. Although water tables in Haryana have been declining, mining of groundwater is occurring only in one or two districts. Hence, on average, it is assumed for illustrative purposes only that net benefits from return flows are 25

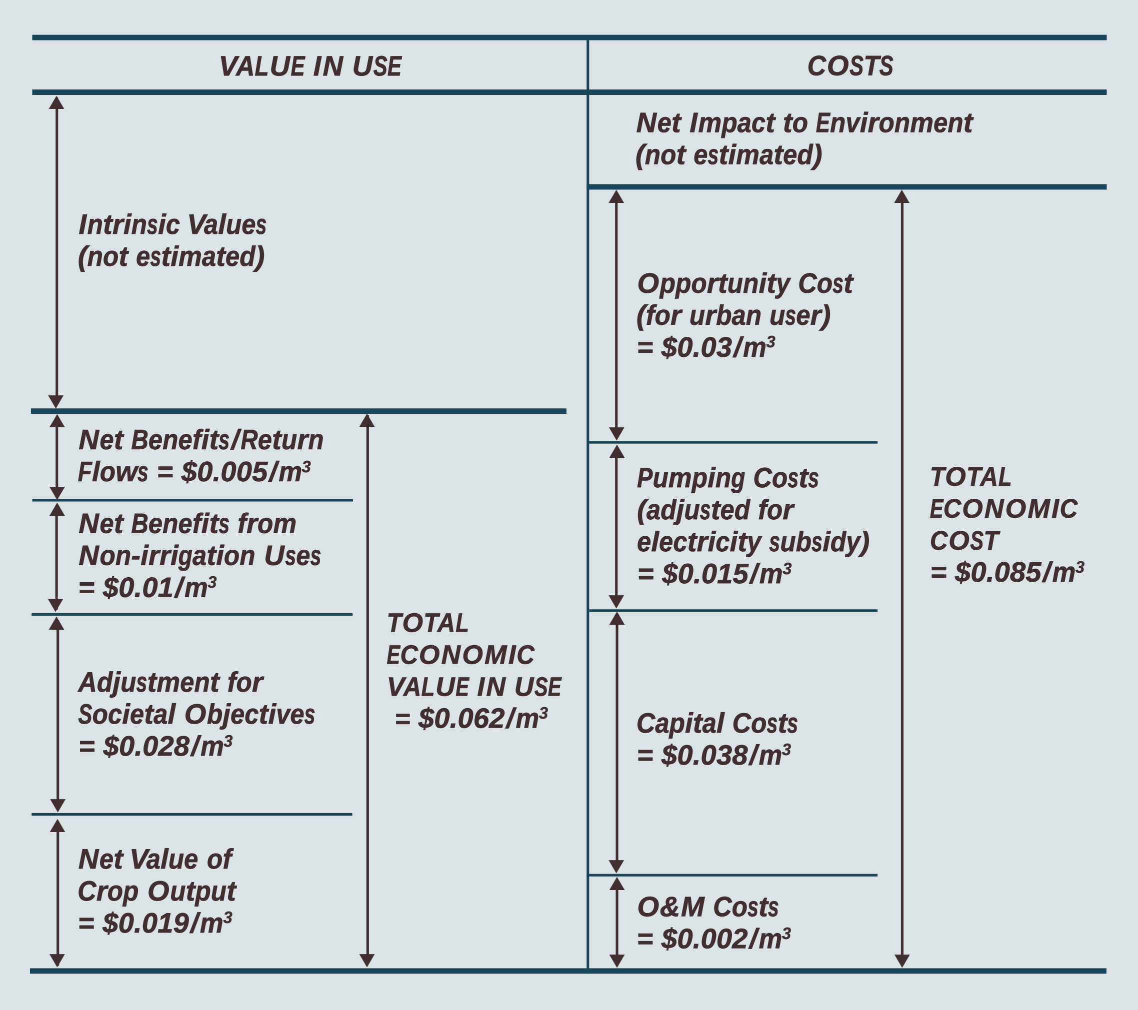

Figure 5. *Estimation of Value in Use for Irrigated Agriculture and Costs of Water in Haryana, India (for details of value to users, see table 1).*

percent of the net value of output in agriculture. This gives an estimate of 0.005/m^3 of water diverted for irrigation purposes.

