Groundwater Pricing and Groundwater Markets: Issues and Challenges in South Asia

Chapter · January 2019

DOI: 10.1007/978-3-319-75115-3_20

Achiransu Acharyya
Visva Bharati University

Chapter 20
Groundwater Pricing and Groundwater Markets

Achiransu Acharyya

1 Introduction

There are several general principles involved in assessing the economic value of water and the costs associated with its provision. First, an understanding of the costs involved with the provision of water, both direct and indirect, is key. Second, from the use of water, one can derive a value, which can be affected by the reliability of supply, and by the quality of water. These costs and values may be determined either individually, as described in the following sections, or by analysis of the whole system. Regardless of the method of estimation, the ideal for the sustainable use of water requires that the values and the costs should balance each other; full cost must equal the sustainable value in use so that the full range of environmental and economic services of groundwater need to be accounted for in policy decisions. Non-recognition of these services imputes a lower value for the groundwater resource in establishing policies. In this chapter, an attempt has been made to assess the value of groundwater in terms of pricing and cost and to analyse the role of groundwater markets in terms of groundwater pricing and accessibility to groundwater, especially for irrigation purposes.

2 Value of Water: A Historical Overview

As water resources have become increasingly scarce in the last few decades, the perception of water has changed. The debate over the treatment of water as an economic good has been a prevalent part of water resource management discussions in the literature as well as in real world. The topic is quite complicated, and

A. Acharyya (✉)
Department of Economics, Visva Bharati (A Central University), Santiniketan, India
e-mail: achiransu@gmail.com

P. K. Sikdar (ed.), *Groundwater Development and Management*,
https://doi.org/10.1007/978-3-319-75115-3_20

a general overview is difficult. However, the following review attempts to present a short summary of some of the main issues related to this topic.

2.1 The Dublin Statement and United Nations Agenda 21

The Dublin Statement, issued from the International Conference of Water and the Environment (ICWE) held in Dublin, Ireland, in January of 1992, was a primary catalyst of the debate over treatment of water as an economic good (ICWE 1992). Resulting from the call from 500 participants from 100 nations for fundamental new approaches to the management of freshwater resources, the Dublin Statement included within it the principle that, "Water has an economic value in all its competing uses and should be recognized as an economic good" (ICWE 1992, Guiding Principle No. 4). This was the first explicit recognition of water as an economic good, and this principle is often found quoted in literature that has ensued since its establishment. Shortly thereafter, this same idea was adopted by the Plenary in Rio de Janeiro at the United Nations Conference on Environment and Development in June of 1992, with some additions to the statement. Agenda 21, emanating from that meeting states, "Integrated water resources management is based on the perception of water as an integral part of the ecosystem, a natural resource and a social and economic good, whose quantity and quality determine the nature of its utilization" (Agenda 21, Proceedings of the United Nations Conference on Environment and Development, United Nations 1992).

2.2 The Many Values of Water

Water is not strictly limited to the status of an economic good. It is also a social good, and it has cultural and religious value as well (Gleick et al. 2003).

Water as a Social Good Access to clean water is vital to people. Water quality affects public health in the short and the long term. Water supply management for populations involves the building of large infrastructure. Such works are best handled with public oversight.

Water as an Economic Good Water is a scarce resource with value in competing uses. Allocation of water resources could be optimized to maximize benefits to society.

Water Has Ecological Value Water is not only essential for humans, but also for all life. Changing the hydrology of ecosystems threatens populations of many species.

Water Has Religious, Moral and Cultural Value Water figures into cultural and religious identities as part of rituals and symbolism. Moral values may come into play with property rights issues, when people feel they morally have a right to water.

Globalization, Privatization and Commodification of Water Globalization, privatization, and commodification of water are all relatively new phenomena in recent times. Commodification is the transformation of a formerly non-market good to a market good. While water has on a smaller scale had a market value in the past, with the issue of the Dublin Statement on water and changes in global markets, the commodification of water has increased (ICWE 1992). Globalization is the process of integrating markets internationally. The uneven distribution of water across the globe, coupled with newly opened global markets, has made water an item to be traded on the global scale. Water can be traded as a bulk good or as a value-added product as bottled water. Bottled water sales have been increasing noticeably in the last decade. As the case studies in this document show, water trade as a bulk quantity is also occurring. Privatization of water involves transferring control of all or parts of water systems from public into private hands. Privatization of water resources has been promoted as a way to improve water systems. There is a belief that business control is more efficient than government control and that the private sector can mobilize capital more quickly. There are also concerns about privatization. Among many risks of privatization that Gleick et al. (2003) outlines, privatization may result in social inequities, public ownership of the water itself may be at risk, ecosystem impacts could be ignored, and water use efficiency and water quality may not be as valued.

2.3 Complexities in the Economic Behaviour of Water

The question whether or not water can actually be treated as a true economic good is debated. Looking at water resources from a big picture perspective, it appears that by treating water as an economic good, pricing will improve overall allocations and encourage sustainable use. Dinar and Subramanian (1997) state that on both individual and social levels, if price reflects the value of the resource, water use efficiency will improve**.** Some argue that water cannot be treated like other economic goods because of its unique characteristics. Savenije (2001) outlines several characteristics of water that, together, illuminate how it is not an ordinary economic good. These characteristics of water lead it to behave differently from ordinary economic goods. To be effective, water pricing schemes need to be able to handle these complexities.

