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WATER RESOURCES AND WATER POLICIES

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WATER RESOURCES AND WATER POLICIES*

Francesco PROTA**

Abstract

In recent years, new alarms have been sounded about growing water scarcity and the likely inability to meet the water requirements of rapidly growing populations. Water has thus become a resource that requires careful economic and environmental management.

The cross-country evaluation of water sector problems and institutional responses shows a shift toward an integrated management of water resources which targets the total water cycle and includes environmental sustainability as a key consideration. Key aspect of this new approach is to establish appropriate water pricing regimes that over time reflect the full costs of supplying water, preserving water quality and maintaining the resource base. Aim of this paper is to analyse conditions for water conservation and sustainable water use.

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1. *Introduction*

Water is a vital resource, necessary for all aspects of human and ecosystem survival and health. Water is not only essential to sustain life, but to support economic development, community well-being and cultural values.

New alarms have been sounded about growing water scarcity and contamination and the likely inability to meet the water requirements of rapidly growing populations (Postel, 1992 and 1999; Gleick, 1993; Engleman and LeRoy, 1993).

The global demand for freshwater for human consumption has increased over four fold in the last 50 years[1]. Water for irrigation and industrial production is the major component of this increase, but the demand for water in municipal areas is also increasing, particularly in countries undergoing rapid urbanisation.

The question that emerges thus is the extent to which present patterns of water use are sustainable in the long-term.

According to Gleick *et al.* (1995) water use is sustainable if "the use of water […] supports the ability of human society to endure and flourish into the indefinite future without undermining the integrity of the hydrological cycle or the ecological systems that depend on it".

Sustainability of water requires a balance between demand and availability. Demand can be reduced by suppliers and regulators, using such measures as charging for use, supply metering and educating and increasing the awareness of users about water conservation. Availability depends on a number of factors, including the ability to capture annual flow of surface waters; economic, social and environmental feasibility of new infrastructure projects to dam and divert surface waters and pump groundwater and minimum water flow threshold levels below which aquatic ecosystems are damaged.

Determining sustainable limits requires recognition that although water resources are renewable, water systems can be so degraded that they are potentially lost, and that ecosystems dependant on water (aquatic flora and fauna, river systems, wetlands, etc.) have a minimum quantity and quality threshold beneath which they are damaged.

Aim of this paper is to analyse conditions for water conservation and sustainable water use, that is improved management and institutional changes and full cost pricing.

The paper is organized as follows. The section 2 addresses the problem of water scarcity. The section 3 focuses on water management problems, starting by reviewing and analysing the sources of the market failures as well as government failures in water resources management. The section 4 examines water pricing reform; it contains also a review of pricing practices in OECD countries. Finally, I present some conclusions (section 5).

2. *Water availability and water quality*

Providing adequate supply involves providing an adequate quantity of water, of the required quality, where and when is needed. Fulfilling these supply conditions depends on a country's capital endowments, namely on natural capital, on man-made capital - infrastructures able to (re)distribute water over space and time and water treatment facilities - and on a country's

[1] Over the last two and a half decades, freshwater withdrawals have risen in the OECD region from approximately 830 billion m^3/year in the early 1970s to a current level of just under 1000 billion m^3/year (OECD, 1998).

social capital, that is the relationships between individuals, between institutions and between individuals and institutions (Pearce and Atkinson, 1998).

On a global scale, the problem of water is more a case of distribution and quality than one of quantity. Water is rarely a region-wide concern, with some notable exceptions, but all regions have some problems related to either groundwater or surface water resources.

Scientists estimate that the average amount of global runoff (the amount of water that is available for human use after evaporation and infiltration takes place) is between 39.500 km^3 and 42.700 km^3 a year (Fekete *et al.*, 1999). However, not all of this water is available to humans. Much of the runoff occurs in flood events or is inaccessible to people because of its remote location. In addition, part of the runoff needs to remain in waterways so that aquatic ecosystems continue to function. In fact, only around 9.000 km^3 is readily accessible to humans, and an additional 3.500 km^3 is stored in reservoirs (WMO, 1997).

Water supplies are distributed unevenly around the globe, with some areas containing abundant water and others a much more limited supply. Great disparities are noticeable if one looks at a national or regional basis. For example, Iceland, Norway, Canada and New Zealand all get more than 100.000 m^3 of water per person per year; some countries in Northern Africa and the Middle East have less than 100 m^3/person/year (Gleick, 1993).

Just as physical water availability is unevenly distributed around the world, per capita water use also varies widely for physical, economic and social reasons. North Americans use over 1.600 m^3 per person per year, while the average in Europe is 725 m^3/person/year. In Africa the average water withdrawal is under 250 m^3/person/year, reflecting the limited physical resources available, the large populations and poorly developed water supply systems.

The development and efficient management of water resources is of particular concern in West Asia and parts of Africa, particularly the Sudano-Sahelian belt and the Horn of Africa. Not only is there relative scarcity of water resources, but these locations also face the transboundary problems associated with water resources. Measured against the future requirements of urban centres, agriculture and industry, access to adequate quantity and quality of water will soon become problematic in those areas of West Asia, Africa and the parts of Latin America that have mega-cities. In some cases, competition for water may lead to conflicts over transboundary resources[2].

Anyway the present situation of water quality management is far from satisfactory also in developed countries[3].