Total Economic Value in Irrigated Agriculture: The estimated total economic Value of Water diverted to irrigated agriculture is estimated at \$0.062/m^3 (figure 5, p. 23).

Full Economic Costs: The Full Economic Costs of water diverted for agriculture are: \$0.002 for O&M Costs, plus \$0.038/m^3 for Capital Costs, plus \$0.015/m^3 for Pumping Costs, plus \$0.03 as Opportunity Cost of water (in the urban household use). These components (figure 5) add up to \$0.087 as the Full Economic Costs of supplying water for irrigation in Haryana. The gap between the costs and values clearly indicate the lack of sustainable use.

Costs and Values in Jamshedpur, Subernarekha River Basin, India

In this section we present estimates of costs and values of water used in agriculture, urban areas, and in the industries near Jamshedpur in the Subernarekha River basin in eastern India. These data are based on field surveys which were carried out in 1991 and 1992 to estimate willingness to pay, cost of conserved water, and the cost of water treatment by industry and municipalities for its recycling and reuse (Bhatia et al. 1994). For this river basin, we have data and results based on partial equilibrium approaches, as well as on the use of systems analysis models (Anandalingam, Bhatia and Cestti 1992; Harshadeep 1995).

Value of Water in Irrigated Agriculture in the Subernarekha River Basin

The estimated net value of output with irrigation (over that without irrigation) was \$244/ha in 1991-92. In this region, water requirements for irrigation have been estimated to be 8800 m^3/ha/yr, reflecting relatively lower evapotranspiration needs and higher rainfall (as compared with Haryana). Thus, the net value of output in agriculture in this region is estimated at \$0.027/m^3 of water diverted, about 45 percent higher than that in Haryana.

Adjustment for Societal Objectives: As with Haryana, the societal benefits of food security, lower foodgrain prices (particularly in rural areas), and the objective of increasing employment, are estimated to be $\$0.053/m^3$.

Net Benefits from Non-Irrigation Uses: Similarly, we use the same estimate as for Haryana of $\$0.01/m^3$ for the additional benefits to the value of water diverted for irrigation.