2.4 Water as a Human Right

As a response to the Dublin Statement identifying water as an economic good, there has been much outcry about the need to treat water as a human right (Baillat 2010). Because water is essential to life, and there are no substitutes for it, there is concern that treating it as an economic good will leave certain people without access to much needed freshwater resources. Scanlon et al. (2004) provide a review of this topic that covers many of the arguments found in literature. In their review of international laws, conventions and judicial decisions, they find that the human right to water has not been clearly defined by international instruments. It is implicit in existing fundamental human rights laws, and explicitly included only in non-binding instruments. Defining water as a human right would provide more protection to people and would obligate governments to ensure water to all people. A human right to water could help to set priorities for water policy and may help to focus attention to resolve conflicts over shared waters. It also could help to safeguard other human rights and environmental principles.

3 Measuring the Price of Water

In common terminology, water price is a volumetric price placed on metered water. A water rate is often the same thing as a water price. The term water rate, expressed plurally, typically refers to the entire package of charges applied by a water supplier. Indeed, any given supplier may simultaneously apply an extensive array of charges, with good reason. To begin with, water rates almost always include two categories:

(a) Charges that depend on the amount of water used, where the per-unit charges may vary according to the type of use, the amount of use, the time of use, and so on.
(b) Charges that are not based on water consumption such as new connection fees, "meter" charges, or irrigated acreage charges.

The fact that rates include water and non-water charges, and that the prices vary with an assortment of factors is an immediate complication of the issue at hand. Ideally, to foster good scarcity signalling the water charges will be independent of the non-water charges. Because the adequacy of revenue to cover the supplier's costs is an important concern, elements of the rate package are interdependent. Increase in one charge may allow another charge to be lowered. As a consequence, any study of the "best" water price is obligated to consider other elements of the rate structure. Just as importantly, the pursuit of efficiency should take full advantage of all available pricing tools.

3.1 Water-Based Charges

In many places water rates are sometimes called water tariffs. Although governments may be responsible for setting both taxes and water rates, there is an important distinction to be respected. Taxes are revenue-collecting mechanisms that enable governments to perform varied functions (maintain streets, build schools, operate the government, defend the borders, fund welfare programmes, etc.). Water rates are charges for the measured delivery of a valued commodity. This is not a tax. It is the cost of a service, and it is good to encourage an appreciation of this fact through one's choice of terminology. The term rate structure may address whether the per-unit price of water decreases, stays the same, or increases with the amount of water consumed. Figure 20.1 portrays the three available rate structures. The uppermost rate structure depicts decreasing block rates. For each customer, price is constant within every "block," but as metered consumption increases into the next higher block, price falls. The first block in this schedule exists from w_1 to w_2 units of water, and each water unit in this block costs the consumer p_1 rupees. While it is often true that $w_1 = 0$, some suppliers grant each consumer a small amount of water consumption, free of any volumetric price. If water consumption lies within a higher block, all units of water are still billed at the rate applicable for their block. Hence, the metered water bill for w units of water is not $p_2.w$. It is $p\ (w_2 - w_1) + p_2\ (w - w_2)$. It is also notable that the "marginal price" faced by this consumer is p_2. Different consumers served by this system may then face different marginal prices.

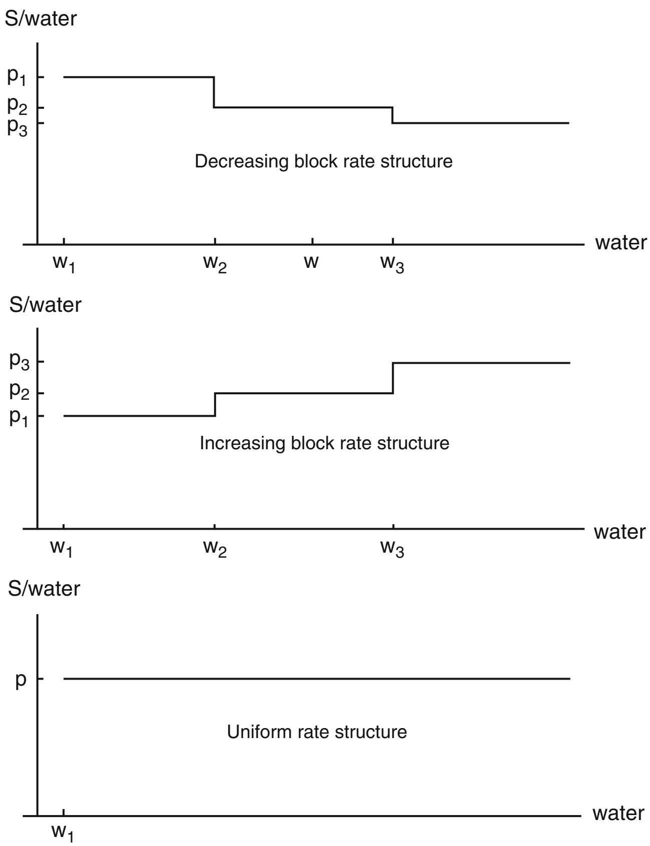

Fig. 20.1 Three types of water rates

Historically, decreasing block rates were favoured; although this has been changing as the economic circumstances of utilities evolve (Organisation for Economic Cooperation and Development 1999).