In Europe both the quantity and the quality of fresh water present major problems over much of the region and the issue is of growing importance (UNEP, 1996). Although there is no overall water shortage, water availability varies considerably. Low availability is a characteristic of the relatively dry, southern countries of the region and those with high population densities and moderate precipitation in the west.

Total water withdrawal has stabilised or even decreased in some countries in recent years and there are some encouraging signs of increased water use efficiency due to improved technology in industrial and agricultural sectors. On the other hand, large amounts of water are being lost through leakages, particularly in urban water systems where losses of up to 80% have been reported (UN-ECE, 1996). On balance, water use is still increasing in the region (EEA, 1995 and 1995a).

The regional imbalance between water supply and demand is a major concern, as it leads to unsustainable exploitation of water resources in many areas. The noticeable increase in

[2] See Homer-Dixon (1991; 1994); Lonergen (1997); Lonergen and Kavanaugh (1991).

[3] See Somlyody (1995).

frequency and severity of droughts in the region, possibly an early sign of climate change, could exacerbate this situation (UNEP, 1996).

Groundwater is of enormous importance for public water supplies in the region, providing around 65% of the total (EEA, 1995). About 60% of European industrial and urban centres are close to areas where ground water is overexploited and some are experiencing water shortages as a result: 25% of wetlands west of the Urals are threatened by lowered groundwater tables, and extensive tracts of the Mediterranean, Baltic, and Black sea coasts are suffering from salt intrusion in groundwater supplies.

Water quality is the second freshwater concern. The range of possible contaminants and the mobility of water in the environment make this a complex issue. European waters tended to show a marked increase in both phosphorus and nitrogen loadings during the 1960s and 1970s, making them more prone to eutrophication and toxicity. While point sources, particularly municipal sewage outflows, make a major contribution to phosphorus levels, in some areas, agriculture is estimated to be responsible for up to 80% of the nitrogen loading and 20-40% of the phosphorus loading in surface waters (EEA, 1995). Despite a levelling off in average inputs of nitrogen fertiliser to agricultural land and a drastic fall in many countries, nitrogen levels have continued to rise in more than two thirds of the European rivers measured. In groundwater, nitrate concentrations are frequently above levels considered safe for human consumption.

However, for phosphorus the trends have now reversed where countries, mainly in the west and south, have taken positive measures to reduce discharges (EEA, 1995; WHO, 1995).

Loadings of organic matter have decreased in many European rivers as sewage treatment practices have improved. However, this form of freshwater contamination is still widespread in some parts of the region. The worst affected countries are Belgium, Bulgaria, the Czech Republic, Denmark, Italy, the Netherlands and Poland (EEA, 1995).

Recent information shows that the regulations introduced in response to the alarming concentrations of heavy metals in many European lakes and rivers in the 1970s have been effective. In general, concentrations today are well below standards for drinking water; only mercury and cadmium exceed drinking-water standards in some rivers. There are, however, still some heavy-metal "hot spots" associated with mining areas and industries using large quantities of metals that pose a risk to human health.

Groundwater pollution is expected to become increasingly widespread and acute in coming years, particularly because of uncontrolled waste deposits, leakage from petrochemical tanks, and continuing percolation of untreated sewage, pesticides and other pollutants into aquifers. As the already high proportion of Europe's drinking water from this source is expected to increase, groundwater quality is a priority issue.

3. Institutional changes in the water sector

The water sector is undergoing remarkable changes in recent years. While past achievements were associated mainly with investment in new physical structures, recent developments in the water sector are associated to a greater extent with improved management and institutional changes.

The shift from relying on additional construction, as a means for solving water needs, to improving water resource management and institutions of individual countries has been caused by (Dinar, 1998):

- ✓ increasing awareness regarding water availability;
- ✓ the increasing demands for fiscal austerity in most countries that have resulted in growing interest in least-cost alternatives for meeting water needs;

- ✓ increased awareness about the environmental impacts related to the construction of hydraulic infrastructures;
- ✓ competition by various sectors for scarce water resources that has increased as a result of growing population and increased economic activity.

The crisis in the water sector has made apparent the inherent limitations of the existing institutions in dealing effectively with the new set of problems that are not related to resource development but to resource allocation and management. The diverse economic and political consequences of water scarcity, including the widespread occurrence of inter-regional and inter-sectoral water conflicts, have heightened the need for creating flexible but effective water allocation and management mechanisms.

The cross-country evaluation of water sector problems and institutional responses shows rather clearly that the dominant water sector concerns revolve no longer around water development and water quantity but around water allocation and water quality (Saleth and Dinar, 1999a). With a shifting nature of water problems, the development paradigm underlying current water institutions is also undergoing irreversible changes. These changes include:

- ✓ addressing water as an economic good;
- ✓ strengthening allocation capabilities;
- ✓ increasing the reliance on market forces;
- ✓ reviving the payment culture;
- ✓ ensuring financial self-sufficiency;
- ✓ promoting decentralized decision structure;
- ✓ encouraging the adoption of modern technology and information inputs.