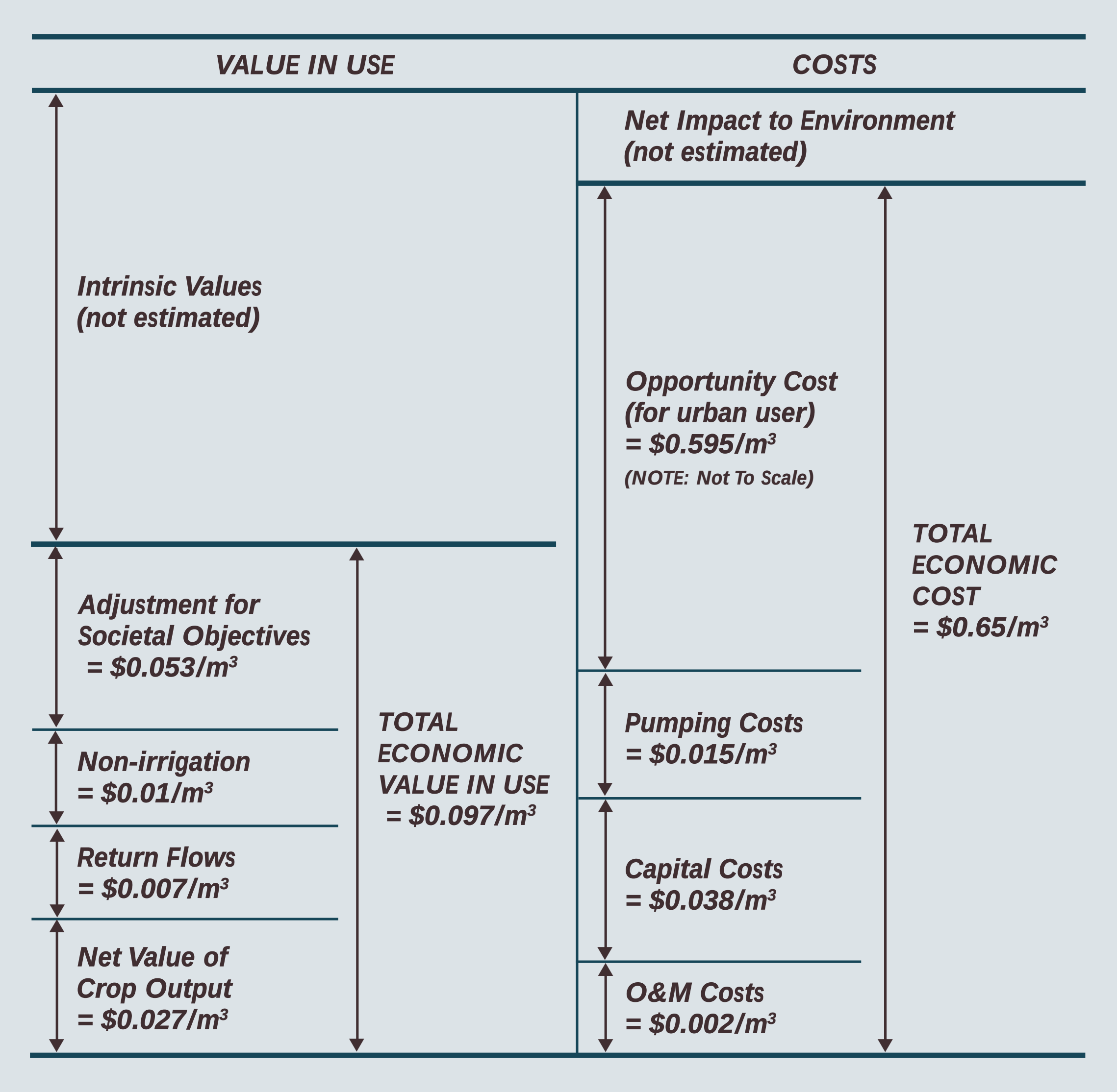

Figure 6. *Estimation of the Value in Use for Irrigated Agriculture and Costs of Water in the Subernarekha River Basin, India.*

NET BENEFITS FROM RETURN FLOWS: It is assumed (for illustrative purposes) that net benefits from return flows will be about 25 percent of the net value of output in agriculture. This gives an estimate of \$0.007/m^3 of water diverted for irrigation purposes.

TOTAL ECONOMIC VALUE IN IRRIGATED AGRICULTURE: The estimated total economic value of water diverted to irrigated agriculture is estimated at \$0.097/m^3, based on the sum of the above components (figure 6, p. 25).

FULL ECONOMIC COST: The Full Economic Cost of water diverted for agriculture is the sum of: \$0.002 for O&M Costs, \$0.038 for Capital Costs, \$0.015 cents for Pumping Costs, and \$0.595 for the Opportunity Cost of water (in the urban household and industrial uses, determined below). These components (figure 6) add up to \$0.65 cents as the Full Economic Cost of supplying water for irrigation in the Subernarekha River Basin.

Value and Costs of Water in Urban and Industrial Sectors

It may be noted that Full Supply Costs at \$0.066/m^3 in Jamshedpur are relatively lower than those in Phuket, Thailand, because in Jamshedpur the industrial users can pump water from the river and the costs of pumping, conveyance and distribution are relatively low. The industries as well as urban consumers can also obtain supplies from a reservoir (the Subernarekha dam) during summer months and there are economies of scale in storage costs of water because of the large irrigation demand (which is twice the demand for water in urban and industrial uses).

The Opportunity Cost of water used in the urban sector is equated here to the benefit foregone in the irrigation sector, estimated at \$0.097 /m^3 as discussed previously.

The effects of Economic Externalities have been nominally estimated to be \$0.014/m^3 to reflect the water withdrawal impacts on downstream users (other than those captured by the Opportunity Cost, i.e. benefit foregone in irrigation).

