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Standard Review

Review of water pricing theories and related models

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Water is vital for life and plays an essential role for economic development of countries. To address water scarcity issues, better pricing has been recognized as an important tool. In this paper several empirical studies which highlight water pricing theories and related models have been reviewed. These theories explain different aspect of water pricing that can be used as a means to improve water use efficiency. Analysis of partial equilibrium can be viewed as effects of a policy on a specific sector like agriculture, but an analysis of general equilibrium often involves steady-state paths which is in fact a macro-level approach. A comparison of first best pricing with second best pricing models shows that the latter are possible when transaction costs are included. In the absence of storage capacities limits and direct costs of water, development decision studies find that the price of water held in storage must rise at the rate of interest and that the effect of discounting is to cause a cycle in the water price. Finally, recent evidence suggests that the short-run efficiency of marginal cost pricing can be extended to account for long-run fixed cost considerations.

Key words: Water pricing, marginal value product pricing, partial equilibrium, general equilibrium, marginal cost pricing, average cost pricing.

INTRODUCTION

Water is vital for life and plays an important role for economic development. In the past decades, increasing population, urbanization and industrial development, have increased demand for water which has resulted into considerable decrease in annual renewable water resources per capita. On the other hand under-pricing of water may convey the demander the illusion that the real value of water is at the low price level which the consumers are paying. Therefore, design of water price structure is a crucial issue for water utilities and local communities to achieve an efficient allocation of the scarce water resources.

Theoretical Framework

A review of the pertinent literature shows that a wide range of methods for pricing water has been developed over time. These methods differ in information on which they are based, their implementation methods (Johansson, 2002).

In an economically efficient resource allocation, the marginal benefit from use of the resource should be equal across user sectors in order to maximize social welfare (Dinar et al., 1997). According to Easter et al. (1997), efficient water distribution is one that which maximizes the total net benefit ability to be obtained using existing technologies and available quantities of that resource.

According to Johansson (2005) under certain conditions (full information, no externalities, perfect competetion, complete certainty and non-increasing returns to scale), markets would achieve first-best allocations. Allocation maximizing the total net benefit is called Pareto efficient or first-best. When trades are free from government constraints and high transaction costs, the resulting price will be equal to that determined under marginal cost pricing methods and the resulting water allocation will be Pareto efficient. Likewise, in the absence of implementation costs, the marginal cost of supply includes only

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delivery costs and the allocation resulting from marginal cost pricing is Pareto efficient.

When long-run fixed costs are considered in the maximization problem, Pareto efficient allocations are achieved and if the maximization problem include variable (short-run) costs only, the resulting allocations can be regarded as short-run efficient. The allocation is termed second-best efficient when maximization occurs under constraints like institutional, informational, or political constraints; (Mas-Collel et al. (1995); Johansson (2000)).

According to Seagraves and Easter (1983); Dinar et al. (1997); Johansson (2000), equity of water distribution concerns with the "fairness" of distribution across time or economically disparate groups in a society and may not be appropriate with respect to efficiency purposes. For instance, a Rawlsian concept of fairness to investigate equity in India's irrigation systems is used by Sampath (1992). It seeks to maximize the welfare of the well-off minority in a society and allows one to evaluate reform strategies in these terms (Johansson, 2000).

Water pricing mechanisms are generally in the national interest and are used to increase water available for certain sectors or citizens (Johansson 2000). They are not, however, very effective in redistributing income. Dinar et al. (1997) claimed that to meet this goal, it is often necessary to provide a subsidized water provision or adopt different pricing mechanisms accounting for disparate income levels.

Review of water pricing

In the followings, significant theories of water pricing will be reviewed. Also in Figure 1, the schematic of normative theories of irrigation water pricing adapted from Johansson (2002), and in Table 1, pertinent questions addressed by the reviewed water pricing theories and models will be illustrated.

Partial equilibrium versus general equilibrium

Johansson et al. (2002) stated that analysis of partial equilibrium (PE) can be viewed as effects of a policy on a specific sector like agriculture. Such an analysis focuses only on the principal agents affected by a policy. On the other hand an analysis of general equilibrium (GE) includes also other sectors or regions (sometimes across time) to determine the economy-wide effects of a policy. Moreover, an analysis of general equilibrium often involves steady-state paths and is in fact macro-level in approach.

Assuming the rest of the economy operates in a given way, PE analyses focuses on one irrigation unit (farm, district, sector). GE analyses, however, consider other regions or sectors. Considering the public-good nature of water provision, the literature on the second best theories of water allocation will be mentioned. PE analysis tries to set the price such that the marginal cost equals the consumer's marginal benefit. GE analysis, however, exa-examines the effects on other sectors of setting such a price.

Berck et al. (1990) explained how computational GE models can be used to evaluate policies. They believed that in computation of direct effects of a project, the GE models suffer from the same limitations as a standard cost-benefit analysis does. However, for a large irrigation project, computational GE allows those endogenously determined variables to be estimated.