An important issue is to find what explains these institutional changes and how these changes are interrelated. One of the key premises in institutional economics literature is that institutional change occurs only when its transaction costs are less than the corresponding opportunity costs (Olson, 1971; Bromley, 1989; North, 1990). In the particular context of water institutions, transaction costs cover both the real and monetary costs of instituting the regulatory, monitoring and enforcement mechanisms needed for water resource development, allocation and management. Similarly, the opportunity costs cover both the real and economic value of opportunities foregone or the net social loss due to *status quo*. With increasing water scarcity, the opportunity costs of *status quo* are indeed huge and increasing fast to exceed the corresponding transaction costs.

Since the magnitude of net benefits from institutional changes in water sector is a direct function of the degree of water scarcity, the economic incentives for institutional change increase with every increase in the level of water scarcity as induced by factors like population growth, economic development and climate change. Increasing water scarcity also magnifies the real and economic costs of inappropriate water sector policies which can be approximated by the gap between the scarcity value of water and the prevailing water charges. The opportunity cost of institutional change within the water sector is also strongly influenced by some factors that originate outside the strict confines of the water sector. These factors include the macro economic adjustment policies, socio-political liberalization and reconstruction programs and water-related natural catastrophes such like droughts, floods and soil salinity.

The theoretical literature elaborating the additional gains possible from institutional changes is vast and growing. The issue of institution-performance interaction within water sector is covered by the important works by Frederiksen (1992), Le Moigne *et al.*, (1994) and Piccotto (1995).

Both the general and specific aspects of the linkages between water institutions and water sector performance have been recognized widely either within a theoretical, anecdotal or case study framework (Hartman and Seastone, 1970; Guggenheim, 1992; Le Moigne *et al.*, 1992; Howitt, 1998).

Wade (1982) compares the yield and employment performances of irrigation water control institutions (i.e., the water distribution system and allocation procedure) in Southern India with that in Korea within an essentially descriptive and non-quantitative framework. The better performance of Korea is explained in terms of a better water supply, small, decentralized, and demand-controlled system, and good management structure. Lo and Tang (1994) utilize a case study framework to explain the differential performance of institutional arrangements (governance and management structures) in controlling water pollution from different sources (industrial and domestic) by considering the case of Guangzhou Municipality, China. The main result is that since no one set of institutional arrangements can solve all types of collective problems, a better institutional performance can be ensured only by designing them to be compatible with the type of problems they confront. Other studies specifically consider the role of the context within which the institution-performance interaction occurs in the water sector (Rausser and Zusman, 1991; Yang 1997).

Some recent studies try to quantify the potential gain from changes in a particular segment of water institutions like water markets, inter-regional transfers and water quality institutions (Vaux and Howitt, 1984; Dinar and Latey, 1991; Zilberman *et al.*, 1998). A few studies have simulated the effects of market and administrative transfers in the western USA (Whittlesey and Houston, 1984; Hamilton *et al.*, 1989; Rosen and Sexton, 1993; Weinberg *et al.*, 1993). Other studies have relied on data from actual trades in order to assess the efficiency of water markets. Maas and Anderson (1978) evaluated the water market in Alicante, Spain, and found that the market system produced greater net increases in regional income than the rotation systems. Chang and Griffin (1992) estimated the gains from trade for transfers from agriculture to municipal water supply. Colby (1990) estimated the transaction costs required to obtain approval of water transfers and the litigation costs of third party challenges and suggested that this is not excessively burdensome. Herne and Easter (1997) demonstrated that the market transfer of water use rights produce substantial economic gains from trade in both the Elqui and Limarì Valleys in north-central Chile. These economic gains occur in intersectoral trades and in trades between farmers and they produce rents for both buyers and sellers.

There are also few studies which provide some rough numerical estimates for the opportunity cost (i.e., the potential social gain) of change in water institution as a whole for countries like Chile (Gazmuri and Rosegrant, 1994) and India (Saleth, 1996). Such national level estimates vary from $400 million for Chile to $14 billion for India.

As distinct from the approach of trying to estimate the opportunity costs of institutional change, there are also attempts which tries to directly estimate the transaction costs of reform (Colby, 1990; Easter *et al.*, 1998).

Finally, the study by Saleth and Dinar (1999) makes an analytical decomposition of both the water institution and water sector performance. Utilizing this decomposition exercise, the institution-performance interaction within the water sector is elaborated to analytically demonstrate some of the major layers of institutional inter-linkages and institution-performance linkages. Defining a set of variables to capture the institutional and performance aspects, some of the major layers of institutional inter-linkages and institution-performance linkages are formally modelled as a set of inter-linked equations.

3.1. Improving water management through institutional changes

As we have seen, a re-examination of the ways in which water is allocated and managed is the topic of a growing literature.

Because water is critical to human survival and because reliance on market forces alone would not bring about socially optimal solutions, public authorities in most countries have assumed vast responsibilities for the overall management of water resources.

The performance record of publicly-owned and managed water services system is, however, unsatisfactory and, in some cases, less efficient than that of the private sector. It has become evident that current practices and policies are not sustainable and that reforms are needed[4].

The aim of this section is to provide an overview of these policy options. I start by analysing the sources of the market failure as well as government failures in water resources management.

3.1.1. Market failures in water management

Market failures, as well as political economy considerations, have induced governments to intervene heavily in both the production and delivery of water services.

Water activities are highly interdependent, resulting in several externalities from various uses of surface and groundwater[5]. These externalities imply that private market forces would not lead to an optimal allocation and use of water.

