Cost–Benefit Analysis and Water Resources Management

Edited By **Roy Brouwer and David Pearce**

Cost–Benefit Analysis and Water Resources Management

'Water is not just H_2O, but has a socioeconomic value for many use and non-use purposes. This volume contains a varied set of very interesting evaluation studies on water resources management. The editors have served the scientific community and relevant policy bodies with a balanced collection of operational contributions to a solid cost–benefit perspective on water management. This book is certainly an eye-opener for anyone interested in the significance of cost–benefit analysis for water policy issues.'

– Peter Nijkamp, Vrije Universiteit Amsterdam, The Netherlands

'The book chapters are written to accommodate readers of various disciplines, using a descriptive analysis of complicated issues to be easily comprehended by non-technical readers. The coverage of the issues is also phenomenal, including application of CBA to flood control, river restoration, river basin management, water quality, ground water, and water allocation, to mention only a few. The group of contributing experts is also very impressive, including authoritative practitioners and academicians, all of whom display a high level of expertise and experience. In a world where water becomes a contested scarce resource, the appropriate use of economic tools in a policy context is a very important goal. This book with its authoritative guidance does contribute to achieving it.'

– Ariel Dinar, World Bank and Johns Hopkins School of Advanced International Studies, USA

'This book provides a solid foundation in the theory and methods of cost–benefit analysis of water resources, along with a wide range of case studies that illustrate the practical aspects of applying cost–benefit analysis. There is much an aspiring cost–benefit practitioner and water resources planner can learn from this volume to improve the economic efficiency of water resource management.'

– John Loomis, Colorado State University, USA

'This book offers a unique and very coherent collection of ambitious CBA studies of water-related issues. It can be seen as a showcase of the potential, as well as a test on the limits, of cost–benefit analysis. Given the increasing importance of effective and efficient management of water – in response to water scarcity, water pollution and climate trends – the lessons from this book will be very useful to policymakers and social scientists alike.'

– Jeroen van den Bergh, Vrije Universiteit Amsterdam, The Netherlands

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3. Water as an economic good

J. Briscoe

1. THE THEORY OF WATER AS AN ECONOMIC GOOD

There is an emerging consensus that effective water resources management includes the management of water as an economic resource. The Dublin Statement of the International Conference on Water and the Environment, for example, states that 'water has an economic value in all its competing uses and should be recognized as an economic good'. But there is little agreement on what this actually means, either in theory or in practice. This chapter provides a simple framework for unbundling the different components of water as an economic resource, provides some data on critical variables and discusses the policy implications.

The idea of 'water as an economic good' is simple. Like any other good, water has a value to users, who are willing to pay for it. Like any other good, consumers will use water so long as the benefits from use of an additional cubic meter exceed the costs so incurred. This is illustrated graphically in Figure 3.1(a), which shows that the optimal consumption is X^*. Figure 3.1(b) shows that if a consumer is charged a price P^1 which is different from the marginal cost of supply, then the consumer will not consume X^*, but X^1. The increase in costs (the area under the cost curve) exceeds the increase in benefits (the area under the benefit curve) and there is a corresponding loss of net benefits called the 'deadweight loss'.

But what about groups of users, how is welfare maximized for the group and society as a whole? The simple logic of Figure 3.1 applies in the aggregate – for society as a whole, welfare is maximized when:

- water is priced at its marginal cost; and
- water is used until the marginal cost is equal to the marginal benefit.

So far so good, but what actually do we mean by 'benefits' and 'costs', how are these dealt with in different water-using sectors and what are the implications? These issues are explored in the next section of this chapter.

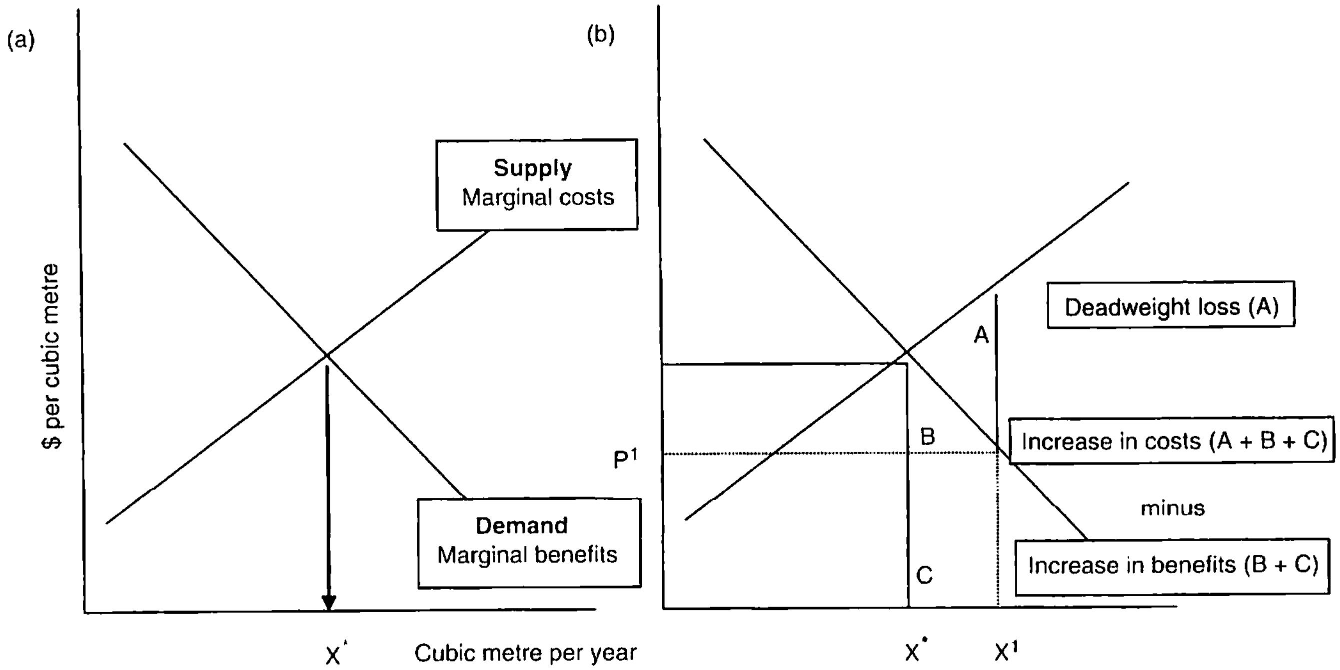


Figure 3.1 Optimal consumption and deadweight losses if water is underpriced

2. THE VALUE OF WATER

The value of water to a user is the maximum amount the user would be willing to pay for the use of the resource. For normal economic goods which are exchanged between buyers and sellers under a specified set of conditions, this value can be measured by estimating the area under the demand curve. Since markets for water either typically do not exist or are highly imperfect, it is not simple to determine what this value is for different users of water. A hodgepodge of methods are used to estimate the value of water in different end uses (Gibbons, 1986). These methods include:

- estimating demand curves and integrating areas under them;
- examining market-like transactions;
- estimating production functions and simulating the loss of output which would result from the use of one unit less of water;
- estimating the costs of providing water if an existing source were not to be available;
- asking (with carefully structured 'contingent valuation' questions – Arrow et al., 1993; Griffin et al., 1995) how much users value the resource.