Three reasons explain the long-standing preference for decreasing block rates. The natural monopoly status of suppliers is due to the declining average costs of providing water. Said another way, greater system-wide deliveries lower the per-unit costs for everyone, so stimulating consumption with a lower price for large water consumers might seem appealing. Second, it is widely assumed that large water users such as businesses and industries are steadier in their water use in that their peak-hour and peak-day water use is not dramatically greater than their average water use. In contrast, it is typically presumed that small water users such as households contribute more to peak water usage. Because system capacity is both expensive and constructed to meet peak demands, it is arguable that residential users are causing higher average and marginal costs for the utility. Third, decreasing block rates are favourably viewed by suppliers because they stabilize revenue in the presence of climate-impacted demand. With decreasing block rates, a greater proportion of revenue is derived from the initial units of consumed water, and these units are less likely to be affected by climate.

The opposing rate structure is naturally termed increasing block rates, although inverted block rates is also an encountered term. Motivation for the adoption of increasing block rates comes from two sources. First, increasing block rates are often claimed to enhance water conservation because large water users are “penalized” for their behaviour. Second, because larger water users tend to be wealthier water users in residential settings, there may be a perceived degree of “fairness” associated with increasing block rates. In developing countries, increasing block rates may enjoy considerable support because the basic water uses undertaken by the poor are internally subsidized by this rate structure (Boland and Whittington 1998).

One method of time-dependent pricing is supported by contemporary metering practices. Monthly meter reading allows water prices to vary by month. Thus, as a utility moves through the year, encountering low-to-high water supply conditions relative to demand, it is feasible to apply month-specific prices. This is called ‘time of year pricing’. While such a system has not gained complete favour, it is more efficient than keeping prices fixed for an entire year. Many urban suppliers now employ a simplified variant known as seasonal pricing in which separate winter and summer rates are applied. Winter rates apply for part of the year, and summer rates makeup the rest. Summer rates are justifiably higher because much of the supply system is only used during the summer. Given that there is idle system capacity during winter periods, it is clear that the purpose of the idle capacity is to provide summer service. It is therefore economically appropriate to assign these costs to the summer period, resulting in higher summer rates. The summer value of natural water is also higher in most regions.

Two other charges to water are also important. Both of these charges are rationalized by the capital intensity of the water supply industry, which has even greater capital requirements per dollar of product than the electricity, telephone, or railroad industries (Beecher et al. 1991). Both of these charges are focused on the many *points of use* at the end points of the water delivery system. Water managers refer to these end points as the number of *connections* or *meters* in their system.

The first of these fees is the meter charge, which is usually paid in every billing period. This fee can also be called the minimum charge or the service charge. When irrigators are charged on the basis of irrigated area (acreage), this fee functions much like a meter charge for each acre. Because it is not based on water consumption, the meter charge serves as a flat rate if it is not accompanied by a volumetric charge. Modern rate systems, however, incorporate both the meter charge and a water price. Historically, the meter charge component was employed in the absence of a volumetric charge. Irrigation districts have a strong propensity to rely on the acreage charge for revenue generation (Michelsen et al. 1999). Suppliers enjoy the revenue stability resulting from meter charges, and overall costs are lowered because meters do not have to be installed or regularly read. Yet the presence of a zero price for water provides a perverse incentive for consumers in light of the value of processed and possibly scarce water, variable operational costs (e.g., energy, treatment chemicals), and the value of the physical capital needed to obtain, store, treat and deliver this water. For these reasons, both meter installation and meter-reading efforts have been accepted as worthwhile undertakings in most modern systems (Organisation for Economic Co-operation and Development 2003).

The combined application of a water charge and a non-water charge also coincides with economic recommendations for declining-average-cost industries. In the technical economic literature concerning “two-part tariffs,” the dual application of a meter charge and a volumetric charge enjoys extensive theoretical support (Brown et al. 1992; Kahn 1988; Ng and Weisser 1974).

The second significant non-water charge is the connection charge that modern utilities place on new connections to the delivery system which is a one-time fee for each new point of water use, such as a new home (Herrington 1987).

3.2 Equity, Efficiency and Sustainability in Groundwater Prices

There are many different ways to promote equity, efficiency and sustainability in the water sector and water pricing is probably the simplest conceptually, but maybe the most difficult to implement politically. For example, the typical command and control approach taken in most countries with respect to water management leads to large government involvement because of its needs for detailed hands-on monitoring and measurement. Using price policies, however, still requires significant government intervention to ensure that equity and public goods issues are adequately covered.