Many of the investment related to water production, as well as to delivery systems, are very large, entailing a huge fixed cost. Both production and delivery systems exhibit economies of scale, whether at a national or local level, giving rise to natural monopolies. Natural monopolies have a tendency to charge more for their services and produce less than what would be observed under competitive conditions. Moreover, because entry costs can be extremely high, the level of contestability of the service can be low. This implies that there are not incentives for innovation and dynamic efficiency.

The rationale of government direct control over water services' production and delivery is the perceived prevalence of public good or open access resources characteristics. Public goods are typically under-provided (or not provided at all), while open access resources tend to be overused under free market regimes. For this reason a certain degree of government involvement may be required to bring about an optimal allocation of resources.

Some water services (i.e., the access to a certain minimum level of water for human consumption) cater to social objectives that have wide political acceptance and are thus considered "merit goods". Private entities providing these water services can be subjected to political intervention if prices are considered too high, but also entities dealing with other water services can be affected by politically motivated interference.

Given the political sensitivity of water as a merit good and the large size and long time horizons of many water projects, we could have a situation where market forces would not generate adequate levels of investment.

3.1.2. Government failures in water management

To overcome market failures in water management, governments have created agencies to finance and maintain public ownership of infrastructures and formulated regulations pertaining to the allocation, use and disposal of water. However this approach has not been free of problems.

[4] Most of the policy options share the objective of treating water and water services as an economic good, by regulating private inefficient appropriation of open -access resources and by making the demand for water less independent of users' willingness to pay for it.

[5] Pollution of water by an industrial user, that reduces the quality of water for other users, is an example of externality.

Public allocation mechanisms often lead to waste and misallocation of water, as well as fragmented investment and management of the existing resource. Also, public allocation often does not support user participation. In many cases, these results contradict the original policy goals in the basis of the public intervention. Namely, social objectives are not fulfilled.

Public allocation or regulation is clearly necessary at some levels, particularly for inter-sectoral allocation. However, problems with this form of allocation are seen in poor performance of government-operated irrigation systems, leaking municipal water supply systems operated by public utilities, licensing irregularities and inadequate controls over industrial water use, and damage to fish and wildlife habitats.

According to Meinzen-Dick and Mendoza (1996), a major reason for such problems lies in the failure of the public allocation mechanism to create incentives for water users to conserve water and improve use efficiency[6].

Moreover, most implementing agencies dealing with water resources have only sectoral responsibility. For this reason they have neither mandate nor incentive to create integrated projects or to balance the needs of various users (Yoder 1981). Thus, the agencies operate within strict limits on the quantity of water use, or respond only to single constituencies. This provides very little flexibility to respond to changing patterns of water demand, and the decision-making mechanisms for inter-sectoral allocation are either unclear or highly politicised.

The imposition of non-economic decision rules contributes to the impairment of financial viability, leading in turn to the cycle of poor services and non-payment of fees.

The pressure of competition and the incentives for efficiency are absent under the typical public ownership set-up, where the managers have less incentives to seek profit-maximising rate structures.

3.1.3. Correcting these failures

Water has traditionally been provided to meet demand with substantial involvement of governments. Public allocation has usually not addressed economic efficiency, but has been necessary because of several features that distinguish water from other scarce resources.

With increased population growth rates, improved life style and declining supplies (both in terms of quantity and quality), the competition over scarce water resources is increasing. It is thus of increasing importance that the existing water resources be allocated more efficiently[7].

A new approach involves changing the role of government in managing water. More emphasis is placed on water as an economic good and less on the idea that since people have a basic right to water it should be provided no matter what the cost.

The key aspect is to improve water management by devising a mix of government activities and market based incentives that are consistent with a country's policies and water resources infrastructure. The first step is to establish an appropriate legal, institutional and economic policy framework, that provides regulatory oversight to protect service quality, safety and the

[6] A policy of water pricing by public entities well below its economic value do not create incentives for the users themselves to save water and use it more efficiently.

[7] Resource allocation is efficient if the net benefits from the use of those resources is maximised by that allocation. Efficiency is not necessarily consistent with sustainability. According to Tietenberg (1994), not all efficient allocations are sustainable and not all sustainable allocations are efficient. We can say that efficiency and sustainability are separate, but complementary criteria for judging the optimal resource allocation. Efficiency criterion maximises the present value of net benefits to society whereas sustainability criterion judges the fairness of inter-generational and intra-generational allocations. For a definition of sustainability referred to water sector, see § 1.

environment, as well as ensure access to water supplies at reasonable prices. Once such a framework is in place, it is much easier to introduce private incentive based solutions to water management problems.

There is a growing realization that water management provides a bundle of services that can be divided up, with some of the services better (more efficiently) provided by the private sector (Easter and Feder, 1997). By unbundling services, the public sector can maintain its role where it is most important, i.e., protect against monopoly power, negative externalities, the under-provision of public goods and the overuse of open access water. The private sector and market forces can then be used to help better manage and allocate water services.

A mechanism that can improve water management is the use of water markets[8]. To establish a competitive water market requires intervention of government to create necessary conditions for markets to operate (Holden and Thobani, 1995):

- ✓ defining the original allocation of water rights;
- ✓ creating the institutional and legal framework for trade;
- ✓ designing some mechanism for resolving conflicts over water rights and water delivery;
- ✓ investing in basic necessary infrastructure to allow water transfers.