What is the point of estimating these values, given the crude and inexact nature of the estimates, and given that the value of water varies widely depending on factors such as the use to which it is put, the income and other characteristics of the user, the location at which it is available, season and time, and quality and reliability of the supply? Most certainly these 'ball-park estimates' can never, and should never, be used to make technocratic decisions on allocations and prices (as has sometimes been proposed). But examination of the values which emerge from these estimates do show some striking and remarkably consistent themes which have major implications for policy. To illustrate these themes, it is useful to work with some actual values. Figure 3.2 summarizes some data (presented by Moore and Willey, 1991) from the western United States, where most valuation work has been done. Other compilations (for example, in Gibbons, 1986) show similar patterns in terms of the relative value of water in different uses.

Conclusions which emerge from Figure 3.2 (note the log scale on the Y axis) and consistently in similar studies and in meta-studies which draw together large amounts of available data include the value of water for:

- irrigated agriculture;
- hydropower;
- household purposes;

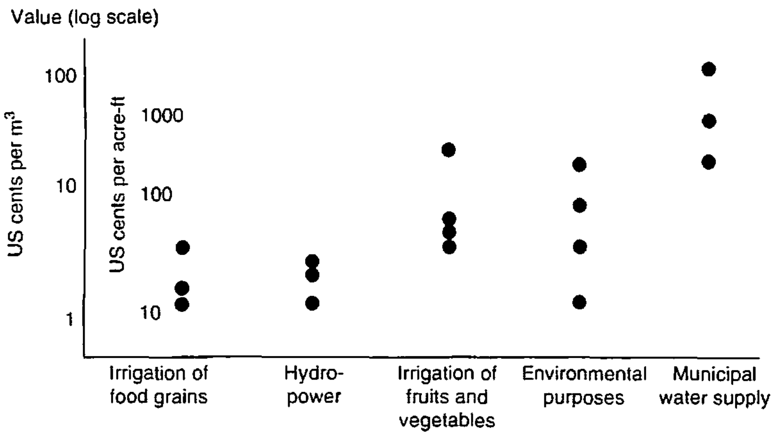


Figure 3.2 Typical market and non-market values for water in the western United States

- industrial purposes; and
- environmental purposes.

2.1 Value of Water in Irrigated Agriculture in Industrialized Countries

It is, first, important to note that irrigated agriculture accounts for a large proportion of water use, especially in many water-scarce areas. The value of water for many low-value crops (such as food grains and fodder) is universally very low. Where reliable supplies are used on high-value crops, the value of water can be high, sometimes of a similar order of magnitude to the value of water in municipal and industrial end uses.

2.2 Value of Irrigation Water in Developing Countries

The picture in developing countries is similar. Consider the case of India. In western India (Shah, 1993) groundwater is exploited by private farmers and is provided in a timely and responsive fashion to users (the farmers themselves and others to whom they sell the water). The water is used on high-value crops (including fruits, vegetables and flowers). The value of water, as reflected in active and sophisticated water markets, is high (typically around US 5 cents per cubic metre). In public (mostly surface) irrigation systems in the same country, the quality of the irrigation supply is poor, food grains are the major crop produced, and the value of water is typically only about 0.5 cents per cubic metre (World Bank, 1994a), orders of magnitude lower than in the private groundwater schemes. Similar very large and persistent differences are found in publicly run irrigation schemes throughout the developing world.[1]

2.3 Value of Water for Hydropower

The short-run values for water in hydropower in industrialized countries are typically quite low, often no higher than the value in irrigated agriculture (Gibbons, 1986). Long-run values are even lower. Whether hydropower is an economic proposition depends greatly on particulars – of the economy, of the power sector and of the water sector. Where water is abundant and there are few competing uses, hydropower is likely to be economically viable; where water is scarce (and therefore competition high), the case for hydropower is less clear-cut.

In developing countries the demand for power is growing very rapidly. Although energy conservation is important here (as it is in industrialized countries), large capacity expansion is inevitable and essential. It has been argued (Goodland, 1996) that the high environmental costs of alternatives (especially fossil-fuel based generation) means that hydropower is a particularly attractive alternative in many developing countries. Interestingly, data suggest that the environmental costs – as measured by flooded area per kw and number of oustees per kw – are substantially smaller for big dams than smaller dams (less than 100 megawatts of installed capacity).

It is frequently argued that hydropower is a non-consumptive use and therefore does not impose costs on others. It is this notion which has, for instance, been behind the creation of two separate categories of water rights – 'non-consumptive' and 'consumptive' – in Chile (Gazmuri and Rosegrant, 1996). What is evident – in Chile and elsewhere – is that the situation is not so simple. By modifying flow regimes and the timing of water to downstream users, hydropower installations can impose major costs on other users (Briscoe, 1996b). The key issue is not consumptive or non-consumptive use, but the costs imposed on others by a particular use of a resource.

2.4 Value of Water for Household Purposes

This value is usually much higher than the value for most irrigated crops. Not surprisingly, the value for 'basic human needs' and for household uses is much higher than the value for discretionary uses (such as garden watering). An important finding (similar to that emerging from the irrigation data) is that people, even poor people in developing countries, value a reliable supply much more than they value the intermittent, unpredictable supplies which are the norm in most developing countries (World Bank Water Demand Research Team, 1993).

2.5 Value of Water for Industrial Purposes

This value is typically of a similar order of magnitude to that of supplies for household purposes.

