Water Consumption & Pricing
The Economic Background

N.P. Dammika Padmakanthi *

It was only after the International Conference on Water and the Environment, which was held in Dublin in 1992, that the world really began to take notice of the over-consumption of water, increasing pollution and rising threats and increasing shortfalls in supply. The main outcome of this conference was that fresh water is a finite and vulnerable resource, essential to sustain life, development and the environment. Although 70 per cent of our blue planet is covered with water, very few of the general public are aware that 97.5 per cent of all water on earth is salt water, leaving only 2.5 per cent as fresh water. Nearly 70 per cent of that small amount of fresh water is actually frozen in icecaps, and most of the remainder is present as soil moisture, or lies in deep, underground aquifers as groundwater. Only 0.26 per cent of the total amount of fresh water on earth is concentrated in lakes, reservoirs, and river systems, which are most accessible for economic needs and are a part of important water ecosystems. Accordingly, less than one per cent of the world's freshwater, or 0.007 per cent (i.e. 2.5 per cent x 0.26 per cent of all water on earth, is readily available for direct human use (Shiklomanov, 2000). This small fraction of the world's freshwater resources has to meet the total global demand by agriculture, industry, human and livestock consumption, municipal and recreational uses. The ever-growing human population continues to increase the world demand for clean water, whilst the available freshwater is constantly declining, owing to the continuing pollution of these finite resources by industrial waste and domestic sewage. The per capita area of agricultural land under irrigation is also shrinking, and competition for water is increasing. Not only are there disputes over water between urban and rural populations, there is also competition between intra-country regions and across international borders.

The greatest concern of the Asian Development Bank (ADB), at the present time is the availability of water for Asian cities, where 56 per cent of the population is expected to live by 2025. Some 830 million people in developing Asia and the Pacific do not have safe drinking water, and two billion lack sanitation facilities. This is far more than two thirds of the total world population who suffer water shortages and have little or no sanitation. In its 1999 Annual Report, the ADB calls this situation "a major human tragedy".

The scientists who have considered the above outcomes states that, there will definitely be a severe crisis in water resources by 2030. Water has been made a valuable good due to its scarcity. On these grounds water as a natural resources is going to be a conventional and a tradable good with a price in the market. Water was declared as a economic good in Dublin, Ireland in 1992. The World Water Commission was established in 1996 and the first summit was held in 1998. The World Bank in 1996 recommended in the " Non Plantation Alternative" report stated that water should be traded by the private sector in Sri Lanka and in order to achieve this target, water resources legislation should be introduced to establish the ownership of the world bank specialist Mr. Matin Thobani who visited Sri Lanka in 1998 to take measures to create a market for water. In recent past, both GATT and the World Trade Organization have pointed out that water supplies must be restricted by creating a market for water. The World Trade Organization meeting held at Seatle in 1999 proposed that not only goods and services but also water should be made a tradable commodity. In this regard, certain multinational companies like Monsanto have discussed this matter at their meetings of board of directors.

In this paper we shall pay attention to the theoretical background of water use and the price for water.

Water is a natural resource that can be renewable or depletable depending on the source and on the use. Water supplies come from surface water and ground water. Surface water includes lakes, streams, and oceans. These are the renewable water sources provided by the earth's hydrologic cycle. Ground water has been accumulated over hundreds of thousands of years in underground aquifers that lie between layers of rock. Ground water is primarily a depletable resource, although a small proportion (less than 5 persent) can be withdrawn each year and renewed by seepage of rainwater or melting snow into the aquifer.

While the total supply of surface and groundwater is quite large compared with current aggregate rates of use, there are many parts of the world where water is extremely scarce because of climatic conditions, geography, patterns of use and water pricing policies.

Ground water can be either a renewable or non-renewable natural resource. Aquifers are "recharged" through percolation of rainwater or melting snow. If the rate of ground water use is less than or equal to the rate of recharge, water use from aquifers can be sustained indefinitely. If

* Lecturer, Dept. of Economics, University of Peradeniya.

however, withdrawals exceed the natural rate of recharge, groundwater is a non-renewable resource; Groundwater may also be an open access resource if property rights have not been established. If no one "owns" an aquifer, there will be an incentive to sink a will and withdraw water before others begin to do the same. The result will be inefficient depletion of the aquifer over time. The early users will obtain water relatively cheaply because there will be large reserves in the aquifer and the cost of pumping the water out will be low. As a result of this, users will have an incentive to consume too much water relative to the efficient level. As the use increases and the stock declines pumping becomes more expensive for subsequent users, who may have much higher valuations for the water. If open access is not a problem and we ignore regeneration, the determination of the efficient use of the non-renewable portion of ground water is analogous to the efficient depletion of a fixed stock of minerals or some other non-renewable resource over time. In this paper we consider surface water.