Gains from such water trades can be substantial[9]. According to Rosegrant and Binswanger (1994) potential benefits of water markets are:

- ✓ empowerment of water users by requiring their consent to any reallocation of water and compensation for any water transferred;
- ✓ to provide security of water rights tenure to the water users. If well-defined rights are established, the water users can invest in water-saving technology knowing that they will benefit from the investment;
- ✓ a system of marketable rights to water would induce water users to consider the full opportunity cost of water, including its value in alternative uses, thus providing incentives to efficiently use water and to gain additional income through the sale of saved water;
- ✓ allocation of water through tradable rights provides maximum flexibility in responding to changes in crop prices and water values as demand patterns and comparative advantage change and diversification of cropping proceeds.

Chile and Mexico are the only countries that have established formal regimes of tradable water rights at the national level, but many of the western states of the United States and some states in Australia have such systems[10] (Rosegrant and Gazmuri, 1995; Pigram *et al.*, 1993).

In Mexico the transfers benefited some small farmers whose unprofitable farming activities had led to the accumulation of unsustainable debt. In Chile farmers sold or leased their surplus water rights to more efficient neighbouring farmers, industrial users or water companies. The sales and leases have allowed some water companies and industrial users to obtain reliable access to water without expensive infrastructure investment. According to Hearne and Easter (1997), the results have been large gains to society. Even if "no one has measured the effect of tradable water rights on economic growth in Chile and Mexico, anecdotal evidence and studies showing the gains from trading water suggest [...] that water rights have facilitated economic growth" (Thobani, 1997).

[8] In a typical transaction, a farmer sells a specified volume of his surplus groundwater or surface water for a season or a specified period to a neighbouring farmer. Or several f armers collectively sell some of their water to a nearby town.

[9] See Chang and Griffin (1992) and Hearne and Easter (1995).

[10] Informal water markets are widespread in South Asia (Saleth, 1996; Meinzen -Dick, 1996).

However there are some difficulties in the design of a well-functioning water market, they include:

- ✓ measuring water;
- ✓ defining water rights when flows are variable;
- ✓ enforcing withdrawal rules;
- ✓ investing in necessary conveyance systems;
- ✓ sale of water-for-cash by poor farmers;
- ✓ externality and third party effects;
- ✓ environmental degradation[11].

Another approach to establishing accountability and improving the delivery of water to consumers, has been to establish financial autonomous water utilities and/or contract with private firms to manage various water delivery functions.

The basic idea is to introduce more competitive pressure in the water industry, involving the private sector in the operation and management of water utilities. The private sector is potentially capable of injecting technological, financial and managerial resources which the public sector may be unable to obtain, because of fiscal and bureaucratic constraints, and the lack of adequate incentives (Spulber and Sabbaghi, 1994).

In recent years, many countries have used competition for water concessions and the approach has often delivered substantial benefits to consumers such as tariff reduction (Webb and Ehrhard, 1998). In developed countries the prevailing approach seems to be improvement of the operation and management of existing assets. For instance, franchising of water services is often combined with public ownership of the main infrastructures[12] (Cowan, 1998).

The benefits stemming from privatisation of water services depend on a number of conditions. These conditions include the degree of competition in the water industry and the long-term credibility of initial contractual arrangements.

The effectiveness of the competition for the market can be undermined by the shortage of competitive bidders. In this respect, it is worth noting that the water industry is dominated by a small number of companies (Hall, 1999). To obtain the full advantages of competition, public entities need to increase the number of private firms interested in contracting for services. This can be done by reducing both ex ante and ex post transaction costs. Anything that government can do to reduce these transaction costs and simplify administrative requirements will increase the number of private firms bidding and competing for contracts to perform water management activities.

Since large initial investment requirements and economies of scale inevitably provide the incumbent firms with market power and reduce market contestability, it is necessary to establish contestability for contracts, so that competition for the contracts will induce firms to be more efficient in meeting the performance criteria.

[11] Water markets could intensify aquifer de pletion, because they provide an additional incentive to pump more water from the ground.

[12] One of the best known example is the French *gestion déléguée*.

4. *Water pricing reform: recent trends and problems*

The fundamental role of prices is to help allocate scarce resources among competing uses and users. One way to achieve an efficient allocation of water is to price its consumption correctly.

Water is over-consumed and wasted in large part because consumers do not receive appropriate signals about the value of the resource. Real costs are masked by water subsidies, including not only under-pricing and subsidies for water supply services, but all types of subsidies that contribute directly or indirectly to the quality of water resources available for use or to the quantity of water actually used.

Full cost pricing, which covers direct economic costs, social costs and environmental costs for supplying water, is a necessary condition for sustainable water resources management, because it provides an adequate incentive for users to use water efficiently. The move to full cost pricing raises a number of important issues in terms of both the speed with which price increases are made and how "full costs" are calculated. Price reforms in general needs to include economic, social and environmental costs of water "production" and consumption and to incorporate a conservation signal so that big consumers have an incentive to increase their efficiency. The discussion on price reforms, however, also underlines the need for a real exploration of basic water "rights" at the individual level and the importance of ensuring that the water needs of the poor are met as water prices are set to rise.

Recently many countries have been engaged in water pricing reforms to regulate water consumption (OECD, 1999; Jones, 1998; Dinar and Subramanian, 1997).