First best pricing versus second best pricing

The oldest discussion on water pricing among economists is whether to price water by its average cost (based on financial reasons of cost recovery) or by its marginal cost (based on the economic reasoning of promoting an efficient use of the resource).

Johansson et al. (2000) pointed out that an economically efficient allocation of water is one that results in the highest return for a given water resource. He also suggested that to attain this effectiveness, the price of water should be identical to the marginal cost of supplying an additional unit of water plus the shortage value of the resource.

Garcia and Reynaud (2004) mentioned that maximizing social welfare leads a public utility to use marginal-cost pricing (MCP). Maximizing aggregate net surplus leads to the famous law of equality of price and social marginal-cost,

$$p=\frac{\partial C(Q)}{\partial Q}+\lambda \qquad (1)$$

where, λ denotes marginal shadow price of water and Q stands for the volume produced by a water utility. The shadow price is positive when water withdrawals have environmental impacts, or when water is scarce.

They argued that due to a number of criticisms against marginal cost pricing (First-best water pricing), the "revenue-recovery principle" has played the primary rule in design of water prices and thus, the price usually used by water utilities corresponds to average cost pricing (Second-best water pricing). This is shown by the following equation;

$$p=\frac{\partial C(Q)}{\partial Q} \qquad (2)$$

They also pointed out that in a second-best world where the budget of a water utility must be balanced, an alternative to average cost pricing is "Ramsey–Boiteux" pricing. Under a budget constraint, it ensures a maximal economic welfare. The equation below shows this fact:

$$\frac{P-\partial C(Q)/\partial Q}{P}=\frac{\mu}{1+\mu}\times\frac{1}{\varepsilon} \qquad (3)$$

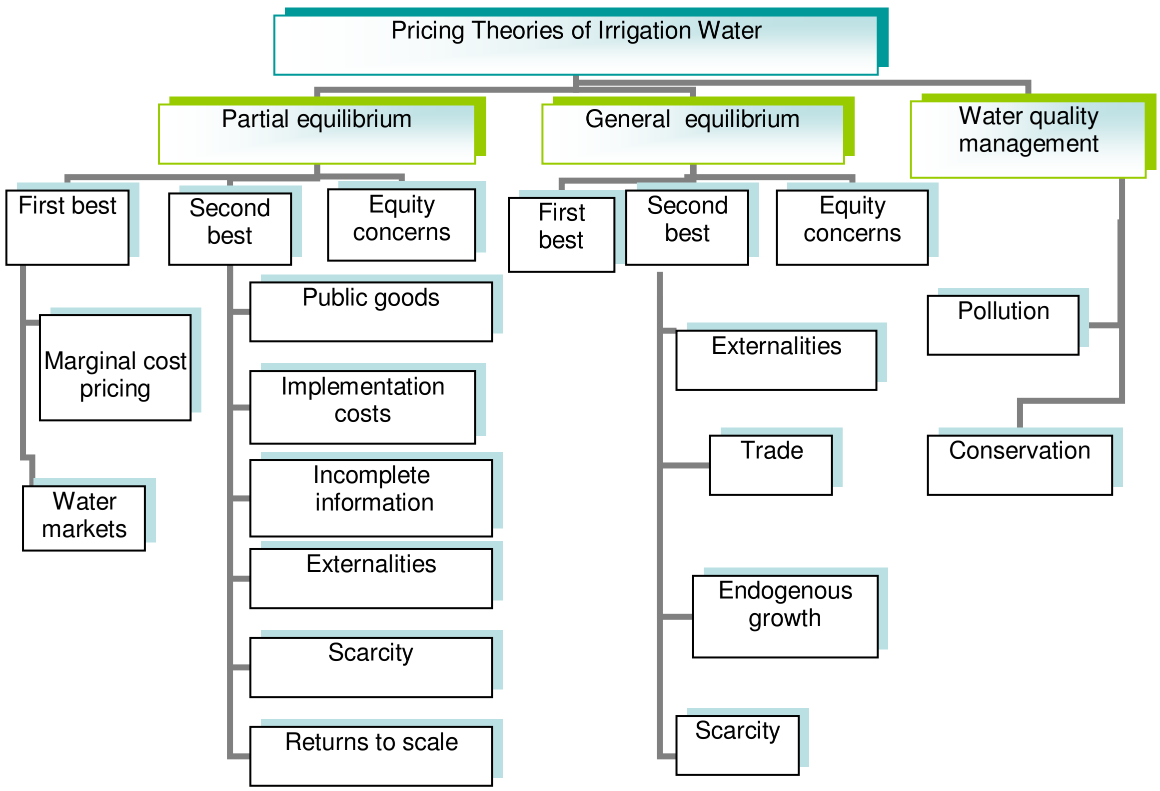

Figure 1. Schematic of normative theories of irrigation water pricing.

where, ε denotes the price elasticity of the water demand and the term $\mu/(1+\mu)$ reflects the cost of the budget constraint. Carrying out this pricing, however, requires a perfect knowledge of marginal-cost and price elasticity.