Some key issues must be addressed in determining the efficient pricing and use of water. They include -

a. Provision for, conflicts among, users with very different needs
b. Accommodation of fluctuations in water supply due to climatic factors

We will illustrate these issues using a simple model developed below, because surface water can be a renewable resource. We can use a static model.

Figure 1 shows two demand curves for surface water. DU represents the demand of urban users of water DR shows the demand of rural water users, we assume that urban use is more inelastic than rural use because of agricultural users. Water prices suppose that the rural users represent agricultural needs and the urban users represent household needs DU is drawn in the usual downward-sloping direction from left to right on the diagram DU is also to be interpreted as a downward-sloping of the horizontal axis indicating the total amount of water available for these two types of users . This is the amount OW.

The simple diagram can illustrate a number of important points about water pricing and use. First suppose that the price of water is zero: that is no attempt is made to put a unit price on water. In this situation the total demand for water will be OUO+WRO, which exceeds the available supply of OW. It is clear that this is not a sustainable situation, because the demands of both groups cannot be met. Some means of allocating the scarce water among the different users must be found.

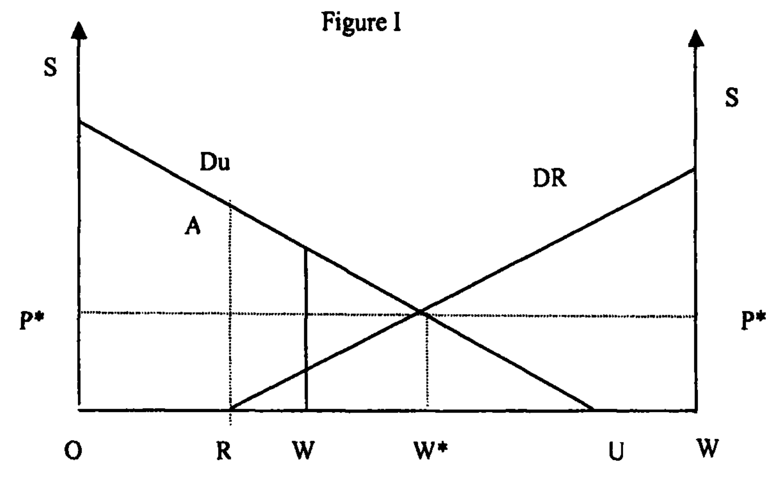
There are a number of different ways in which the water can be allocated. We start with the economically efficient solution. Economic efficiency requires the marginal value of water to be the same for the two users for the last unit of water consumed by each group and equal to the marginal cost of supplying water. In this simple model, the supply of water is perfectly inelastic. Hence demand determines the price. An efficient equilibrium occurs where DR=DU. The equilibrium price is P*. At any other allocation of water among the users the marginal value of one will exceed that of the other. This means that water could be reallocated from the low-value user to the high value user and improve aggregate social welfare.

Very few systems of water distribution have deficient pricing of the sort illustrated and the reasons must be identified. First, there are very few examples of a competitive market in water supplied directly to households. (We are excluding here the market for bottled water, which would be perfectly competitive) To have a perfectly competitive market in water, a clear assignment of property rights must exist for the sellers and buyers of water. This means that buyers must be able to purchase water from any seller, and sellers have the right to sell to any buyer. Water rights don't work this way in many parts of the world. The doctrine of prior appropriation rights exist in many countries for example in the Western United States. The first person to use the water acquires a property right that can often be traded. These rights contribute to economic inefficiency. The rural users have a prior right and are required to use the water available to them or else lose it. In times of a shortfall in water supply, prior appropriative rights indicate that those users who acquired rights first in time may draw on the supply ahead of subsequent users. This is the "first in time, first in use" principle. The right to use it or lose it ' principle can be illustrated by using our simple model. Suppose rural users have a prior right. They will consume water until their demand for it is exhausted. In Figure I they will use R.W amount of water leaving only the amount OR available for the urban users. (i.e. the rural users "lose" this amount of water) Economic waste occurs because the urban users have a higher value for water for amounts lying to the left of W*. The value of the losses incurred by urban users for RW* water consumed by the rural users in the area RAB when markets exist to trade these water rights, economic waste will not occur.