2.6 Value of Water for Environmental Purposes

The value of water for environmental purposes such as maintenance of wetlands, wildlife refuges and river flows also vary widely, but typically fall between the agricultural and municipal values, as shown for the western United States in Figure 3.2. In developing countries, most similar work has been done on the value of mangrove swamps (in El Salvador. Malaysia. Indonesia and Fiji), which are critically dependent on inflows of fresh water. These data, too, show quite high values (primarily due to the off-site impacts on fisheries) (Lai, 1990).

Before discussing the policy implications of these remarkably consistent findings, it is relevant to summarize a related area of work on the economic value of water, which also has major impacts for policy. There is a substantial literature assessing how users react to changes in the price of water. The concept used is that of 'elasticity', with the measure being defined as the percentage change in use of water for each percentage increase in the price of water. Once again, there is a striking consistency to the findings (and to their import for resource management, as discussed later). Figure 3.3 presents some values (again from Gibbons, 1986) which do not purport to be universal, but which illustrate consistent findings in the literature.

In assessing data on elasticity, it is necessary to clear up a confusion generated by a piece of economic jargon. When the price elasticity of demand is less than -1.0 (that is, when the percentage change in consumption is less than the percentage change in price) then economists say 'demand is inelastic with respect to price'. The common-sense (but erroneous) interpretation is that demand is not reduced as prices change. In fact, as long as price elasticity is negative, demand is reduced when prices increase.

An obvious omission from Figure 3.3 – the lack of estimates of the price elasticity of demand in irrigated agriculture – needs to be explained. This is best done with reference to the place where it has been most studied – the western United States. In the western USA the price elasticity of demand for irrigation water is low. The reason for this low elasticity is not that farmers do not respond to prices (as is often inferred), but rather because users' reactions to price changes depend on the original price and

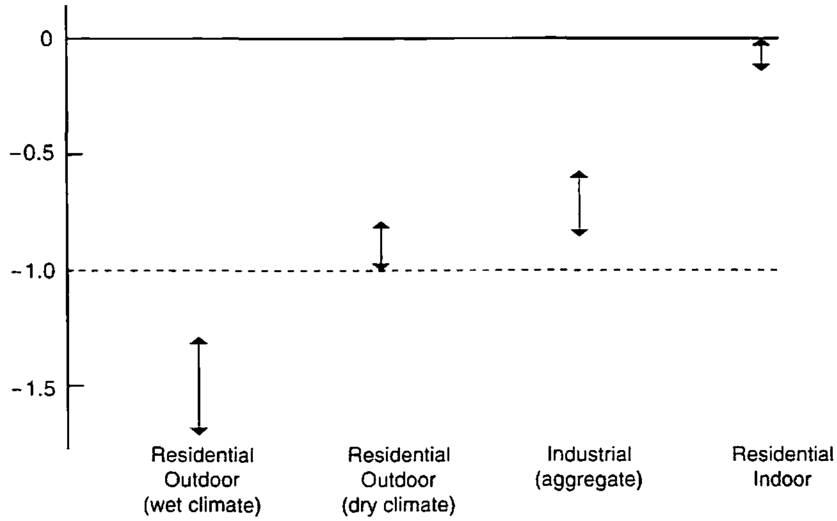


Figure 3.3 Range of price elasticities of demand for water in the United States

because irrigation water costs are held artificially low (Gibbons, 1986). In California, for example, where water is priced at $3 per thousand cubic metres, a 10 per cent price increase causes a 5 per cent decline in water use, whereas where water is priced at $14 per thousand cubic metres, a 10 per cent price increase results in a 20 per cent drop in use (Rogers, 1986).

The major point that emerges from the (quite large) literature on the price elasticity of water demand is that, in developing and developed countries alike, the price elasticity is significantly negative, meaning that users react to price increases by reducing demand. A second important point is that the price elasticity is, as common sense would suggest, related to the price level – the higher the price, the greater the elasticity. Obvious and commonsensical as these findings may be, they contradict a large body of folklore about 'non-responsiveness to prices' in the water profession.

Before concluding this discussion of 'value', it is relevant to focus on the issue of the 'value' of waste water treatment, or the 'value' of environmental quality. The usual approach to this has been to assume that it is impossible to assess this value and, instead, to promulgate standards (by type of treatment required, quality of effluent stream, or quality of the receiving stream). This is often perceived as a way of 'getting round' the issue of value. As was shown in a seminal work by Harold Thomas (1963), setting of a standard is equivalent to imputing a value for the resource. As will be discussed later, there are institutional arrangements for setting standards which violate (at great cost) this understanding, but there are also institutional arrangements which provide practical and proven methods for taking these values into account implicitly in setting standards.

3. THE COST OF WATER

So much for the value side of the equation – what of the cost side? In thinking about 'the cost of water' it is first necessary to acknowledge that there are two different types of costs incurred in providing water to, say, a household or a field. The first (obvious) cost is that of the constructing and operating the infrastructure necessary for storing, treating and distributing the water. In this chapter this is referred to as the 'use cost'. The second, less obvious, cost is the 'opportunity cost' incurred when one user uses water and, therefore, affects the use of the resource by another user. For example, greater abstraction of water by a city might affect the quantity and quality of water available to downstream irrigators, thus imposing costs on these users.[2]

3.1 Use Cost

In discussing 'use costs', it is first necessary to define three concepts. First is the concept of 'historical costs'. Consider the example where a water board constructs a reservoir from which it supplies water to its customers. What should the board charge its customers for the service provided by the reservoir? Frequently, the charging system mimics the mortgage payers of a homeowner – the board charges its users that which is necessary to pay for the remaining portion of the debt incurred in financing the dam. This is known as 'historical cost' pricing. The second, less intuitively obvious concept is that of 'replacement cost pricing'. Accountants will argue that the value of the asset (the dam in this case) is not correctly measured by its historic costs (which are often heavily distorted by government intervention), but rather the cost that would be incurred in replacing the asset. The analogy here is that of the housing rental market. If a homeowner has paid off his or her mortgage, he or she does not charge a tenant nothing – rather, he or she charges a rental fee that reflects the replacement cost of the asset. The third concept is that of marginal cost. Economists argue that when someone is thinking about using a bucket of water, they should not be told (through prices) what it costs to produce that water but, rather, be told the cost that will have to be incurred if capacity needs to be expanded to produce another cubic meter of water (Turvey and Warford, 1974). Where cost curves are relatively flat, the distinction between the former (average costs) and the latter (marginal costs) is unimportant. When costs are falling (as happens where there are economies of scale. for instance in treatment plants), marginal costs are less than average costs. For raw water, however, the situation is just the opposite. because the closest, cheapest sources are those which are used first. The cost curve for raw water, then. is almost always rising, and marginal costs are greater than average costs.