Economic theory has long ago explained how correct pricing of private and public goods can lead to gains in economic efficiency. Three generally accepted effects of price policy—demand reduction, efficient reallocation of the resource, and

Table 20.1 Effects of price policy on groundwater

Three well-known and three lesser known effects of price policy
(a) *Increased price reduces demand*
(i) Substitutes become cheaper
(ii) Conservation becomes affordable
(iii) Change consumption preferences
(b) Increased prices increase supply
(i) Marginal projects become affordable
(ii) Provides economic incentives to reduce water losses
(c) Increased price facilitates re-allocation between sectors
(i) From irrigation to domestic and industrial
(ii) From off-stream to in-stream uses
(d) Increased prices improve managerial efficiency due to increased revenues by
(i) Improving maintenance
(ii) Improving staff training and education
(iii) Making modern monitoring techniques affordable
(iv) Making modern management techniques affordable
(e) Increased prices lead to sustainability
(i) Reduces demands on resource base
(ii) Reduces pollution loads due to recycling of industrial water
(f) Increased prices reduce the per unit cost of water to poor people
(i) Increases coverage of poor urban and peri-urban populations because additional water is available for extending the system
(ii) Reduces reliance by the poor on water vendors

increasing the supply—together with three effects which are not generally associated with price policy, namely, improved equity, improved managerial efficiency, and improved sustainability of the resource are listed in Table 20.1. Here “water resources” encompasses surface water, groundwater and wastewater. We show that if water resources are managed in an integrated fashion where the economics, legal and environmental aspects complement each other, increased prices do improve equity, efficiency and sustainability of the resource.

3.3 *Full Cost Pricing of Water*

The problem faced by the water sector is that prices and tariffs are almost universally below the full cost of supply. This means that almost everywhere there are large inefficiencies in the water sector and that water prices need to be raised. The World Water Commission strongly endorsed the need for full-cost pricing of water services: Commission members agreed that the single most immediate and important measure that we can recommend is the systematic

Table 20.2 Important concept of groundwater for setting price

COST:	O&M costs, capital costs, opportunity costs, costs of economics and environmental externalities
VALUE:	Benefits to users, benefits from returned flows, indirect benefits, and intrinsic values
PRICE:	Amount set by the political and social system to ensure cost recovery, equity and sustainability. The price may or may not include subsidies. Prices for water are not determined solely by cost

adoption of full-cost pricing of water services (World Water Commission, 2000). Three important concepts from water economics is shown in Table 20.2.

4 Groundwater Markets

The term water markets connotes a localized, village level informal institutional arrangement through which owners of a modern water extraction mechanism (WEM) sell water to other farmers at a price. The poor farmer in the absence of a sound economic base and resource rich and big farmers due to the high degree of farm fragmentation enter into water markets as a buyer.

4.1 Important Features of Water Markets

(a) *Spontaneity:* Even though the WEMs are not installed primarily to sell water, water markets come into existence by spontaneous action initiated by individual farmers to exploit a mutually beneficial opportunity.
(b) *Informal:* The sole basis of the whole transaction is the mutuality of need between the buyers and sellers. There is no formal legal sanction behind the transactions in these water markets.
(c) *Unregulated:* These are unregulated and the state government or state electricity board does not exercise any direct or indirect control.
(d) *Localized:* Markets are mostly limited to a part of a village’s fields.
(e) *Fragmented:* The option of one seller does not depend on the action of other sellers, but it depends upon the number of buyers and their respective area.
(f) *Non-seasonality:* Water markets operate in all the three crop seasons, namely, rabi (winter), kharif (monsoon) and boro (summer).
(g) *Impersonal:* Water markets are impersonal in the sense that sellers generally do not distinguish between various buyers in term of selling or quality of service provided.

4.2 Major Forms of Water Markets

(a) *Purely buyers:* This form of water market arises mainly because of small size of holding. Buyers are generally resource-poor farmers and they do not get a suitable partner to pool their resources to install a WEM.
(b) *Self users and buyers:* This form of water markets exists generally because of fragmentation of holdings.
(c) *Self users and buyers and sellers:* Existence and operation of this form of water markets is also due to high degree of farm fragmentation.
(d) *Self users and sellers:* These farmers are owner of WEMs and their land holdings are consolidated. They sell surplus water to other farmers because their land holdings are small to utilize a WEM at full capacity.
(e) *Purely self users:* Water markets do not exist in this category of farmers because they have WEMs to irrigate only their fields. Land holdings are generally consolidated requirement.

4.3 Experiences with Water Markets

Water markets can be broadly divided into formal and informal markets.

4.3.1 Formal Groundwater Markets

Formal water markets specify the volume and share of water to be sold, either for a set period of time or permanently. Informal markets usually involve the sale of unmeasured flows of surface water from a canal for a set period of time or of water pumped from a well for a set number of hours. Although the units sold in informal markets may not be metered, both the buyer and the seller have good information about the volume transferred. The key difference between the two markets is the way in which the trade is enforced. If the users must self-enforce trades because no formal water rights exist that can be enforced through the legal or administrative system, the market is informal. Formal water markets are usually found in North and South America, whereas informal markets are prevalent in the irrigated areas of South Asia.