Smith and Tsur (1997) used mechanism design theory to propose a mechanism to price irrigation water when farmers are heterogeneous in their production technologies and their individual water uses are unobserved. They found that the second-best allocations are possible when transaction costs are contained, but not the first-best allocations. They also suggested that when implementation is free from transaction costs, this mechanism achieves first-best allocations.

One accepted way for determining tariffs in water sector is to recover the partial or full cost of irrigation services. This approach is called cost-of-service approach (self- finance) and is of an equitable economic appeal for public utility rates (electricity, gas and railway, road, or irrigation charges). In this method, interpreted to mean average rather than marginal costs, users should be charged only an amount sufficient to recover the outlay incurred in providing the service.

Marginal cost changes according to irrigation decisions which are functions of geographical conditions and seasonal differences. This fact requires that different prices to be charged at different times. Likewise, the marginal cost to society of delivering one unit of water to a farmer at tail end may be higher than that of the same unit of water to a farmer nearer to the source of water supply.

An advantage of marginal cost pricing is that it is theoretically efficient and the most important result from the existing water pricing literature is that efficiency calls for marginal cost pricing. Monteiro (2005) pointed out that pure marginal cost pricing, because of financial fairness (with fairness worry that marginal cost pricing could impose an undue burden on the poorest), may not be possible or even desirable.

The marginal cost pricing improves the economic efficiency in allocation of irrigation water when prices in other private/public sectors are set at the marginal costs of production.

Lewis (1969) cited by Sahibzada (2002) indicates that from the viewpoint of promoting the efficient use of water resources, water charges should be set at marginal costs or the equilibrium price, whichever is the lower. But Small and Carruthers (1991) indicated that whenever a capacity restriction exists, the price should be raised above marginal cost to a point where quantity demanded equals available supply exactly; when, however, an excess capacity exists, the price of irrigation water should equal the marginal cost for providing.

According to Johansson (2000), marginal cost pricing equates price with the marginal cost of supplying the last unit of water and to equate marginal benefits of an addi-

Table 1. Pertinent questions addressed by the reviewed water pricing models.

	Pertinent questions	Related articles
1	First best pricing versus second best pricing	Tsur and Dinar (1997); Zarnikau (1994) Thobani (1998); Mitra (1997); Monteiro (2005); Lewis (1969); Sahibzada (2002); Johansson (2000); Dandy et al. (1984); Riordan (1971b); Garcia and Reynaud (2004); Small and Carruthers (1991); Mas-Collel et al. (1995).
2	Partial equilibrium versus general equilibrium	Johansson et al. (2002) for PE. Berck et al. (1990) for GE.
3	Efficiency and fairness concerns	Lewis (1969); Seagraves and Easter (1983); Saliba and Bush (1987); Sampath (1991 and 1992); Easter (1997); Small and Rimal (1996); Dinar et al. (1997); Johansson (2000 and 2002).
4	Temporal or seasonal rates	Gysi and Loucks (1971); Zarnikau (1994); Dinar et al. (1997); Sahibzada (2002); Schuck and Green (2002); Monteiro (2005).
5	Development decisions or capacity restrictions	Riordan (1971b); Manning and Gallagher (1982); Riley and Scherer (1979).
6	Scarcity	Moncur and Pollock (1987); Einaboulsi (2001); Griffin (2001); Zilberman (1997); Shah et al. (1995); Easter (1997); Sahibzada (2002); Seagraves and Easter (1983); Monteiro (2005); Sunding (1994); Small and Rimal (1996); Laffont and Tirole (1993).
7	Marginal value product pricing	Sahibzada (2002); Sunding (2005). Hussain et al. (2007).
8	Storage	Riley and Scherer (1979).
9	Hedonic pricing model or implicit marginal price	Latinopoulos et al. (2004); Torell et al. (1990); Faux and Perry (1999); Coelli et al. (1991); Griffin(1985).

tional unit of irrigation water to its additional supply cost (a special case of volumetric pricing). However, water supply costs include items such as corresponding to maintenance (Easter, 1987) and collection of water and the relevant fees (Small and Carruthers, 1991), social cost (benefit), scarcity, infrastructure, extraction cost externalities (Johansson, 2000).

Basically, a resource is considered to be used efficiently if the cost of obtaining the resource (including the opportunity cost of the foregoing other alternative uses) is the same as the benefit society makes from consuming its last or marginal unit. If the price of the resource equals its marginal cost, the consumer can compare with the benefits they obtain the costs they undergo due to their consumption decisions. If the unit price differs from marginal cost, consumption levels are either too low (for prices above marginal costs) or too high (for prices below marginal costs) in relation to the socially optimum level of consumption (Monteiro, 2005).