The Environmental Costs have been represented by the cost to treat water to its original quality, estimated to be \$0.145/m^3 at 1991-92 prices (Bhatia et al. 1994). Treatment and reuse of wastewater from a power plant (containing fly ash and coal particles) is estimated at \$0.127/m^3.

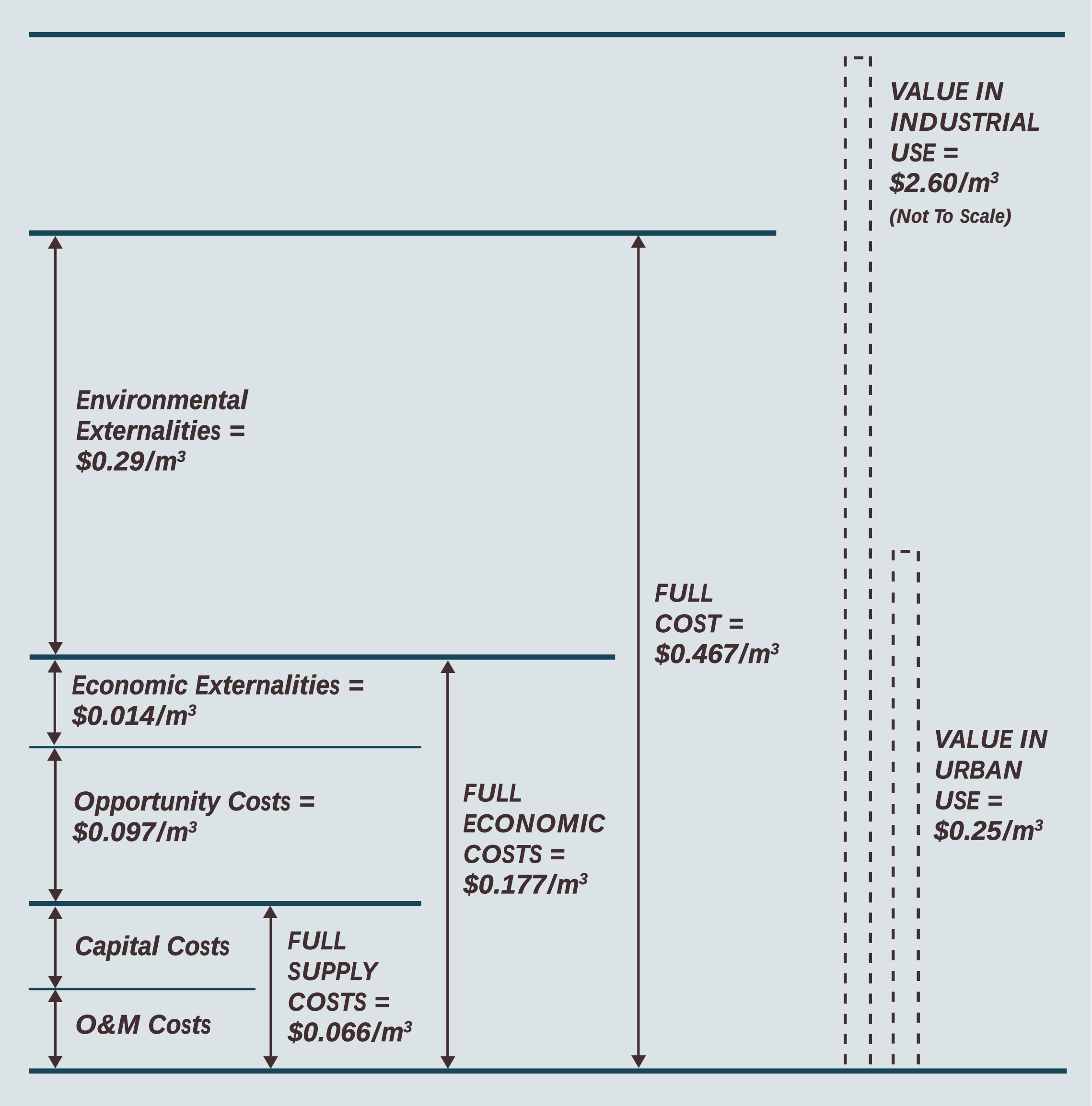

Figure 7. *Estimation of Costs and Values for the Urban and Industrial Sectors in the Subernarekha River Basin, India.*

The costs of treatment of wastewater from coke ovens and blast furnaces (containing high levels of phenol, ammonia and suspended solids) have been estimated at \$0.45/m^3 of water (Bhatia et al. 1994).