4.3.2 Informal Groundwater Markets

Most of the groundwater markets are important for agricultural production and the distribution of water throughout the irrigated areas of South Asia. Saleth (1998) estimates that 20% of the owners of the 14.2 million pump-sets in India are likely to be involved in water trading. This means that water markets are providing water for about six million hectares, or 15% of the total area irrigated by groundwater. In Pakistan a survey reported that 21% of well owners sold water (NESPAK 1991). In areas where dependable precipitation recharges the groundwater, the benefits of buying and selling water from tubewells have increased farmers' income and production. The economic gains from groundwater markets reflect improved efficiency in pump management, in reducing conveyance losses, and in farm-level water use. These markets also increase access to irrigation, especially for smaller-scale farmers who do not own tubewells and cannot afford to invest in a well without a market for their water. Meinzen-Dick (1998), in one of the few studies estimating the economic returns from access to water markets, found that water markets increased the availability and reliability of water supplies. Both yields and income rose for those who purchased water, particularly for those who also had access to canal water supplies. The highest yields and income, however, were still found among farmers who owned their own tubewells and had access to canal water.

4.4 Problems with Groundwater Markets

4.4.1 Problems with Informal Groundwater Markets

There are several problems with informal groundwater markets. These include:

Preventing Overdrafts Given that markets for the sale of groundwater draw on an open-access resource (that is, one that is available for capture to anyone who has access), it is not surprising that problems arise in areas with high demands and limited supplies. Farmers have an incentive to ignore the scarcity and buffer stock value of the groundwater and pump until their cost of pumping equals the market price of water (Ramasamy 1996). Over time, the cost of pumping and the price of water rise as the groundwater level declines.

For example, the overdraft (that is, water use in excess of recharge) in the Coimbatore District of India is almost 5000 cubic metres a year. Ramasamy (1996) estimates that if the over-pumping continues, it will mean a drop in total net returns to farmers of between \$42 million and \$69 million, a result of the increased costs of power necessitated by increased pumping and additional investment to deepen wells. Here is a case where informal markets may exacerbate the problem, and formal markets may not work any better unless water rights can be established and enforced in strict quantity terms. The problem is not the water markets but the lack of exclusive property rights for groundwater. To establish such rights, the number of wells and the amount of water to be pumped would have to be agreed on and restricted. Such restrictions are probably unrealistic without strong support in the irrigation community. If exclusive water rights can be established, however, the water market should reflect the scarcity value of water and help restrain over-pumping.

Blomquist (1995) reports on one case where the demand for water is increasing and the community of water users has been able to stop the overdraft. In the dry Los Angeles metropolitan area in southern California, pumping is metered and taxed so that users have an incentive to shift from local groundwater to more expensive but more plentiful imported water. Surface and imported water are stored and used to recharge the groundwater in the basin. One result has been a halt in saltwater intrusion from the ocean in the area's coastal groundwater basins. In some of these basins, pumping rights have been defined, limited to the basin's average recharge, and made transferable to other users through sales. A more typical case, reported by Shah (1993), is in coastal Gujarat, India. Here, the overdraft of coastal aquifers has caused a decline in groundwater supplies in some areas and saltwater intrusion in others. Shah (1993) argues that any effective reduction in this overdraft is unlikely without good local leadership and the involvement of water user groups. He argues that legal, quasi-legal, and organizational instruments of public policy will not, on their own, succeed in securing the compliance of farmers unless they are accompanied by measures aimed at affecting private returns to irrigation or unless the structure of property rights on the water resource itself is drastically reformed. Similarly in Pakistan, Meinzen-Dick (1998:218) doubts whether government would have the institutional capacity to regulate sales among hundreds of thousands of private tube-well owners, and if it had such capacity, it is unclear what such direct intervention could achieve.

Yet in both India and Pakistan, any effect that water markets might have on the over drafting of groundwater is much less than the effect of subsidized electricity. The zero or near-zero marginal cost of pumping means that farmers have an incentive to use groundwater to the point where the marginal value of production is close to zero. This, of course, encourages farmers who can sell water to use their wells at close to full capacity. The low power rates not only create over-drafting problems but also waste electricity in countries without adequate power. As noted above, water markets can actually help solve the over-drafting problem by increasing the incentives for efficient water use and making it possible to purchase water from areas where water is abundant. The ability to find another source of water, but at a higher marginal cost, can help promote community action for self-regulation and demand management. Shah (1993) cites a case in coastal Gujarat where self-regulation became possible when additional new supplies were piped into the area.

Over-drafting tends to be concentrated in coastal areas of India and Pakistan and in the hard rock areas of southern India. In many of the northern areas, pumping actually improves growing conditions by lowering the water table below the root zone (Shah 1993; Meinzen-Dick 1998). In cases where water tables are high or recharge rates are rapid, water markets are not likely to cause negative externalities except possibly temporarily if neighbouring wells are too close or deep tubewells interfere with shallow wells. Where these externalities are small, personal trust and reputation may be enough to foster competitive informal water markets. This is particularly true where farmers own a number of separate plots that cannot be served by the same well. In such cases, most water sellers are also buyers because most farmers who own a well are able to irrigate only their large plots and must purchase water to irrigate other plots (Shah 1993; Meinzen-Dick 1998; Saleth 1998). In addition, their wells are likely to be underutilized unless they can sell water. Yet because of the costs of conveying water and the need for cooperation from neighbouring farmers when water is to be conveyed any distance, high transaction costs can restrict trades in areas with only a few wells and prevent water markets from being competitive.