Spulber and Sabbaghi (1994) discussed four definitional problems associated with marginal cost pricing. For instance, (i) due to water quantity, quality and location, the marginal cost is multi-dimensional in nature; (ii) it varies depending on whether a demand increment is temporary or permanent (due to the composition of fixed and variable costs as determined by short and long-term demands); (iii) it varies with the period over which it is measured, that is, short-run vs. long-run marginal cost and (iv) marginal cost pricing tends to neglect equity issues. Within the periods of shortage or scarcity, if prices increase to the needed level, groups with lower income may be negatively affected.

Riordan (1971a) found that multistage marginal cost pricing is able to provide a 10 to 20% increase in the total net benefits. Dandy et al. (1984) analyzed a constrained water pricing method and found that such a method, while being less efficient than the optimal water pricing derived in their model, is still able to increase benefits to society when compared to actual average cost pricing practices.

The spot-market pricing system developed by Zarnikau (1994) provides a model of pricing for water (short-run marginal cost pricing) that may provide some guidance towards effective water utility planning strategies and in the design of more economically efficient water strategies to rationing water in times of drought or scarcity. This system of water pricing would also provide information regarding customers' evaluation of system enhancements or capacity increases, through the amounts they actually pay when capacity constraints are binding. Short-run marginal costs must include, besides operating costs, the costs imposed by capacity constraints or by the scarcity of water resources, to ration the available water towards the uses of highest value.

Mitra (1997) cited by Sahibzada (2002) stated that setting the price of a product equal to incremental costs associated with incremental production is a marginal cost pricing. From an economic theory viewpoint, she also indicates that when marginal cost is ceaselessly falling with the size of the unit due to economies of scale, it will remain below the average cost throughout and any price based on marginal cost will not recover the full average cost, thus necessitating subsidization.

According to economic theory, when the marginal cost falls below average cost, the revenue generated by marginal cost pricing may not be enough to recover the costs leading to financial losses by the water company. On the other hand if marginal costs rise above average costs, excessive profits made through monopoly supply of what is perceived to be an essential good may not be acceptable to the public opinion or legal standards. However, in cases where the costs for water treatment and delivery per unit declines as a result from increases in the number users, marginal cost pricing will not recover full costs since the marginal cost will always be lower than the average cost.

Efficiency and fairness concerns

Efficiency is a word often used in, for example, economic considerations. However, the word must be defined explicitly for each use since one kind of efficiency may be achieved at the expense of another. The most common use of efficiency is in economic efficiency where refers to the quantity of goods or services obtained per consumer cost (Samuelson, 1976). There are many ways to describe efficiency in water allocation. Johansson et al. (2002) indicated that an efficient allocation of water resources is one that maximizes net benefits to society, using existing technologies and water supplies. Dinar et al. (1997) explained that, in the short run, an efficient allocation maximizes the net benefits from variable costs and results in equalization of marginal benefits from use of the resource across sectors which can lead to maximization of social welfare. They stated that in the long run, maximization of net benefits also includes optimal choices of fixed inputs.

As mentioned above, Lewis (1969) mentioned out that from viewpoint of promoting the efficient use of water resources, water rates should be set at marginal cost or the equilibrium price, whichever is the lower. According to Accounting, Business, Studies and Economics Dictionary, private efficiency is where a person's marginal benefit from a given activity equals their marginal cost.

Private efficiency is achieved where marginal private benefit equals marginal private cost (MC = MB). However, social efficiency is a situation of Pareto optimality where it's impossible to make anyone better off without making someone else worse off. Social efficiency is achieved where marginal social benefit equals marginal social cost (MSC = MSB). Consequently, price efficiency means that productivity of a factor (for example water) rises as the factor rate increases.

Seagraves and Easter (1983) showed that fairness concerns include items such as recovery of costs from users, subsidized food production and income realcation. Moreover, Small and Rimal (1996) showed some tradeoffs between equity and efficiency. They simulated effects of alternative water distribution rules on equity and efficiency for typical Asian irrigation systems.

Considerations of income allocation are sometimes used to justify departure from efficient allocations and equity or social awareness (Johansson, 2000). Proponents of this idea believe that consumers benefit from agricultural investments through lower food prices and so, should be expected to share in recovering the costs (Sampath, 1992). By the way, fairness concerns regarding irrigated agriculture are also important when addressing international aid and development issues. He stated that fairness concerns regarding income reallocation via irrigation allocation have become one of the major objectives across various disciplines.

Krueger et al. (1991) indicated that subsidized inputs/outputs (e.g. water) inflict domestic social costs, alter production decisions and adversely affects international trade. They believed that if governments were to support farmers, they should find tactful ways to do so.