Government controls water supplies in many countries and these countries typically do not allocate water on the basis of economic efficiency but use other criteria. Fairness or equity may be guiding principles, suppose rural users require the water for irrigation of crops Governments may feel that irrigation is more important than household consumption by urban users. They may respond by charging rural users a lower price than urban users. This drives the solution away from an efficient outcome, and rural users end up consuming relatively more water than urban users.

Efficiency may also be hard to obtain if water supplies fluctuate in response to climatic conditions. Suppose there is a drought and the available water supply shrinks to W, as shown in figure 1. Now there is no price at which DU=DT. The high-value users (urbanites) will therefore be able to outbid rural users for all quantities of water available. Governments are unlikely to allow the market to reach equilibrium where a group of people cannot afford water. Markets are therefore not necessarily the ideal mechanism for distributing an essential goods such as water one should distinguish market allocation systems from other systems. Below we look at examples of how water is priced in many municipalities in North America and suggest ways in which efficiency could be improved by alternative pricing techniques and suggest ways in which efficiency could be improved by alternative pricing techniques.

Figure I



This simple theoretical model indicates that economically efficient water use and pricing will occur when the marginal values of water of each user are equated and in turn are equal to the marginal cost of supplying water. This rarely happens in practice. We have already noted that the type of property rights assigned to water may be an important factor in preventing efficient allocations, while governments in North America and elsewhere use the market system to allocate water in many cases water markets are by no means ubiquitous. There are two major reasons. First, if the price of water is set where aggregate demand equals the marginal cost of supplying the water, the supplier will earn a produce surplus or rent. This is shown in figure 2 as the area P* AB. Local government is the principal supplier of water in many countries. They are typically prevented by regulation from earning these rents. Second, market pricing may be very regressive. Low-income users may be unable to purchase water at the market-clearing price, or they may be forced to spend a large proportion of their income on water. In figure 2 suppose the demand for water of a low-income household is shown by DL Equating DL to the market –clearing price P* would result in a very small amount of water consumption, WL and an expenditure of P* CWL O. This expenditure may be a large share of the household's income, and WL may be insufficient to meet its basic water needs.

Now we look at water pricing practices for household use. We then examine agricultural water use. Both categories are examples of consumption water use from the source. It will ultimately return via the hydrologic cycle however the amount returned varies according to use.

The provision of water for drinking and household use requires the construction of considerable infrastructures. First water has to be collected from a source (lakes, reservoirs rivers, oceans). Government typically owns or regulates the use of such sources. Next, water requires purification. No doubt there are economies of scale in purification although this idea is being challenged somewhat by the introduction of potable and relatively inexpensive water purification technologies available to individuals. Nonetheless there is still a natural monopoly in the distribution of water to households. Water utilities are typically owned by government and are responsible for the construction and maintaining water pipe lines. This complicates the pricing of water, because charges must cover the collection, purification and distribution of water. In developing countries purified water may be available only at public wells. A fee may be collected at the well. Households may also have their own private wells, drawing upon ground water supplies. In this case, the household bears all the costs to obtain the water. We confine our discussion to municipal water supplied by public utilities to households.

Water is distributed by municipal utilities that are local monopolies linked to two general types of pricing.

1. Flat rates independent of the amount of water consumed
2. Unit pricing based on the amount of water consumed.

In practice, neither of these pricing mechanisms provide for the efficient use of water.

Flat rates mean that consumers can use as much water as they wish without regard to the price. A household that uses 100 gallons, will pay the same amount as a household that uses 1000 clearly, this is extremely inefficient. The marginal price to the consumer of another gallon of water consumed is zero for all units consumed. The marginal price of water supplied by municipality is certainly not zero (though of course it could be quite low). One study has shown municipalities that do not meter their water users consume at least twice as much water annually as in communities where households have meters. Rectifying this situation requires the installation of meters. The cost of doing this can be quite high. However, as population grows and pressure is put on the existing networks for collecting, purifying, and distributing water, the lack of metering is an increasing problem and clearly contributes to non-sustainable levels of water consumption.