4.1 *Water pricing theory*

An efficient allocation of water resources is that which maximizes the total net benefit able to be generated under the existing technologies and available quantities of that resource (Easter, Becker and Tsur, 1997). In the absence of taxes or other distortionary constraints, an allocation that maximizes total net benefits is called *first-best* or *Pareto efficient*. When maximization occurs under distortionary constraints (e.g., informational, institutional or political) the allocation is termed *second-best efficient*.

Resource allocation may also be based on equity. Equity objectives are particularly concerned with fairness of allocation across economically disparate groups and may or may not be consistent with efficiency objectives (Dinar, Rosegrant and Meinzen-Dick, 1997). Meeting this objective may entail providing subsidized water provision or adopt differing pricing mechanisms that account for disparate income levels.

To achieve an economically efficient, or socially optimal, allocation of water the price should be equal to the marginal cost of supplying an additional unit of water plus the scarcity value of the resource[13]. One way to achieve this efficient allocation is via marginal cost pricing (Dinar, Rosegrant and Meinzen-Dick, 1997).

Water supply costs include collection, transport to a treatment plant, water treatment to meet quality standards, distribution to customers and monitoring and enforcement; but also such things as the collection of water and fees, maintenance, infrastructure, extraction cost externalities and social costs (or benefits).

If there are higher costs to allocate water to some uses than to others, then the price should be differentiated to be equivalent to the relevant marginal cost of provision to each type of use

[13] The scarcity value of water corresponds to the consumption of "raw" water (i.e. to its opportunit y cost or scarcity rent) and aims to ration water use.

(Tietenberg 1988; Spulber and Sabbaghi 1994). Similarly, if water supplied is of different quality the marginal value of supply should be reflected in the price (Yaron, 1997).

The main advantage of marginal cost pricing is that it is capable of achieving an efficient allocation and of avoiding the tendency to under-price (and consequently overuse) water. A marginal cost pricing system could avert overuse because prices would rise to reflect the relative scarcity of water supplied. This approach to water allocation can also be combined with pollution charges or taxes so that the externalities in use of water are embedded in the incentives facing the water user.

The main disadvantage of marginal cost pricing is the difficulty in including all the marginal costs and benefits when determining the correct price to charge (Spulber and Sabbaghi, 1994). In addition, this approach ignores equity concerns (Seagraves and Easter, 1983; Dinar, Rosegrant and Meinzen-Dick, 1997). In periods of scarcity the marginal cost (price) of providing water will increase, which may adversely affect lower income groups.

4.2. Difficulties in water pricing reforms

The pricing of water is made difficult considering the many peculiarities associated with the provision of water services. Pricing reforms in practice often do not adhere to *first best* allocations as prescribed by the classical economic framework, but produce *second best* solutions.

Implementation, or transaction, costs may make *first best* allocation pricing methods impossible by modifying optimal prices from their efficient level[14]. According to Tsur and Dinar (1997), the effects of implementation costs on the performance of different pricing methods are significant in the sense that small changes in costs can change the order of optimality of those methods.

Pareto efficient solutions are impossible to achieve when there are externalities associated with water provision to the environment (pollution) or to other interest groups (third party effects). MacDonnell *et al.* (1994) investigate three types of third party effects: impacts on other water users, local economic impacts on parties other than water users and impacts on environmental values.

Another type of market failure exhibited by water provision is increasing returns to water production technology. The costs for water treatment and delivery per unit declines as the number of users increase. In such cases, marginal cost pricing will not cover full costs because the marginal cost will always be lower than the average cost.

Moreover considerations of income distribution are occasionally used to justify departure from efficient allocations. Proponents use arguments of fairness or social awareness to use redistributive pricing policies. When examining equity concerns between heterogeneous water users and sectors, pricing policies may provide the most effective means to redistribute income. For example, water pricing may have a role in policies aimed at affecting income distribution between farming and non-farming sectors (Diao and Roe, 1998) as well as between irrigation districts (Brill, Hochman and Zilberman, 1997).

Water pricing reform, which result in a redistribution of economic benefit, inevitably create considerable political opposition. Interest groups form and attempt to impact the decision-making process so that the end result best serves their interests. Powerful vested interests of political groups may slow, divert or even stop a desirable reform. The strengths of the various groups depend on such things as informational power, which can lead to *second best* allocations (Rausser, 2000). Tsur (2000) illustrates how asymmetric information can lead to *second best*

[14] One such implementation cost is incomplete information. For example, some information on user behaviour or technology can be unavailable to water agencies (asymmetric information).

allocations in pricing reform. Because of opposition to reform by various affected groups, adequate compensation mechanisms are an important part of a reform[15] (Williamson, 1994).

Difficulties can also come from existing institutions. It is necessary to actively engage existing bureaucracies in the reform process in order to overcome political transaction costs in reform (de Azevedo and Asad, 2000).

4.3. Water pricing in OECD countries

Water supply and sewage disposal prices have generally increased over the past decade (table 1).