Temporal or seasonal rates

Water demand and its production cost are changing over time and thus water authorities set various prices for different seasons. In summer, when weather is warm and dry, consumers' water demand increases and water authorities use higher prices to encourage consumers to decrease their water consumption. Using various rates in summer is the most effective method in comparison with the use of maximum rate in this season. While various seasonal prices reflect seasonal change of parsimony costs, rates could be strong motive for conservation, economical return and equality.

Gysi and Loucks (1971), Riordan (1971a) and Monteiro (2005) argued about the investment-pricing decisions by considering block rate water tariffs and seasonal variations in the prices. They separated nonlinear demand functions for five residential sectors. Their results indicated the advantages of an increasing block rate schedule combined with a summer price differential.

As mentioned earlier, Zarnikau (1994) developed a model of spot market pricing for charges that vary with location and time (including different times in a day). Consumers are expected to respond to time-of-day pricing or spot market pricing by changing their consumption from periods with higher prices to periods with lower prices. Schuck and Green (2002) extended a supply-based water pricing model (model of water pricing able to reflect in price of water changes in water supply) in which they considered the revenue restrictions of water providing

agencies. The model combines the techniques of conjunctive use system management with and the second-best (Ramsey) water pricing. They assessed the impact of the pricing policy on water, energy and land use, by applying simulation techniques to a water using district in California. Their results indicate that the adoption of the supply-based pricing policy reduces water demand and energy use and increases fallowing (leaving the land uncultivated) in periods of drought, adjusting agricultural activities to the water supply of each period.

According to Dinar et al. (1997) and Sahibzade (2002) water for irrigation in France is generally sold on binomial tariff basis. This system accounts for off-peak and on-peak costs. A peak period is identified lasting for five months from mid-May to mid-September and that it plays a central role in determination of tariff. Tariff design is based on the objective that tariffs should reflect, (i) in the off-peak period, marginal operating costs; (ii) in the peak period, long run marginal capital costs plus marginal operating costs and (iii) possible discharge reduction in the form of pollution fees.

Finally, Monteiro (2005) suggests that the development of this kind of seasonal water pricing methods must take explicitly into account the possibility of water storage.

Development decisions or capacity restrictions

In his seminal article, Monteiro (2005) pointed out that determination of water price when facing capacity restrictions has been an issue of research for both water supply and other public utilities like electric power supply for which such decisions are generally studied together with the decisions to expand the system. Additionally, he found that peak-load pricing may postpone investment in system development in comparison with other more inefficient pricing schemes.

According to Riordan (1971a), a model of optimal water pricing and investment by regulated monopoly or a publicly owned utility, called multistage marginal cost pricing, is based on a short-run marginal cost pricing rule. He also developed a general model of investment-pricing decisions to the particular problem of choosing the timing and sizes of additions to capacity in urban water supply systems. On the basis of empirical data, typical but hypothetical cost and demand curves for water supply are defined and incorporated into the model. He advised dynamic programming techniques for optimal capacity extensions and their suitable timing for urban water supply treatment facilities (Riordan, 1971b).

For cases in which both supply and demand are disharmonic and seasonal, Riley and Scherer (1979) used a peak-load pricing for water. Three years later, Manning and Gallagher (1982) extended the model above and found that in the absence of storage capacity limits and direct costs of water, the price of water held in storage must rise at the rate of interest and that the effect of discounting is to cause a cycle in price of water. They observed that the Hotelling lemma regarding for the optimal price of an exhaustible resource available in a fixed quantity is just a limiting case of the kind of storage period and with no limit on the ability of storage capacity to carry this quantity over to the following periods.

Scarcity

According to Monteiro (2005), scarcity is a more recent apprehension than capacity restrictions, reflecting the fact that the common approach in rising water demand in the past was to extend the water supply system.

There are many ways that pricing mechanisms can be used to address scarce resources. Seagraves and Easter (1983) indicated that during seasonal shortages, higher marginal cost prices should be applied in order to recover fixed costs to ration all of the water during peak demand. In 2000, Johansson pointed out that many informal allocation systems had developed in the absence of prices or formal markets to address the scarcity. For example, Pakistan and India have been using the Warabandi system. Bali and Cape Verde have been using the Subaki system and the Entornador-Entornador system respectively.

Moncur and Pollock (1987) studied the problem of determining the scarcity rent of water. They used a non-renewable resource efficient extraction model to determine the rareness value and the price efficient path in the future. They calculated the rareness value by considering the future increase in costs originated from the necessity to use costly backstop technologies to satisfy water demand. They found that efficient price would have to be equal to marginal cost and that marginal cost should include not only accounting costs but also opportunity costs reflected in the scarcity rent for water.

Sunding (1994) cited by Johansson (2005) investigated the alternative supply reduction strategies for environmental improvement in a multi-dimensional system. They unified certain models to provide a holistic evaluation of environmental protection policies affecting California's Bay/Delta region. These models showed that increasing water costs (irrigation reduction in channel which diverts water) and labor distortions due to environmental legislation can be mitigated through water trading.