Countering Monopoly Pricing This raises the other concern about water markets, the potential for monopoly pricing and discrimination. Groundwater markets are somewhat confined by the physical limits of the location and supply of groundwater. Still, pipelines can extend markets, and the investment costs of new wells should put a limit on monopoly power. An abusive monopolist who raises prices too high will find others investing in wells and undercutting the price. Shah (1993) notes a lack of balance between the numbers of buyers and sellers in areas with high capacity wells, where one seller may serve as many as 70 or 80 buyers. He fails to say how many sellers the average individual buyer can access. Monopoly pricing may be avoided if the buyers can purchase water from three or four sellers—so long as the sellers do not collude. The evidence on monopoly pricing is mixed. In a 1991–92 survey in Pakistan, Meinzen-Dick (1998) found that sellers were pricing water at little more than the cost of pumping. The two most common ways of charging for groundwater are a flat charge per hour of pumping (ranging from $0.57 to $3.27 an hour, depending on the pump type, capacity, and location) and arrangements whereby the buyer supplies the diesel and motor oil for the pump and pays an additional fee of $0.16 to $0.24 an hour to the well owner to cover the wear and tear on the engine. Sellers with diesel pumps were just recovering their own costs under either type of contract. In contrast, Saleth (1998) suggests that in some areas of India, monopoly rents may be extractive. He cites as evidence the variation in water charges compared with pumping costs in different areas. For example, water charges are 1.3–2 times higher than operating costs in the Indo-Gangetic region but 2.5–3.5 times higher in the water-scarce hard rock regions of southern India. The difference in rates, however, might be explained in part by the difference in water scarcity and in the value of water in those two regions. The degree of monopoly power may also be related to the terms of the transaction or contract for water. Not surprisingly, some of the contracts for water are quite similar to contracts for land. Water contracts include crop sharing, crop and input sharing, and labour arrangements. If the payment is cash-based, buyers have more freedom to take their business to another well owner anytime during the season. When the transaction is a contract in kind, especially one based on crop sharing or on crop and input sharing, the buyer is tied to the seller for at least one season, if not longer. Similarly, if buyers contract to pay for the water with their labour, they may find it difficult to change suppliers until they have fulfilled the contract. Yet in the villages, informal markets do not appear to face extreme cases of monopoly rents.

In fact, monopoly power that restrains trading in areas with serious problems of declining groundwater levels may help reduce over-extraction. In contrast, when suppliers are taking advantage of their monopoly position and there are adequate groundwater supplies, the best strategy is to encourage (legalize) trading and increase competition through community and private well development (Palanisami and William Easter 1991).

Thus informal water markets can improve water use and incomes in irrigated areas where water rights are not well defined or recorded. They also may be a good option if formal water markets are likely to produce third-party challenges and result in excessively high transaction costs. Finally, informal markets would work well in traditional irrigation systems where the farmers manage the irrigation system and would be able to maintain a relatively modest level of transaction costs.

4.4.2 Problems with Formal Groundwater Markets

In situations where informal markets can work well, it may not be necessary to incur the extra expense of establishing formal water markets. Formal markets will be required, however, to provide the certainty necessary for permanent water transfers or transactions between different sectors and jurisdictions. Because the need for permanent trades and inter-jurisdictional water exchanges is likely to become more important as non-agricultural demands for water grow, formal water markets are likely to become more common. The growing demand in water-scarce regions has been one of the driving forces behind the new interest in water markets. Several studies have illustrated the benefits that are possible from inter-jurisdictional trading in permanent water rights for short-term use.

In Texas, USA, 99% of the water traded has been transferred out of the agricultural sector in the Rio Grande Valley to non-agricultural users (Griffin 1998). Of the municipal water rights in the valley that existed in 1990, 45 percent had been purchased since 1970. Although water markets are not active in other areas in Texas, Griffin (1998) notes that the surface water law has evolved to the stage where trading will be more widespread in the future. In contrast, the groundwater law is just beginning to evolve.

Economic Gains In a study of the Guadalquivir Basin of southern Spain, Garrido (1998a) finds that the economic gains of trading within an individual water district or community may be relatively modest. In contrast, if permitted, trades among communities subject to different supply constraints and drought conditions could produce substantial gains. Garrido (1998a) estimates the total welfare gain at no more than 10% over the current water allocation for four communities where trades were only intra-community. Inter-community trading, however, could produce estimated economic gains in one of the older irrigation communities of almost 50%. Garrido (1998a) also shows that both types of trades are very sensitive to the level of transaction costs. If those costs exceed 8–12% of the market price, trading and the gains from trading would be too small to justify the expense of establishing formal markets. Yet Garrido (1998b) may underestimate the potential gains because he considers only the crops traditionally grown in the region (cotton, wheat, corn, oilseed and sugar beets) and excludes any transfers to non-irrigation uses. Evidence from Chile found significant changes in cropping as a result of water trading (Hearne and Easter 1997).