Table 1 - Summary of recent changes in water price levels in selected OECD countries

Country	*Years*	**Nominal (aggregate) increase**	**Average real (annual) increase**
USA	1992-1998	34	2,4
Australia	1995-1996	0,7	-0,6
Japan	1995-1998	2,5	0,3
Korea	1992-1996	45	2,6
Belgium	1988-1998	65	2,7
Denmark	1984-1995	175	6,3
Finland	1982-1998	234	3,8
France	1991-1996	55	7,0
Germany	1992-1997	36	3,8
Greece	1990-1995	114	2,2
Hungary	1986-1996	3923	18,7
Italy	1992-1998	39	2,0
Czech Republic	1990-1997	2591	n.a.
Luxembourg	1990-1994	42	6,0
Netherlands	1990-1998	73	4,6
Sweden	1991-1998	35	1,9
England/Wales	1994-1998	22	2,0
Scotland	1993-1997	28	3,4

Source: Jones (1998)

Even if there are considerable variation in pricing structures across OECD countries, it is possible to distinguish some common trends: the acknowledgment of the need for "full cost recovery" in the provision of water services[16] and a shift away from decreasing block and flat fee pricing structures and towards uniform volumetric or increasing block tariff systems. Most countries are replacing flat fees with tariff schemes consisting of two parts: a fixed charge and a variable charge. The fixed charge gives the service provider a reliable stream of revenue to cover overhead expenses and the variable charge provides consumers with incentives to use water efficiently.

[15] These mechanisms have to address negative impacts of the reform on various sectors and allow a fair share of the reform outcome to be allocated to powerless groups.

[16] This is accompanied by some reductions in total subsidies and in cross -subsidies among users.

The implementation of "full cost recovery" prices to all water users is also a key aspect of the EU Water Framework Directive[17]. This issue is also stressed by the Commission communication entitled "Pricing policies for enhancing the sustainability of water resources".

4.3.1. Household water pricing

In the public water supply system there is a trend away from fixed charges and toward volumetric charging (OECD, 1999c). Even where fixed charges persist, there is evidence of a move toward the reduction (or even abolition) of large minimum free allowances. There are also some experiments occurring with "peak pricing" arrangements, but not much interest is being expressed in other forms of temporal variation in price structures (e.g. time of day).

Sewage charges are directly related to volumes of water delivered from the public water supply system. Thus, the structure of waste water charging systems tends to closely follow that of domestic water supply systems in most OECD countries. The trend toward more incentive-based charging for the public water supply has therefore generally led to more wastewater revenues being recovered through volumetric charging.

4.3.2. Industry water pricing

Industrial water services on the public system are subject to two part tariffs, involving fixed and volumetric components. Connection charges also exist in some countries (table 2).

The volume and characteristics of industrial sewage vary considerably from one company to another. So there is a trend towards the separate identification of sewerage and trade effluent prices for industrial sewage[18]. In most countries, standard sewerage charges are supplemented by "special strength" charges, designed to recover the costs of any extra capacity that is required to treat particular industrial effluents.

[17] The Directive 2000/60/EC of the European Parliament and of the Council, commonly known as the Water Framework Directive (WFD), revises and reconciles EU water policy and provides a basis for subsequent legislation. The main objectives of the WFD are to protect and improve the Community's aquatic environment and to make a contribution to sustainable, balanced and equitable water use.

In line with similar developments in many countries, the Directive gives due consideration to the economic dimension of water. It reinforces the role of economics in water policies through two key elements:

- ✓ the use of economic instruments, i.e. prices and charges, for enhancing the sustainability of water resources (Article 9);
- ✓ the economic analysis of water uses (Article 5 and Annex III) to identify the most cost-effective set of measures for achieving the environmental objectives of the Directive.

More specifically, Article 9 specifies Member States shall account for the principle of recovery of the costs of water services, including environmental and resource costs.

[18] There are now only a few OECD countries in which the costs of industrial sewerage services are still included in the price of water supply (or in general local taxes).

Table 2 - Price structure for industrial sewage services from the public system in selected OECD countries

	SC	Tariff structure	FCR	ND	MC	DTS	Subs	Special tariffs
Australia	yes	fixed (various bases) + volume (various bases)	yes	no	yes	yes	yes	n.a.
Canada	yes	treatment costs included in water bill if "no extra strength"	n.a.	n.a.	no	yes	n.a.	n.a.
France	yes	percentage of water bill	n.a.	n.a.	n.a.	yes	n.a.	contract-based
Germany	yes	based on water volume or surface area	yes	yes	yes	yes	no	rebates if less discharges than water used
Hungary	yes	based on water volume	n.a.	n.a.	n.a.	n.a.	yes	n.a.
Italy	yes	based on water volume	no	no	yes	yes	yes	n.a.
Japan	yes	based on water volume	no	n.a.	n.a.	yes	yes	n.a.
Mexico	yes	based on water volume	no	n.a.	n.a.	n.a.	yes	n.a.
Netherlands	yes	function of pollutant	yes	n.a.	n.a.	yes	yes	n.a.
Poland	no	percentage of water bill	n.a.	no	n.a.	yes	yes	n.a.
Portugal	yes	based on water volume or property size	n.a.	n.a.	n.a.	n.a.	yes	n.a.
Spain	yes	recover operating and maintenance costs	yes	no	n.a.	yes	no	n.a.
Sweden	no	fixed (size of meter or property) + volume based	yes	no	yes	yes	n.a.	n.a.
UK (England and Wales)	yes	based on water volume; surface/highway drainage charges	yes	yes	n.a.	yes	no	large user tariffs
United States	yes	uniform structure or increasing-block tariffs	n.a.	n.a.	n.a.	yes	n.a.	no seasonal tariff

Notes:

n.a.: not available.