Laffont and Tirole (1993), Johansson et al. (2002) proposed to recover scarcity costs with another mechanism which is a set of fixed charges to balance the budget. They stated that the short-run efficiency of marginal cost pricing can be extended to account for long-run fixed cost considerations.

Small and Rimal (1996) and Johansson (2005), utilizing efficiency and fairness criteria evaluated water scarcity effects on irrigation system performance in Asia. They noted that optimal conveyance strategies to account for scarcity may reduce economic efficiency and equity marginally.

Easter et al. (1997) investigated inter temporal allocations under scarcity and uncertain supply (which it may also be related to the choice of water source and irrigation system) which will affect the eventual water price.

In 2001, Griffin suggested a tariff structure for water that aims both at efficiency and revenue neutrality of water utility. He showed that water price should also include opportunity costs such as, user's marginal cost of water (to take into account sacrifice of future uses of unrenowned groundwater supplies); marginal value of raw water (surface water and fully renewable ground water sources, in scarcity situations); marginal capacity cost (when water supplied with capacity installed is less than water demand).

Hedonic pricing model or implicit marginal price

The hedonic valuation technique is used to disaggregate the sale price of a bundled good (that is, land characteristics) to reveal part of it corresponding to water to be able to analyze market for a distinguished good (Latinopoulos et al., 2004). They utilized that technique to reveal the implicit value of irrigation water by analyzing agricultural land values in Chalkidiki, a typical rural area in Greece that is suffering from a severe problem of irrigation water shortage. Subsequently, they used a sample of both nonirrigated and irrigated characteristics and estimated the value of irrigation water through disaggregating the total price of each area of land obtained by a local survey. Results show that, apart from attributes of typical values, the agricultural characteristics of lands, including irrigation water availability, have an important influence on the land prices.

The hedonic pricing method has been used regularly in the analysis of land prices. Most agricultural economists have studied the balance between agricultural productivity and residential demand on the urban and rural fringes. This approach is also used to measure the contribution of water value to farm prices. Torell et al. (1990) estimated water value in the Ogallala Aquifer. Likewise, Faux and Perry (1999) obtained the water value in Oregon, Malheur county.

Coelli et al. (1991) formulated a hedonic model of farm land values. This method was used for cost benefit analysis of a public water supply scheme. They showed that the benefits of scheme water are considerably less than its costs.

Marginal value product pricing

In 2002, Sahibzada noted that the water rate determination principle often favored by economists is to base charges on the value of service, that is, on the marginal product value of water which equals, at equilibrium, the price farmers are willing to pay for water.

Three methods of estimating the marginal product value of water include, (i) The residual imputation which deducts from gross product value the costs of inputs other than water and then, attributes the whole of the remainder to the water input, (ii) The linear programming technique which is well suited to estimate the marginal value of water; (iii) The production function technique which is used to derive the marginal product value of water. Cross-sectional, time series and Panel Data are often used for estimating the value of inputs in crop production. Conradie and Hoag (2002) indicated three alternatives to residual imputation:

"The first estimates a crop-water production function from field trials and then scales this physical production function by the price of the product (Colby, 1989); (Penzhorn and Marais, 1998). The second approach is to estimate a demand function directly from water price data. Griffin (1985) presented an econometric model using panel data of irrigation prices in Texas. The third approach is to use Hedonic pricing methods to measure the contribution of water value to farm prices."

Hussain et al. (2007) stated that at a farm level, the optimal value of water will be achieved when the value of marginal product equals the marginal cost of water. In this case, farmer's marginal private benefit and marginal private cost would be equal.

According to Sunding (2005), if the corresponding production function is differentiable, optimal water use per acre with crop *i* at district *j* will be at a level where the value of marginal product of water equals the shadow price of water.

DISCUSSION

Pricing based on first best pricing is a widely accepted pattern for recovering partial or full cost of the irrigation services. According to Sahibzada (2002), it is called the cost of service approach in which public utility rates has both an economic and an equitable appeal. In this approach farmers should be charged only a quantity sufficient to cover the outlay incurred in providing the service. There are two variants of this approach: 1) Charging rates which cover only current operation and maintenance costs and is considered as partial cost recovery or the rock bottom variant. 2) Full cost recovery insists on charges which not only cover maintenance but also yield a depreciation allowance and some net return on the historical capital costs of the irrigation channel (Sahibzada, 2002).

Sahibzada (2002) also illustrated that average cost pricing involve inefficiencies in water use. Lewis (1969), cited by Sahibzada (2002), claimed that average cost pricing would means that a cultivator using an extra unit of water for crop production would be charged less for it than it costs the community to provide. He also pointed out that this pricing takes only the supply side into account and ignores the demand side and its application under both increasing (lead to profits) and decreasing (lead to subsidization) average costs leads to inefficient outcomes.

