# ECONOMIC VALUATION OF WATER

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**Keywords:** Value of water, cost of water, externalities, opportunity cost, intrinsic values, water allocation.

## Contents



## 1. Introduction and Scope

Agenda 21 and the Dublin Principles put the concept of water as an economic good on the global agenda, and 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 2 presents the general principles and methodologies for estimating costs and values in the water sector. In Section 3, some illustrative estimates of costs and values in urban, industrial and agricultural sectors are presented based on available data. Section 4 provides a summary of results and conclusions.

## 2. 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. 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 (*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.")* imposed upon others nor the alternate uses of the water. 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.

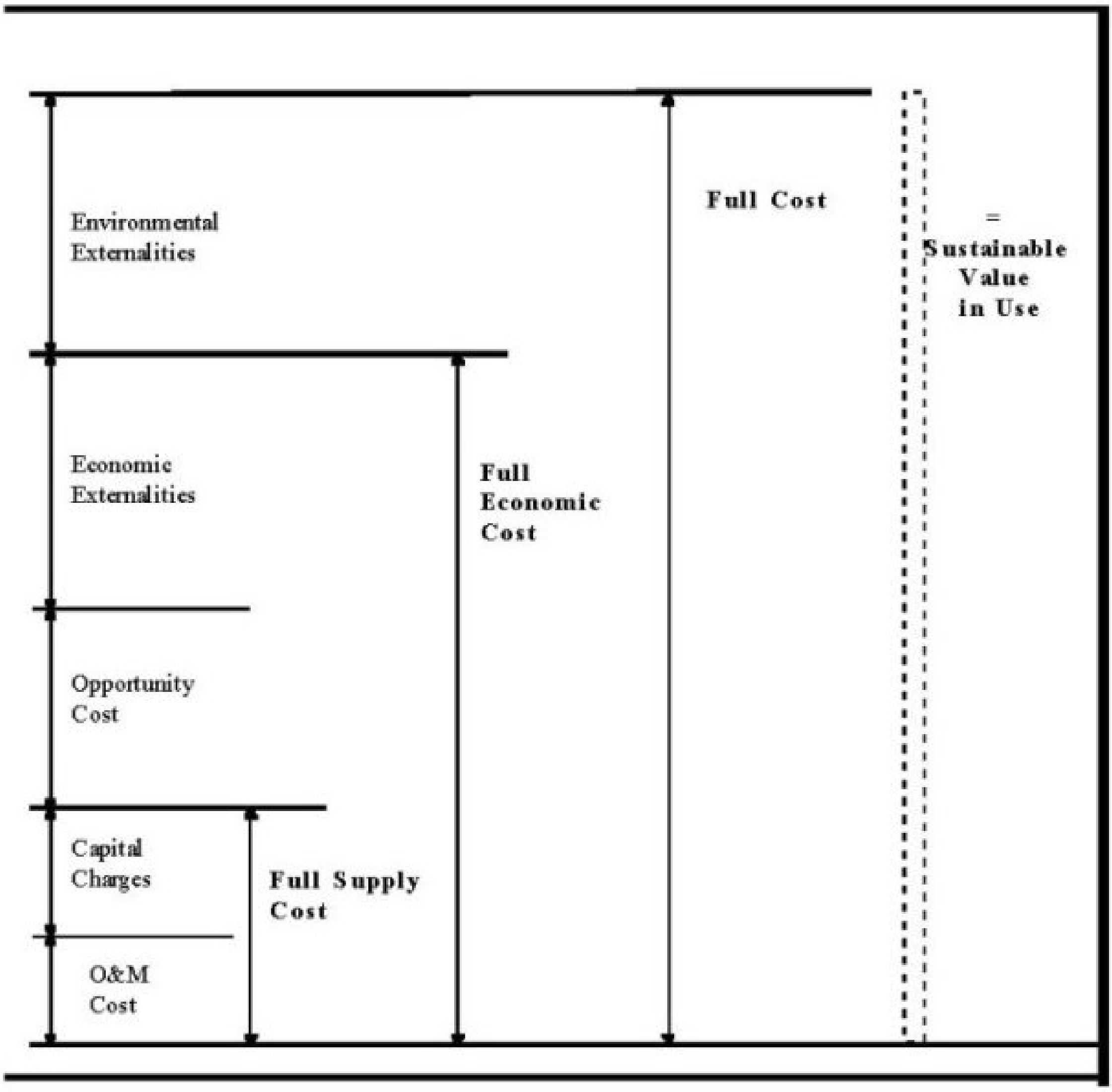


Figure 1. General Principles for Cost of Water

**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. 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 mis-allocation 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 in the further in the paper.

**Economic Externalities:** As a fugitive resource (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.), water results in pervasive externalities. The most common externalities are those associated with the impact of an upstream diversion of water or the release of pollution on downstream users. There are also externalities due to over-extraction from, or contamination of, common pool resources (*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.),* such as lakes and underground water. 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 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 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 literature. 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 because 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 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

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