SC: is there a separate sewage charge? Tariff structure: what are the types of tariff structures in place?

FCR: is there full cost recovery? (i.e. are total revenue required to cover operating expenditure, plus depreciation, plus a return on capital employed?).

ND: is non-discrimination a requirement? (i.e. do the tariffs for each customers group reflect the costs of the customer group concerned?).

MC: is there any marginal cost pricing?.

DTS: do industrial customers have a different structure to other customer s? Subs.: are there any subsidies? Special tariffs: are there any special tariffs for industrial customers? This does not include extra strength trade effluent charges.

Source: OECD (1999a)

The public system is not the major source of water to industrial sector: direct abstractions from the environment represent roughly 75% of total water consumption by the industrial sector, on average, in OECD countries. For this reason abstraction charges, levied on water abstracted outside of the public system, are in place in about half of OECD countries. These charges vary by category of use and often by location. In some countries, they have an explicit environmental objective.

Discharge controls are also often imposed on sewage discharges which do not go through the public sewer[19].

4.3.3. *Agricultural water pricing*

Metering is still an exceptional procedure in most irrigation districts in OECD countries (OECD, 1999b). Marginal cost charging is rarely encountered in irrigation water prices. More commonly, irrigation prices are intended only to make farmers responsible for all variable costs of supplying water, whereas part or all the fixed costs are covered by public agencies, at tax-payers' cost.

Some irrigation water pricing mechanisms are:

- ✓ volumetric pricing: water is charged based on direct measurement of volume of water consumed;
- ✓ area-pricing: charges for water used per unit of irrigated area. Sometimes area-pricing discriminates based on the crops that are irrigated, on irrigation technologies or on the season of the year;
- ✓ tiered pricing (sometimes called block-rate pricing): this is a multi-rate volumetric method, in which water rates vary as the amount of water consumed exceeds certain threshold values;
- ✓ two part tariff pricing: involves charging irrigators a constant marginal price per unit of water purchased (volumetric marginal cost pricing) and a fixed annual (or admission) charge for the right to purchase the water;
- ✓ betterment levy pricing: water fees are charged per unit area, based on the increase in land value accruing from the provision of irrigation;
- ✓ water markets: markets for water or water rights have been formed and determine water prices;
- ✓ passive trading: the district offers a price (presumably the one which equates aggregate water supply and demand) and farmers make use of whatever amount of water they want. Farmers' consolidated rights to water are then charged at the average price, but those whose consumption is higher would have to pay the offered price, and those consuming below their rights would receive a payment for their thrift;
- ✓ volumetric pricing (of any kind) with a bonus: farmers are required to pay for any water that exceeds a certain volume and are financially rewarded if their consumption is below another threshold.

Several OECD countries have recently been taking steps toward reforming subsidy regimes (but not necessarily eliminating them).

5. *Conclusions*

Water has become an increasingly scarce resource that requires careful economic and environmental management.

This paper has outlined the need of new policies and legal and institutional reforms aimed at more efficient and equitable distribution of water among competing users. The cross-country evaluation of water sector problems and institutional responses shows a shift toward

[19] The most common form of discharge control is the n eed to have a permit to discharge directly back into the river or aquifer.

an integrated management of water resources which targets the total water cycle and includes environmental sustainability as a key consideration.

Key aspect of this new approach is to establish appropriate water pricing regimes that over time reflect the full costs of supplying water, preserving water quality and maintaining the resource base. Nevertheless, many barriers still exist to achieving patterns of water use that meet human needs while protecting water resources.

Integrated water cycle management considers both supply and demand-side pressures and has multiple objectives (minimising water waste; maximising the efficiency of water use; maximising water availability by limiting the degradation of water supplies and through reuse; optimising water allocation to competing users, including the environment; limiting withdrawals to sustainable levels). Achieving these broad objectives implies approaching water management from a number of different angles and designing packages of measures targeted to the range of water users (OECD, 1998). A number of steps are needed to implement total water cycle management:

- ✓ institutional reform;
- ✓ reform of water allocation policies and mechanisms;
- ✓ influencing the behaviour of water users;
- ✓ restructuring of water pricing and tariffs;
- ✓ water-efficient technology development and dissemination;
- ✓ infrastructure maintenance to reduce waste;
- ✓ improved environmental management related to water use (e.g. land use, agricultural techniques), protection of ground and surface water quality;
- ✓ improved information on water resources and use (metering, monitoring).

Greater involvement of water users, including private sector firms and communities, is a critical element of successful strategies for sustainable management of water resources. Explicit mechanisms are needed to promote user "ownership" of water issues, and involvement and responsibility in water policy planning and implementation.

Governments have the responsibility of setting the framework for sustainable water resources management. The mix of government policies and instruments to promote sustainable management of water resources will vary between countries and will depend on social, economic and environmental considerations, technological possibilities and the specific end-use patterns in question. There are nevertheless some common priorities:

- ✓ establishing appropriate water pricing regimes that over time reflect the full costs of supplying water, preserving water quality and maintaining the resource base;
- ✓ strengthening social instruments designed to modify user behaviour to increase the efficiency of use and to conserve water;
- ✓ employing mechanisms to promote a faster and wider diffusion of available water efficient technologies in industrial, agricultural and commercial/residential sectors, including through the identification of economic, technical and social barriers to technology diffusion.

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