On the other hand pricing based on the second best pricing is another criterion that is adopted for determining rates in the irrigation water. Marginal cost pricing sets the price of irrigation water equal to the marginal cost of providing it or incremental costs associated with incremental production. According to Dinar et al. (1997) a marginal cost pricing mechanism, targets a price for water to equal the marginal cost of supplying the last unit of that water. One of the most advantages of this pricing is that it is theoretically efficient. But Dinar et al. (1997) and Sahibzada (2002) in their studies showed that using of this pricing system confronts some practical problems such as: 1) Marginal cost alters with the nature of the irrigation decision with which the irrigation methods are concerned. 2) The marginal cost varies with the period over which it is measured (like seasonal differences and short- run vs. long-run) and space (the tail end and near to the source of water supply) which will require that different prices be charged at different times. 3) This method is difficult to estimate and apply in real conditions. Therefore, pricing based on marginal cost would necessitate charging varying prices within a single irrigation system and also overtime.

Another famously accepted criterion for determining rates in the water sector is pricing system based on value of marginal product of water. According to Sahibzada (2002), in this method, prices will be just low enough so that all water available is used, but just high enough so that no farmer wants more irrigation water at the price facing him. In the other word, at equilibrium, the water value marginal product will be equal to the price which farmers are willing to pay for water. On the other hand Shiferaw et al. (2008) pointed out where no market price exists, optimal allocation of irrigation water will require the shadow price to be equal to its marginal value product. According to Dinar et al. (1997) an allocation which equates water's unit price (the water's marginal value product) with the marginal cost is considered an economically efficient, or socially optimal, allocation of water resources.

CONCLUSION

Water is the vital for life and is a major asset for development of each country that squandered due to underpricing. The increasing water demand for increasing population, urbanization and industrial development has caused which countries to consider various mechanisms to improve water use efficiency. The theories, reviewed in this paper, explain different aspect of water pricing that can be used as a means to address water scarcity issues in terms of quantity as well as quality. The empirical findings reveal that the first best pricing is a widely accepted model for partial or full cost recovery of the irrigation schemes as it considers inefficiencies in water use. On the other hand the second best pricing model sets price of water equal to the marginal cost of providing it or incremental costs associated with incremental production. Most of the economists agree that if water users pay the marginal cost of its supply water use efficiency, would be significantly improved. The marginal product value is used to assess efficiency of inputs applied. In other words, a deviation of the marginal product value from price represents inefficient use of input. Finally, there exists currently a debate that while water pricing programs promote economically and environmentally efficient water use they may not always be appropriate as water pricing is often perceived as a policy intervention that negatively affects poor farmers and small holders. It can be concluded that all of the mentioned theories consider water pricing as an important tool which policy makers can apply for management of this valuable resource.

REFERENCES

Berck P, Robinson S, Goldman GE (1990). "The Use of Computable General Equilibrium Models to Assess Water Policies." The Economics and Management of Water and Drainage in Agriculture, A. Dinar and D. Zilberman, eds., Kluwer Publishing Company, Amsterdam.

Coelli T, Lloyd-Smith J, Morrison D, Thomas J (1991). "Hedonic Pricing For a Cost Benefit Analysis of a Public Water Supply Scheme." Australian J. Agric. Econ., 35(1), 1-19.

Colby GB (1989). "Estimating the value of water in alternative uses." Nat. Resour. J, 29(2), 511-527.

Conradie BI (2002). "The Value of Water in the Fish-Sundays Scheme of the Eastern Cape." Water Research Commission, Pretoria.

Dandy G, McBean C, Hutchinson B (1984). "A model for constrained optimum water pricing and capacity expansion." Water Resour. Res., 20(5): 511-520.

Dinar A, Rosegrant MW, Meinzen-Dick R (1997). "Water Allocation Mechanisms: Principles and Examples." World Bank and IFPRI.

Easter KW (1997). "Inadequate Management and Declining Infrastructure: The Critical Recurring Cost Problem Facing Irrigation in Asia." Report ER87-2, Insti. Agric., For. Home Econ., University of Minnesota,. Easter KW, Becker N, Tsur Y (1997). "Economic Mechanisms for Managing Water Resources: Pricing, Permits