3.2 Opportunity Cost

It is obvious that measuring the opportunity cost of water is a difficult task. It needs a systems approach and a number of more or less heroic assumptions about real impacts and responses to these. What can be said with certainty is that:

- Opportunity costs are related to value in a non-transitive way. That is, if a city and an irrigation district lie on opposite banks of a stream, the opportunity costs imposed by abstraction by the high-valued user (the city) will be much lower than the opportunity costs imposed by abstraction by the low-value user (the irrigation district).
- Opportunity costs increase substantially as the water in a basin becomes more 'densely used' (both in quantity and quality terms) and are, therefore, substantially higher, all other things being equal, in arid, heavily used basins.
- The existence and imposition of opportunity costs can give rise to conflicts amongst users, unless there are institutional mechanisms for recognizing these costs and for ensuring that these are taken into account by users (on which more later in this chapter). Such conflicts are. of course, not a new phenomenon – the etymology of the word 'rivals', originally meant 'one living on the opposite bank of a stream from another' (Oxford English Dictionary, 1971).

4. THE BALANCING OF VALUE AND COSTS

The overall 'economic cost of water', therefore. comprises two separate components – the use cost and the opportunity cost. It is useful to maintain and deepen this disaggregation in thinking about how the idea of 'the cost of water' is understood, and how this understanding frames the public. political and theoretical discussions of water management. In doing this. it is instructive to recognize that there are a variety of ways in which the use cost and opportunity cost are perceived, and how different institutional arrangements mean that users are faced with different vectors of 'use' and 'opportunity cost'.

In exploring these relationships it is useful to first define the 'golden standard', namely, that combination of use and opportunity costs which ensure that users take the full economic costs of using water into account. As illustrated in Figure 3.4, a user faces the full economic cost when he or she (a) has to pay a 'use cost' which corresponds to the marginal financial cost of supplying the water to him or her and (b) incurs an opportunity cost which reflects the value of water in its best practical alternative use. This combination of 'use cost' and 'opportunity cost' is shown in the upper right-hand corner of Figure 3.4.

So much for theory, what about practice? This varies by sector and by country. A few examples will illustrate the general situation.

4.1 Urban Water Supply in Industrialized Countries

Practice in urban water supply in industrialized countries deviates from 'the economic optimum' in two ways, which are significant in theory, but of little importance in practice. Regarding 'use charges', water utilities in industrialized countries are generally operated on commercial or quasi-commercial principles (World Bank, 1994b), and recover the full average financial costs (level III in Figure 3.4) from users. There are two reasons why few utilities operate at level IV (the economic optimum).

First, although there are negative economies of scale for raw water, there are positive economies of scale for the major civil works, which account for much of urban water supply costs. Accordingly, marginal costs may not be different from (and may actually be less than) average costs. Second, setting tariffs to cover average costs is a simple, transparent process, which mimics that of commonplace financial transactions. A corollary is that the (small) economic benefits of moving to marginal cost pricing have to be weighed against the (large) administrative and governance costs of dealing with a system which 'defies common sense' for most customers.

Urban water tariff setting also deviates from the economic optimum in that the opportunity costs of water are often not visible to the utilities (except in well-functioning water resource management systems, two of which are described later in this chapter). In any case, these opportunity costs are, from the point of view of urban water supplies, usually very small relative to the financial costs of abstracting, transporting, treating and distributing water. For the urban water sector Figure 3.4 would usually look like a 'tall L', as shown in Figure 3.5.

The 'tall-L' shape for urban water arises both because the value of raw water for municipal uses is typically (as shown in Figure 3.2) an order of magnitude higher than the value of the next best use, and because the costs of raw water constitute only a minor part (typically less than 20 per cent)

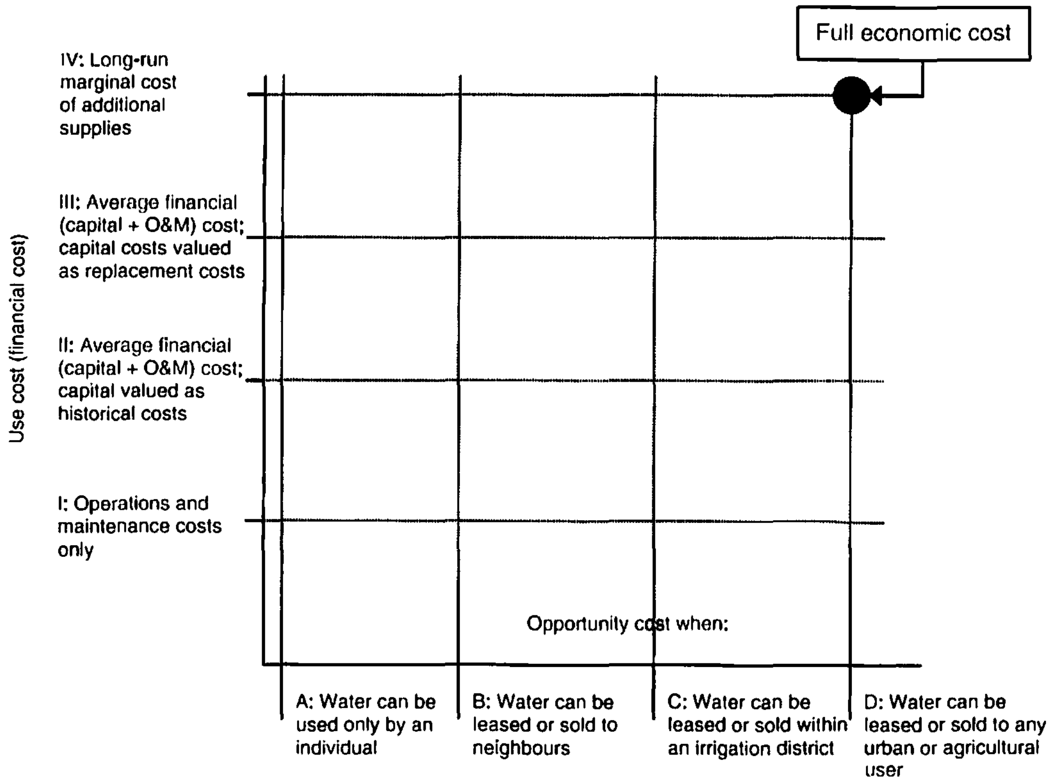


Figure 3.4 Schematic representation of the definitions of use cost and opportunity cost