In contrast, Horbulyk and Lo (1998) found that most potential gains from introducing water markets in Canada's Alberta Province were likely to come from trades within a sub-basin**.** They considered four sub-basins and compared the current water allocation situation with the allocation under four separate markets (one in each sub-basin), as well as with a market encompassing the total basin. The four separate market scenarios created 90% of the welfare gains that were obtained when unrestricted trading was allowed among the four sub-basins. The urban sectors purchased most of the water, except on the River South Saskatchewan, where the agricultural sector purchased additional water when market trading was allowed among the sub-basins.

Trading Patterns and Transaction Costs In their analysis of selected water markets in Chile, Hearne and Easter (1997) found trading both within and between sectors. In the case of permanent transactions either within or between sectors, well-established water use rights that were recorded and recognized by the government were critical in fostering trade.

Several trades between farmers and the city of LaSerena were not consummated because of uncertainty regarding ownership of the water rights. La Serena is a growing vacation destination located on the coast in a dry region some 400 km north of Santiago. Rapid growth in demand has strained the city's water supply, particularly during the summer tourist season. The opening of water markets allowed the city to purchase water and delay development of new water sources. Starting in 1992, the city's water company purchased enough water to increase its water supply by 28%. Additional purchases were made by upstream households for domestic uses and by farmers.

Similarly, Archibald and Renwick (1998) found that high transaction costs in California limited a large number of potentially profitable trades. Two types of transaction costs were identified: administrative-induced costs, which are explicit and included in the price of water sold through the California Water Bank, and policy-induced transaction costs, which stem from existing legal requirements designed to avoid injuring owners of water rights, damaging fish and wildlife, and creating negative third-party effects in exporting areas. Policy-induced transaction costs in this range would be as much as or more than the potential gains from trading in the California Water Bank (Archibald and Renwick 1998).

Because of high transaction costs in Colorado, Howe (1998) recommends shifting the administrative responsibility for water transfers from the water courts to the State Engineer's Office. He also recommends reserving or acquiring water for "public good" uses such as recreation, as well as making other changes to allow water to be marketed as freely in Colorado as it is in the neighbouring states.

Colby (1990) suggests that the claims of Native Americans have the effect of imposing high transaction costs on water trading in many western rivers. She argues that even though markets do not work well with high transaction costs, when those costs are compared with the costs of litigated solutions, water markets look like a much better alternative.

Howitt (1998) reports that spot and options markets performed well during California's droughts in the 1990s. Even though these markets are a fairly recent phenomenon, he thinks they are a promising option for stabilizing available water supplies in California and other similar areas. Permanent shifts in demand, however, require a much more active formal market for water rights.

5 Conclusion

Contrary to the claims of many critics, water markets have worked and are likely to be a better mechanism for reallocating water than the alternative methods. There are both formal and informal water markets at work today. In addition, there are spot market sales, sales of permanent water rights, and leasing arrangements that are similar to those used for land, including crop sharing and cash rents.

Where water is scarce and large amounts of the available water supplies were committed to particular uses a long time ago, the economic benefits from water markets are likely to be large. In contrast, if the allocation was made fairly recently, based on the most highly valued uses of water and new opportunities are not available, then the gains will be much more modest.

For markets to be effective, transaction costs must be kept low. To keep these costs low, the appropriate institutional and organizational arrangements need to be in place, as well as flexible infrastructure and management. As pointed out earlier, the critical first step is to establish tradable water rights or water use rights separate from land, as well as the mechanisms to deal with third-party effects.

If it is difficult to establish legally enforceable, permanent water rights, a "thick" spot market may provide almost the same security as ownership of permanent water rights. In other words, the ability to buy the water needed at a reasonable price may provide enough security so that firms are willing to invest in enterprises that are dependent on this purchased water. A contingent water market can provide additional security so that firms can be assured of a given volume of water at a set price. With only a spot market and no contingent markets, firms may be subject to wide fluctuations in prices.

For those users needing certain supplies, spot water markets are probably cheaper alternatives than having to buy enough senior water rights so that one is guaranteed adequate supplies even in the worst drought. Owners of senior water rights have the right to whatever water is available, before the more junior water rights owners. In Pakistan, for example, the markets for groundwater have greatly improved the security of water supply, particularly in government irrigation projects. This security has allowed increased investment and increased production. It will be important to see if spot and contingent markets have similar effects on the productivity of water.

Finally, the evidence indicates that appropriately designed water markets, supported by sound institutions, are an effective mechanism for reallocating scarce water among sectors. Carefully designed water markets make it possible to meet the growing urban and industrial water demands without derailing growth in crop production.

Market transfers among sectors may make it possible to significantly scale back investments in new water supply projects. Government inaction, ineffective institutions for water management, and high transaction costs, however, are likely to prevent water markets from reaching their full potential for reallocating scarce water resources.

References

Agenda 21 (1992) United Nations Conference on Environment and Development, Rio D Janeiro.

Archibald, S. and Renwick, O.E. (1998). Expected Transaction Costs and Incentives for Water Market Development. *In:* Easter, K. William, Mark W. Rosegrant and Ariel Dinar (eds), Markets for Water: Potential and Performance. Kluwer Academic Publishers, Boston.

Baillat, A. (2010). International Trade in Water Rights. IWA Publishing, New York, USA.

Beecher, J.A., Mann, P.C. and Landers, J.R. (1991). Cost Allocation and Rate Design for Water Utilities. National Regulatory Research Institute, Columbus, OH, USA.