and Markets, in A. K. Biswas (ed.)." water Resources: Environmental Planning, Management and Development, McGraw-Hill, New York.
Faux J, Perry GM (1999). "Estimating irrigation water value using hedonic price analysis: A case study in Malheur county, Oregon." Land Econs. 75(3): 440-452.
Garcia S, Reynaud A (2004). "Estimating the benefits of efficient water pricing in France." Resour. Energy Econ. 26(1): 1-25.
Griffin R (1985). "Volumetric Pricing of Agricultural Water Supplies: A case study." Water Resour. Res., 21(7), 944-50.
Griffin RC (2001). "Effective water pricing." J. Am. Water Resour. Assoc., 37(5): 1335-1347.
Gysi M, Loucks D (1971). "Some Long Run Effects of Water-Pricing Policies." Water Resour. Res., 7(6), 1371-1382.
Hussain I, Nazir A, Ahmad A, Jehangir WA (2007). "Impact of Irrigation Infrastructure Development on Dynamics of Incomes and Poverty: Econometric Evidence Using Panel Data from Pakistan." Japan Bank for Int.Cooperation.
Johansson RC (2000). "Pricing Irrigation Water. A literature Survey." World Bank Policy Res. Working Paper 2449.
Johansson RC (2005). "Micro and Macro - Level Approaches for Assessing the Value of Irrigation Water." World Bank Policy Res. Working Paper 3778.
Johansson RC, Tsur Y, Roe TL, Doukkali R, Dinar A (2002). "Pricing irrigation water: a Review of theory and practice." Water Pol. 4(2): 173-199.
Krueger AO, Schiff M, Valdes A (1991). The Political Economy of Agricultural Pricing Policy: Latin America (World Bank), The Johns Hopkins University Press Baltimore.
Laffont J, Tirole J (1993). A Theory of Incentives in Procurement and Regulation, The MIT Press, Cambridge, Massachussets.
Latinopoulos P, Tziakas V, Mallios Z (2004). "Valuation of irrigation water by the hedonic price method : A case study in Chalkidiki, Greece." Water, Air and Soil Pollution, 4(253-262).
Lewis JN (1969). "Criteria for Determination of Water Rates in West Pakistan." Planning and Development Board, Lahore.
Manning R, Gallagher D (1982). "Optimal water pricing and storage: The effect of discounting." Water Resources Res., 18(1), 65-70.
Mas-Collel A, Whinston MD, Green JR (1995). Microeconomic Theory, Oxford University Press, New York.
Mitra AK (1997). "Economic aspects of irrigation management in magor and medium surface irrigation system in India." Artha Vijnana, xxxix(3).
Moncur J (1987). " Urban Water Pricing and Drought Management " Water Resour. Res. 23(3), 393-398.
Monteiro H (2005). "Water Pricing Models: a survey." Instituto Superior de Ciencias do Trabalho e da Empresa Lisbo, Portugal.
Penzhorn N, Marais D (1998). "Deficit irrigation has financial benefits." Farmers Weekly Sept. 18, 26-28.
Riley J, Scherer C (1979). "Optimal water pricing and storage with cyclical supply and demand." Water Resources Res., 15(2), 233-239.
Riordan C (1971a). "General multistage marginal cost dynamic programming model for the optimization of a class of investment-pricing decisions." Water Resour. Res., 7(2): 245-253.
Riordan C (1971b). "Multistage marginal cost model of investment-pricing decisions: Application to urban water supply treatment facilities." Water Resour. Res. 7(3): 463-478.
Sahibzada SA (2002). "Efficient irrigation water development in Pakistan: Pricing issues and options," Ph.D., State University of New York at Binghamton, United States -- New York.
Sampath RK (1992). "Issues in irrigation pricing in developing countries." World Dev., 20(7): 967-977.
Samuelson PA (1976). Economics McGraw-Hill Inc.,US.
Schuck EC, Green GP (2002). "Supply-based water pricing in a conjunctive use system: implications for resource and energy use." Resour. Energy Econ. 24(3), 175-192.
Seagraves JA, Easter KW (1983). "Pricing irrigation water in developing countries." J. Am. Water Resour. Assoc., 19(4), 663-672.
Shiferaw B, Reddy VR, Wani SP (2008). "Watershed externalities, shifting cropping patterns and groundwater depletion in Indian semi-arid villages: The effect of alternative water pricing policies." Ecol. Econ., 67(2), 327-340.
Small LE, Carruthers ID (1991). Farmer Financed Irrigation: The Economics of Reform, Cambridge University Press, Cambridge.
Small LE, Rimal A (1996). "Effects of alternative water distribution rules on irrigation system performance: A simulation analysis,." Irrigation Drainage Syst. 10, 25-45.
Smith RBW, Tsur Y (1997). "Asymmetric Information and the Pricing of Natural Resources: The Case of Unmetered Water." Fifth Joint Conference on Agric., Food and Environ., June 17-18, Padova, Italy.
Spulber N, Sabbaghi A (1994). Economics of Water Resources, Kluwer Academic Publishers, Norwell, Massachusetts
Sunding DL (2005). "The Economics of Agricultural Water Use and the Role of Prices." Water Conservation, Reuse and Recycling: Proceedings of an Iranian – Am. workshop, Washington,. D.C.
Torell LA, Libben JD, Miller MD (1990). "The market value of water in the Ogallala aquifer." Land Econ. 66(2): 163-75.
Zarnikau J (1994). "Spot market pricing of water resources and efficient means of rationing water during scarcity (water pricing)." Resour. Energy Econ., 16(3): 89-210.