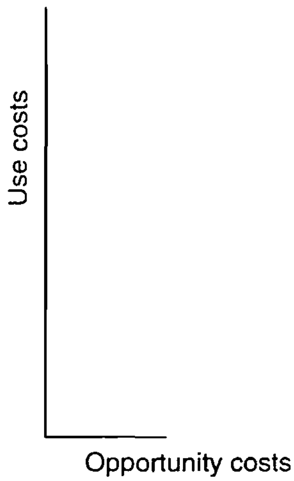


Figure 3.5 The relative magnitudes of use costs and opportunity costs for urban water supply

of the cost of water as delivered to the customer. The bottom line then is that, although opportunity costs are often not taken into account, the 'tall-L' shape of Figure 3.5 means that, in practice, urban water supply pricing in industrialized countries deviates little from the economic optimum.

4.2 Urban Water Supply in Developing Countries

In developing countries the situation is quite varied and generally quite different from that in industrialized countries. The first difference comes on the cost side. Many cities in developing countries are growing rapidly. In many cities incomes are also increasing and industrial demand is growing. The net result is that the demand for municipal water is often growing very fast and new sources have constantly to be found. A consequence is that the costs of urban supplies from new sources are growing rapidly – in current World Bank financed projects the cost of a cubic metre of raw water for a city is typically two to three times greater (in real terms) than was the case in the last project (World Bank, 1992). In terms of Figure 3.4, this means that the difference between marginal (level IV) costs and average (level III) costs are typically substantially greater for developing countries than for industrialized countries. Unfortunately the story does not stop there. Urban water supplies in most developing countries have been financed but of general revenues. In many cases these costs are fully subsidized, with the utility responsible only for operation and maintenance costs (level I).

In other cases the costs are computed in historical terms, which typically greatly undervalue the assets of the utility.

With regard to opportunity costs, the situation is similar to that in industrialized countries – they are not taken into account, but are also usually small relative to real financial costs. In a typical case in India, for instance, average financial costs ('use costs') are about US 50 cents per cubic metre, whereas the opportunity cost of water (for irrigation of food grains) is about 0.5 cents per cubic metre, a difference of two orders of magnitude.

The important challenge for urban water utilities in developing countries, is, therefore to:

- reduce costs by more efficient operation, which increasingly means substantial involvement of the private sector (Serageldin, 1995; World Bank, 1994b); and
- raise tariffs from their very low levels, which typically cover less than one-third of costs (World Bank, 1992). Worrying about opportunity costs they impose – the short leg on the L in Figure 3.5 – is not a priority problem for urban water utilities in developing countries.

4.3 Privately Financed Irrigation

The great distinction here is not between industrialized and developing countries, but rather between publicly and privately financed irrigation schemes. In most countries private irrigators bear the full financial costs of the schemes they construct and thus implicitly face financial costs at level III in Figure 3.4. In a number of countries this is not the case, with subsidies substantially reducing the financial costs incurred by private irrigators.[3]

Private irrigators seldom face any opportunity costs for the water they use. Where groundwater is used, this has led to the unsustainable pumping of aquifers, sometimes on a huge scale, such as the Ogallala aquifer in the United States (Rogers, 1986). Where surface water is used, this is often in the context of a 'prior appropriation' water doctrine, which implicitly encourages the ignoring of opportunity costs.

4.4 Publicly Financed Irrigation

Public irrigation systems throughout the world share several striking characteristics. First, as has been documented in countries as different as the United States (Bradley, 1996; Worster, 1992; Reissner, 1986), and India (Wade, 1986), they have been enormous sources of political patronage. Typically these investments have been subsidized almost completely by the state. In most developing countries charges have been much lower than those required even to pay for operations and maintenance costs (World Bank. 1995). In Bihar in India, for example, water charges are not sufficient even to cover the costs of collection (Rogers, 1992).

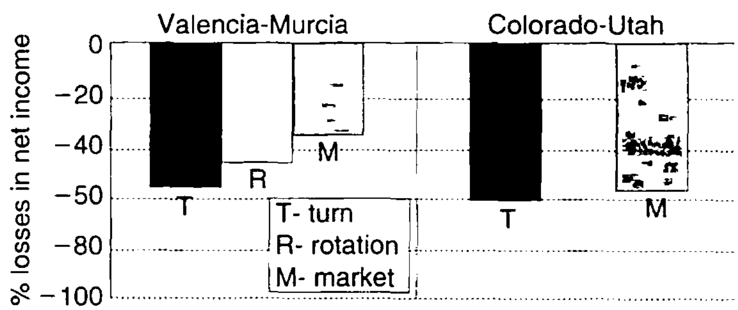
The issue of 'recovering the costs of operations and maintenance' has been the focus of much debate in the irrigation community. This is an important debate, first, because the associated issue of ensuring that systems are maintained and provide a good-quality service to users such as farmers is obviously appropriate and central to improving irrigation performance. This issue thus deservedly occupies centre stage in reviews, such as a recent one by the Operations Evaluation Department of the World Bank (1995). An important finding from such reviews is that the supply side of this question is at least as important as the demand side. It has been shown repeatedly that cost recovery in irrigation systems makes little positive difference unless the revenues so collected are applied to improving the quality of service received by the farmers. Where these revenues go to a central treasury (as is frequently the case), there is little improvement in irrigation performance if 'costs are recovered'.

The 'opportunity cost' axis is an important and subtle one in canal irrigation systems (the dominant technology in public irrigation districts). A typical situation is one in which users are charged a small amount (often zero) for the 'use cost', but where they do take account of one restricted measure of the opportunity cost of the resource. The best-known example of this is the rotational rationing system of north India (the so-called 'waribandi system'). As students of the system have pointed out, in this setting water is often the limiting production resource. Each farmer, therefore, faces an 'opportunity cost' which influences the way in which he uses that resource. While this is true (and is often neglected in criticisms of such systems) it should be observed that the opportunity cost varies considerably depending on 'alternative uses' which come into play. In the waribandi system, the 'opportunity cost' is essentially that of the opportunities which the individual farmer forgoes on another (non-irrigated) field, assuming he has one. The 'opportunity cost' would evidently be greater if all farmers in a particular distributory were included, since it is the value placed by the highest alternative use which defines the opportunity cost.[4]

Similarly, if it were possible (as is increasingly the case) to transfer the water among a wider universe of potential users of that water (which will usually include other farmers, and may include neighbouring towns and industries), then the 'opportunity cost' would be greater still. While 'the best alternative use' needs to take into account location and the hydraulic connections possible between users, it is certain that the restrictive 'opportunity cost' implicit in rationing systems (like waribandi) will often represent large underestimates of the true opportunity costs and will therefore mean that farmers are facing both use and resource costs which represent substantial underestimates of the true costs. Under such circumstances, as explained earlier, deadweight losses are likely to be substantial.