We have taken a weighted average figure of \$0.29/m^3 to reflect the cost of Environmental Externalities.

Using the above estimates of various components, the Full Economic Costs are estimated at \$0.177/m^3 and the Full Costs at \$0.467 /m^3. The value of water in urban households is estimated from the average willingness to pay in urban areas of Jamshedpur, which is \$0.25/m^3

The value of water to industry is estimated at \$2.60/m^3, based on the average of the net value added per unit of water for the 21 industrial units for whom data were available. It may be noted that this value is the total net value of output divided by the volume of freshwater water diverted for the industrial unit. It does not reflect the marginal value of water to the industrial units. This is shown in figure 7, p. 27.

Opportunity Cost of Water Used in Irrigation

As mentioned earlier, users face the full economic cost when the price paid includes: (i) the supply cost which includes O&M Costs and Capital Charges and (ii) the Opportunity Cost which reflects the value of water in its best practical alternative use. The Opportunity Cost of water used in irrigation would depend on the opportunities and costs of transferring the water among potential users of that water (which will usually include other farmers and may include other towns and industries). Under these situations, "the best alternative use" must consider location and hydraulic connections between users as well as the costs of transfer. Further, the Opportunity Cost of water used in irrigation will decline very fast after all the cost-effective possibilities of transfer have been exhausted. Given the fact that irrigation is the predominant user of water in most river basins, the Opportunity Cost would be zero (or close to it depending upon the ecosystem demand for water) after the demands for other sectors or users have been met. Under such a situation, the Opportunity Cost would have to be estimated on the basis of the weighted average of the Value in Use in different subsectors (weighted by their volume). For example, in the Subernarekha River basin, the estimated annual demands are 1,346 million cubic meters (MCM) for irrigation, 440 MCM for industry and