Municipalities that meter water commonly employ pricing policies that are also inefficient. As monopoly suppliers municipalities face a dilemma in setting water prices. As noted above, they are typically prevented by regulation from earning excess profits or rents on the water sold. They also do not want to price water so high that low-income users cannot afford to buy it. The result is that prices per unit of water consumed are generally set below the marginal price that would clear a market in water (where marginal cost equals aggregate demand). A common practice is to set prices so that they cover the average costs of providing the water to users. Water is not assigned a value that reflects the opportunity cost of its use. Moreover, the average costs are typically based on historical costs of providing water. Historical costs will generally be much lower than the costs of increasing capacity or replacing worn-our water infrastructure and building new distribution networks to accommodate urban growth. These construction and replacement costs are often met by annual flat-rate fees levied on all users, buy increases in local property taxes by debt or by requests for subsides from higher levels of government which in turn leads to deficit financing higher taxes, or both. Several inefficiencies result from users who do not consume much water and subsidized users who consume a lot of water, where future users subsidize current users. The general point is that prices that do not reflect the cost of providing water grant users a large subsidy and discourage the conservation of water.

Another common pricing scheme is declining block prices. A high marginal price is levied for a specified initial volume of water consumed subsequent "blocks" of water-consumed come with a lower unit price. This inefficient practice encourages over consumption of water. Those who consume small amounts of water subsidize those who consume large amount of water. As noted above, the cost of bringing on new capacity is also high in most regions. Given the cost structure of providing water efficient block pricing would go the other way. That is the price for a specified initial block of water consumed should be lower for greater volumes.

Figure 3 illustrates an increasing block pricing schedule. This has a number of advantages over other schemes. First it encourages more efficient use, as the marginal price of water increases from the first to subsequent blocks. Second, it could be adopted to deal with peaks in water demand. If, for example auxiliary water supply is needed during dry summer months, a high block price could be charged. This would help cover the additional costs of supplying the water and would encourage conservation. In many municipalities, when seasonal demands are high, some form of rationing is used. These techniques do not allocate water to the highest value user and clearly via the equimarginal principle of increasing block pricing is that low-income users can be accommodated. The initial block can be based on "essential" water need, and a price within the means of low-income users charged for it. If increasing block pricing was implemented, why not go to full marginal cost pricing? Each unit of water would have its own price. This would be efficient but the costs of implementing such a policy may outweigh the gains in efficiency.

The installing of meters (when these are not already in place) and switching to more efficient form of pricing could lend to a gain in aggregate social welfare. However this gains comes at the expense of residential households, which see their consumer surpluses full because of higher water prices.

A final problem with water pricing is that governments typically do not differentiate between high-cost and low-cost users high-cost user are, for example, those who live on hills and must have their water pumped up or they could be new users. Whose demands mean that reservoir capacity must be increased and new pipelines must be installed or old lines enlarged. Unless municipalities planned for new growth when the original pipelines were installed and built reservoir capacity commensurately, urban growth will mean, under prevalent pricing practices, that all users pay the same unit price while old users will subsidize new users while people living in areas not requiring pumping will subsidize people living in areas that do. To achieve efficient water pricing, new users and users with pumping costs should pay higher rates while uniform average cost or block pricing to all users will make an area look cheaper to migrants than it really is in terms of their impact on the costs of supplying water.

Large amounts of water are used in agriculture, primarily for irrigation. The price charged to agricultural users typically does not reflect the marginal cost of supplying the water to them. Government policy is to assist agriculture by subsidizing agricultural water supply. Water used in agriculture often generates adverse environmental effects for example salination of soils and arophication of water bodies due to run off of irrigation waters laden with fertilizer. The subsidization of water has led to inefficient crop choices in agriculture because distortions in crop choice arise when high-value crops are deprived of waters because of prior allocations made to growers of low-value crops and subsidized irritation waters. Efficient pricing of irrigation water would lead to reduction in output from low value water users and an increase in out put from high value users. Governments have recognized these problems and are slowly adjusting water prices and allowing some limited markets to operate. However, prices are still a long way from their efficient level. Clearly major distortions in water allocation result from such inefficient pricing.

Reference

Hartwick, J.M. and Olewiler, N.D. The Economics of Natural Resource

Randal, A. - Resource Economics