The magnitude of these losses has been estimated in a seminal assessment of different irrigation systems in Spain and the United States. Maass and Anderson (1978) did simulation analyses of the effects of different water allocation procedures on the economic impact of water shortages. In the 'turn' system, farms are served in order of location along the canal. When water reaches a farmer, he takes all he needs during the period, before the next farmer is served (a procedure followed in Valencia). In the 'rotation' system each farm has a reserved time in which to irrigate in each period, but the water delivered in this time varies on each rotation depending on the flow in the ditch (a procedure followed at the time of the study in Fresno, Utah and Murcia.) In the 'market' system, all water users bid each period for the water used to irrigate their crops and the water is allocated to the highest bidders (a procedure followed in Alicante). As shown in Figure 3.6:

- the market system is far superior in terms of overall productive efficiency; and
- the differences between the market system (which incorporates the opportunity costs within the command area) and the turn and rotation systems (which do not incorporate these opportunity costs) is large.



Source: After Maass and Anderson (1978).

Figure 3.6 Relative efficiency of different American and Spanish water management procedures when water to an irrigation district is reduced by 10 per cent

A relevant aside is to note the effects of different water management regimes on the distribution of losses amongst farmers when there are shortfalls in water availability. The standard measure for inequality is that of the Gini coefficient – as shown in Figure 3.7. The Gini coefficient is:

- zero when losses are equally distributed equally across the land; and
- unity when all losses are concentrated in a single farmer.

As shown in Figure 3.8, in both Spain and the United States, the market system was markedly superior to the turn and rotation systems in terms of

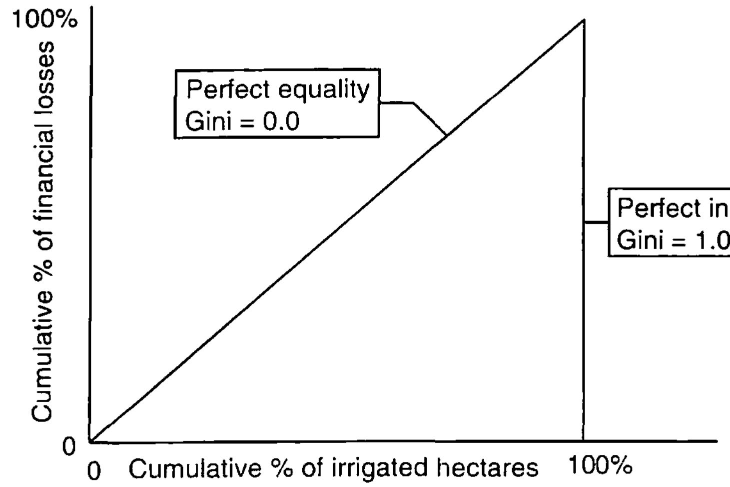


Figure 3.7 Measures of equality – the Gini coefficient

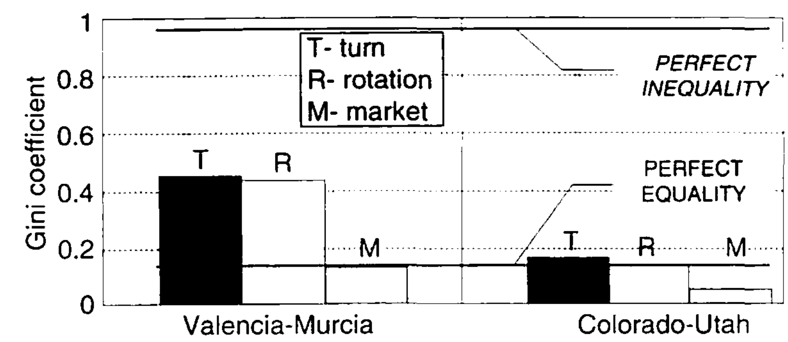


Figure 3.8 The equity of different water allocation systems

the equity of distribution of the losses resulting from a water shortage. As pointed out by the authors,

> although it is a doctrine of many welfare economists that procedures that rank high in efficiency will do poorly in distributing income equally among beneficiaries, while procedures that do well in distributive equality will be inefficient . . . this conventional wisdom does not apply to a wide variety of conditions in irrigated agriculture. (Maass and Anderson, 1978, p. 391)

4.5 The Implications for Irrigation vis-à-vis Urban Uses

In summary, when considering the relative magnitudes of the use cost and opportunity cost of irrigation. the situation is almost exactly the opposite of that pertaining for urban water supply. Financial costs of irrigation systems are usually much lower (per unit of water) than they are for urban water. and opportunity costs are much higher, both absolutely and relatively. as shown in Figure 3.9.

Ignoring opportunity costs is thus a matter of minor practical importance when it comes to the economic management of urban water supplies, but a matter of huge practical significance when it comes to irrigation. As illustrated schematically in Figure 3.10. the shape for irrigation is a 'flat L' in contrast to the 'tall L' in Figure 3.5 for urban water supply.