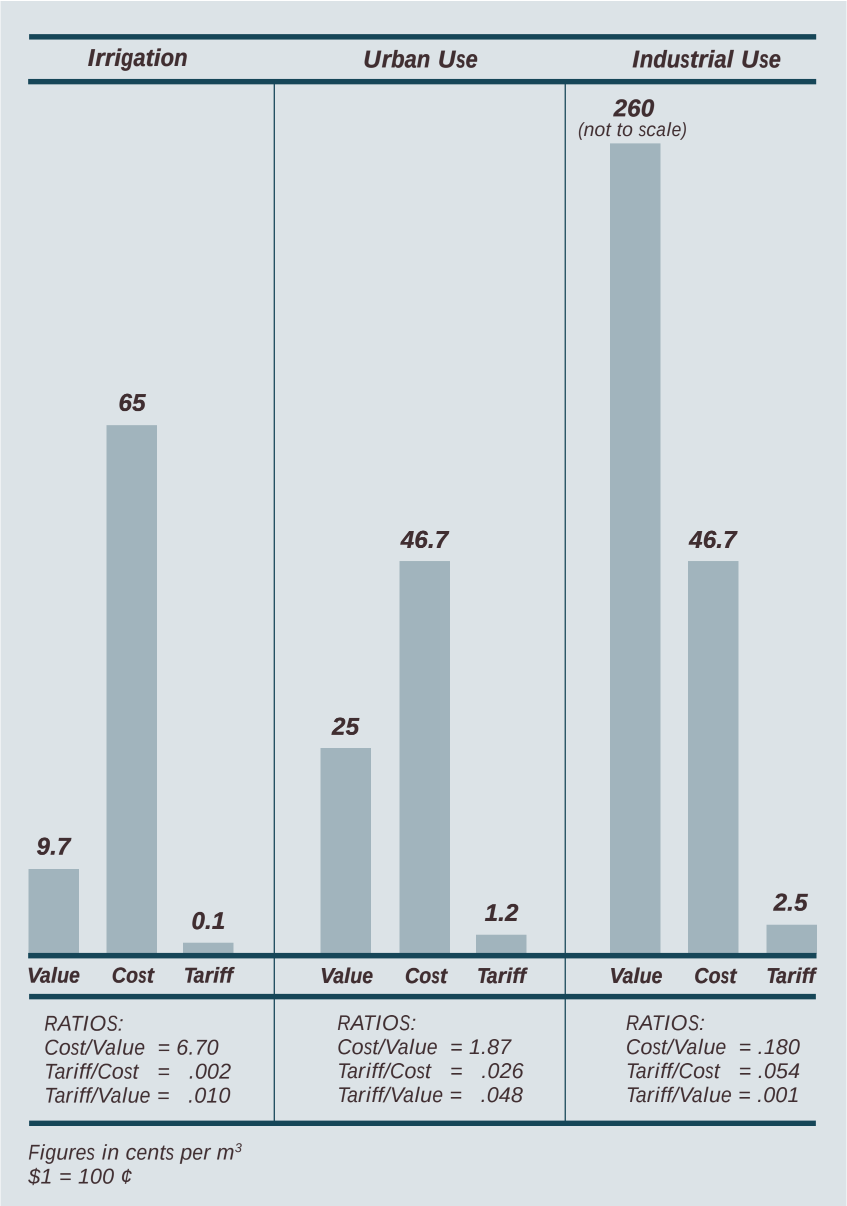

Figure 8. *Comparison of Value in Use, Costs and Tariffs for Three Sectors in the Subernarekha River Basin, India.*[9]

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[9] Tariffs are as follows: Agriculture 0.1 ¢/m^3; Urban households 1.2 ¢/m^3; Industry 2.5 ¢/m^3

235 MCM for domestic users. Assuming that the entire volume of irrigation water could be transferred to industry and domestic sectors, the Opportunity Cost for about 50 percent of the water used in irrigation would be zero. Using these volumes and estimates of Value in Use in the industrial and domestic sectors, the Opportunity Cost of irrigation water is calculated as \$0.595/m^3. This figure is much lower than the average value of water used in the industrial sector. Further, this figure is based on the assumption that as much as 440 MCM of water could be transferred out of agriculture without much of the additional costs as estimated here.

As pointed out by Olivares (1996), in Chile, the need for physical arrangements for the water transacted to be actually transferred from the seller's outlet to the buyer's intake is the main constraint to water transactions and thus to large-scale development of water markets. In the Paloma system in Chile in 1994, transaction between canal systems amounted to 1 percent of water rights (sales) and 3 percent of available water (rentals). This underlines the need for a careful analysis of the scope of water transfers from agriculture to other uses. These issues are best handled in the framework of systems analysis.

A Comparison of Costs and Values in Various Sectors

Figure 8, p. 29 gives a comparison of values and costs of water in three sectors in the Subernarekha basin. The value of water in industrial use is approximately six times the Full Cost of the supply of water, including the costs of Economic and Environmental Externalities. In contrast, the Value in Use in the urban household sector is lower than the Full Costs of supply. In the case of agriculture, the Value in Use is much lower than the Full Economic Cost, which includes the Opportunity Costs of water used in irrigation, which implies that under the current situation there may be issues with sustainability, and given the very low tariffs, there may be opportunities to use tariffs to reach a more sustainable allocation of water.

III. SUMMARY AND CONCLUSIONS

To recapitulate, this paper presents a framework for operationalizing the concept of water as a social and economic good. Four principal conclusions emerge from the discussion:

- First, it is important to estimate the Full Cost of water used in a particular sector and this should include the Opportunity Cost of water as well as the Environmental Externalities. The Full Cost should present the context for setting water prices, effluent charges, and incentives for pollution control.
- Second, in estimating the value of water, it is critical to reflect societal objectives of poverty alleviation and food security, and incorporate the net benefits from return flows and non-irrigation uses of water.
- Third, the above considerations should be taken into account while setting water tariffs for domestic users and for irrigation.
- Finally, raising water tariffs, levying effluent charges and encouraging water markets can play significant roles in improving economic efficiency and environmental sustainability of water use.

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