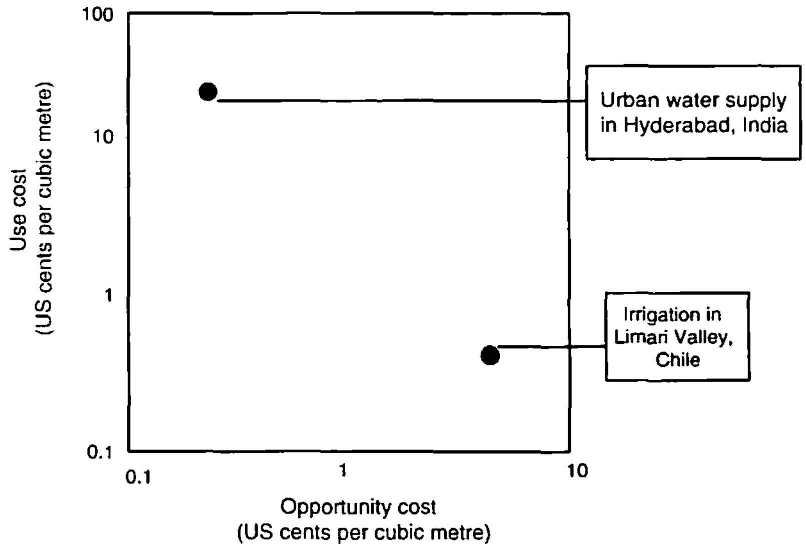


Figure 3.9 Illustrative values of use and opportunity costs for urban supply and irrigation opportunity costs

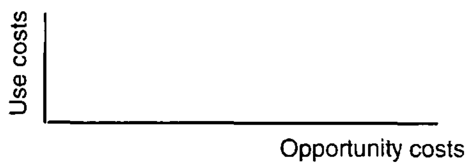


Figure 3.10 *The relative magnitudes of use costs and opportunity costs for irrigation*

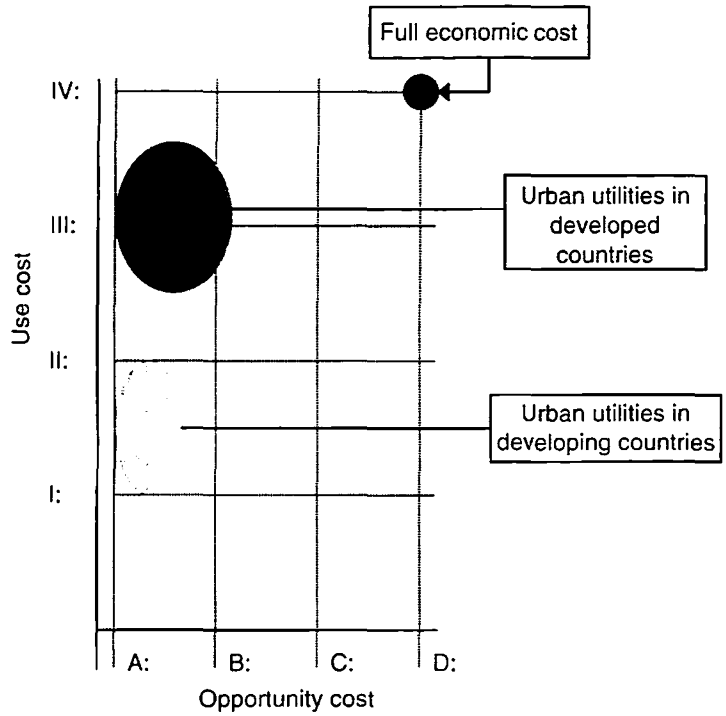


Figure 3.11 *Schematic representations of deviation from economic pricing for urban water supply*

Finally, it is instructive to return to the graphical format developed in Figure 3.4 to summarize the issues on use and opportunity costs as they pertain to different water using sectors. Figures 3.11 and 3.12 provide a schematic representation of how the management of different water using sectors deviate from the economic optimum.

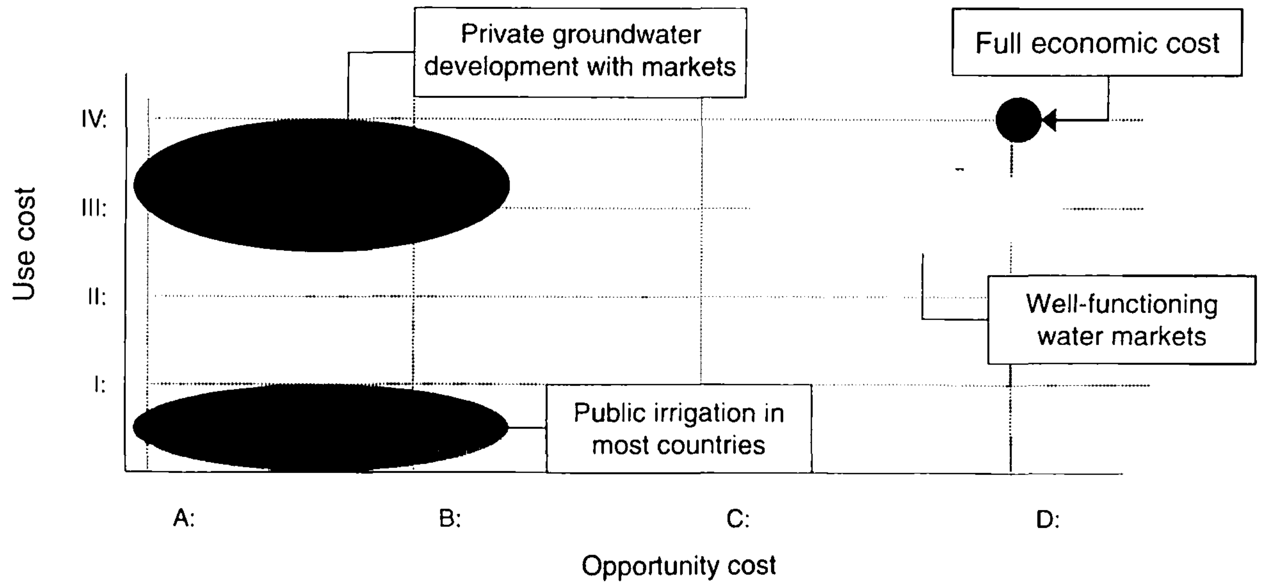


Figure 3.12 Schematic representations of deviation from economic pricing for irrigation

5. EXAMPLES OF GOOD PRACTICE

5.1 Where Water Quality Management is the Principal Challenge – the Ruhr/French Model

Probably the most widely admired water resource management model is that which was developed in the Ruhr Basin in Germany in the early part of the twentieth century, and subsequently adapted on a national scale by France in 1964. The evolution and details of the Ruhr and French experiences have been described elsewhere (Cheret, 1994; Ruhrverband, 1992; Serageldin, 1994). The core elements of this system are:

- management of the basin by a policy-making 'water parliament', comprising all important stakeholders in the basin, supported by a high-quality technical agency; and
- the extensive use of negotiated abstraction fees and pollution charges.

How does the economic value of water come into play in the Ruhr/French type of system? With regard to use costs the answer is simple: the users pay the full financial cost of the infrastructure required to deliver water to them. The way in which the model deals with opportunity costs is more important and less obvious. Abstraction fees are set through a negotiation process. If there is a shortage of water and a potential user without access wants water (or an existing user wants more water), then that user's voice will be heard in the parliament in pushing for higher abstraction prices so as to bring supply and demand into balance. In economic terms this 'next best use' is precisely what is meant by 'opportunity cost'. On the quality dimension (of dominant importance in industrialized countries), the operation of the basin agency is similar: the costs imposed on others in the basin are revealed in both the work of the technical agency and in the course of negotiations, and pollution fees accordingly set in part to take account of these 'externalities'.

On the one hand, then, opportunity costs do come into play in decisions on prices. On the other hand, this expression is indirect and muted by a complex administrative process. As a result, the signals on opportunity cost in such a system do not have the desired specificity and flexibility. While administratively set prices in these systems are affected by opportunity costs, they cannot mimic a market, which, as described in the next section, automatically differentiates by location, quality, season and other complex and changing variables.

5.2 Where Water Scarcity is the Principal Challenge – Experience with Water Markets

In arid areas of the world the foremost water resources management problem has long been that of allocating scarce water among competing uses and users. A wide variety of approaches have been taken, and are taken, to this problem.

In the twentieth century, the most common approach has been a combination of 'first come-first served' (known as the 'prior appropriation doctrine' in the western United States (Worster, 1992)), and the augmentation of supplies through massive investments and allocation of the additional water on political grounds. The problems with such an approach has become manifest throughout the world – the financial costs are enormous, precious water is wasted on low-value activities, while high-value uses cannot secure adequate supplies, and environmental destruction and degradation are the norm (Postel, 1992; Reissner, 1986; Worster, 1992). Recently there has been a surge of interest in the use of water markets as a means of performing this allocation function in an efficient and consensual fashion.

Water markets have a long history both informal, as documented by Shah (1993) for groundwater in Western India, and formal, most notably in Spain (Maass and Anderson, 1978). There have been major developments in Australia (Dudley, 1994), and innovative proposals on the use of markets to solve international water disputes in the Middle East (Fisher, 1994). Most of the attention, however, has been focused on the western United States, where, a wide range of water markets have developed (Saliba and Bush, 1987), with some sophisticated developments (such as the recent development of electronic water markets for the huge Westlands Water District in the Central Valley of California (Zachary, 1996).

In the context of the present discussion of the economic management of water, it is instructive to concentrate on a single, much discussed case, that of the water markets in Chile. The key policy decision in Chile was the separation of land and water rights in 1981 and the simultaneous encouragement of trading of water without restriction. The water market is a brilliant conceptual solution to the enduring problem of reconciling practical and economic management of water. On the one hand, 'common-sense pricing' suggests that the water management unit charges users for the use costs – the investment and operating costs incurred in storing and delivering the water to the user (it is this which is done by users' associations who operate water systems at various levels in Chile).

The problem arises because these financial costs are much lower (often an order of magnitude) than the opportunity cost.[5] The existence of a water market means. however, that behaviour is not driven by the financial cost of the water, but rather by the opportunity cost. If the user values the water less than it is valued by the market, then the user will be induced to sell the water. This is the genius of the water market approach: it ensures that the user will in fact face the appropriate economic incentives. but de-links these incentives from the tariff (which is set on 'common-sense' grounds).

In well-regulated river basins in arid areas of Chile, the water markets function as one would wish: within a particular area water is traded from lower-value uses to higher-value uses. Prices are responsive to both temporary (seasonal) scarcity as well as longer-term scarcity and trading is quite active. Two comments are appropriate here. First, it is evident that no administrative mechanism, even the very good Ruhr and French systems, can mimic water markets in transmitting information on opportunity costs in such a flexible and specific way. Second, it is important to note that water markets are not a simple panacea. The major challenge facing water resources managers in Chile is more effective basin-level management, which will both complement and enhance the workings of the water markets (see Briscoe, 1996).

From the perspective of the economic management of water, a critical issue is the 'breadth' of the water markets, with the dictum being 'the less restrictions there are on water trades, the more the true opportunity cost will come into play'. In Chile, where water can (and is) traded from agriculture to towns, a farmer who owns water rights faces the full opportunity cost of the resource. In many instances (such as the water market of Alicante, and the large market in the Northeast Colorado Water Conservation District) there are specific, and sometimes absolute, prohibitions on the sale of water to non-agricultural users. In such situations, the opportunity costs are obviously truncated, with important resulting distortions in the economic signals.

6. CONCLUSIONS

In this chapter, an attempt was made to develop a framework for thinking about management of water as an economic resource and to assess the policy implications in light of available empirical evidence.

Three principal conclusions emerge from the discussion. First, economic development and environmental sustainability in many countries depend on considering water as a scarce resource, and using economic principles for its management. Second, the challenge is particularly great with respect to irrigated agriculture, which is, simultaneously, the largest user of water in many countries and the sector which is managed (in most places) least like an economic resource. Third, while it is clear that the distance between the 'bad' bottom left-hand corner of Figure 3.4 and the 'good' top right-hand corner is great (particularly for irrigation), there are also examples of good practice which show that change is possible and how it can be effected. Finally, it is important to acknowledge that the idea of 'water as an economic good' is but one of a triad of related ideas which will increasingly shape the way in which societies are organized (and water managed) in the twenty-first century. These ideas are:

- broad based participation by civil society in decisions (including those on water management) which were previously often treated as the province of technocrats alone;
- the hegemony of the market model of development, and the corresponding move to using market-like and market-friendly instruments for managing all elements of the economy (including water); and
- the emergence of the environment as a major focus of concern.

NOTES

1. A comprehensive review of World Bank-financed irrigation schemes (World Bank, 1995) showed that food grains were the predominant crop in 90 per cent of such schemes.
2. Technically speaking, the 'opportunity cost' is defined as the value of the water in its highest value alternative use.
3. Subsidized energy prices for water pumping is widely practiced, from the United States to India. While it has been, or is being, phased out in many countries, in some – India is a prime example – farmers benefit from large subsidies for irrigation pumping.
4. This is confirmed by the fact that, although not formally sanctioned, limited water markets – often involving only neighbours – exist in waribandi-like systems.
5. In the Limari Basin, in Chile, for example, the use cost is about 0.5 cents per cubic metre, and the opportunity cost about US 5 cents per cubic metre.

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