Blomquist, W. (1995). Institutions for Managing Groundwater Basins in Southern California. *In:* Ariel Dinar and Edna T. Loehman (eds), Water Quantity/Quality Management and Conflict Resolution: Institutions, Processes, and Economic Analysis., Praeger Publications, Westport, Conn.

Boland, J.J. and Whittington, D. (1998). The Political Economy of Increasing Block Tariffs in Developing Countries. Inter Develop Res Centre, Canada.

Brown, D.J., Heller, W.P. and Starr, R.M. (1992). Two-Part Marginal Cost Pricing Equilibria: Existence and Efficiency. *J Econ Theory*, **57:** 52-72.

Colby, B. (1990). Transaction Costs and Efficiency in Western Water. *Ameri J Agri Econo*, **5(72):** 1184-1192.

Dinar, A. and Subramanian, A. (1997). Water Pricing Experience: An International Perspective. World Bank Paper No. 386. The World Bank. Washington D.C.

Garrido, A. (1998a). An Economic Analysis of Water Markets within the Spanish Agricultural Sector: Can They Provide Substantial Benefits? *In:* Easter, K. William, Mark W. Rosegrant and Ariel Dinar (eds), Markets for Water: Potential and Performance. Kluwer Academic Publishers, Boston.

Garrido, A. (1998b). Economics of Water Allocation and the Feasibility of Water Markets in Agriculture. *In:* Organisation for Economic Co-operation and Development. Sustai Manag of Water in Agri: Issues and Policies. Paris.

Gleick, H.P., Burns, W.C.G., Chalecki, E.L., Michael, C., Cushing, K.C., Mann, A., Reyes, R., Wolff, G.H. and Wong, A. (2003). The World's Water 2002-2003: The Biennial Report on Freshwater Resources. Island Press: Washington DC.

Griffin, R.C. (1998). The Application of Water Market Doctrine in Texas. *In:* Easter, K. William, Mark W. Rosegrant and Ariel Dinar (eds), Markets for Water: Potential and Performance. Kluwer Academic Publishers, Boston.

Hearne, R.R. and Easter, W.K. (1997). The Economic and Financial Gains from Water Markets in Chile. *Agri Econ*, **15:** 187-199.

Herrington, P. (1987). Pricing of Water Services. Organisation for Economic Cooperation and Development, Paris.

Horbulyk, T.M. and Lo, L.J. (1998). Welfare Gains from Potential Water Markets in Alberta, Canada. *In:* Easter, K. William, Mark W. Rosegrant and Ariel Dinar (eds), Markets for Water: Potential and Performance. Kluwer Academic Publishers, Boston.

Howe, C.W. (1998). Water Markets in Colorado: Past Performance and Needed Changes. *In:* Easter, K. William, Mark W. Rosegrant and Ariel Dinar (eds), Markets for Water: Potentialand Performance. Kluwer Academic Publishers, Boston.

Howitt, R. E. (1998). Spot prices, option prices, and water markets: An analysis of emerging markets in California. In Easter, et al. (Ed.), Markets for water: Potential and performance. Boston: Kluwer.

ICWE (1992). International Conference on Water and Environment: Development Issues for the 21st Century, The Dublin Statement and Report of the Conference. Hydrology and Water Resources Department, Water Meteorological Association, Geneva.

Kahn, A.E. (1988). The Economics of Regulation: Principles and Institutions. Two vols. MIT Press, Cambridge.

Meinzen-Dick, R.S. (1998). Groundwater Markets in Pakistan: Institutional Development and Productivity Impacts. *The World Bank Research Observer*, **14(1)** (February 1999).

Michelsen, A.M., Taylor, R.G., Ray, G.H. and Thomas McGuckin, J. (1999). Emerging Agricultural Water Conservation and Price Incentives. *J Agri and Resou Econo*, **24:** 222-238.

NESPAK (National Engineering Services of Pakistan) (1991). Contributions of Private Tubewells in the Development of Water Potential. Field Report. Government of Pakistan, Ministry of Planning and Development, Islamabad.

Ng, Yew-Kwang and Weisser, M. (1974). Optimal Pricing with a Budget Constraint—The Case of the Two-Part Tariff. *Review of Economic Studies*, **41:** 337-345.

Organisation for Economic Co-operation and Development (1999). The Price of Water: Trends in OECD Countries. Organisation for Economic Co-operation and Development, Paris.

Organisation for Economic Co-operation and Development (2003). Improving Water Management: Recent OECD Experience. Organisation for Economic Co-operation and Development, Paris.

Palanisami, K. and William Easter, K. (1991). Hydro-Economic Interaction between Tank Storage and Groundwater Recharge. *Ind J Agri Econ*, **46(2):** 174-179.

Ramasamy, C. (1996). Intertemporal Allocation of Groundwater Resources with Stochastic Surface Supplies: The Case of Southern India. Ph.D. thesis. University of Minneapolis, Department of Applied Economics, St. Paul.

Saleth, M.R. (1998). Water Markets in India: Economic and Institutional Aspects. *In:* Easter, K. William, Mark W. Rosegrant and Ariel Dinar (eds), Markets for Water: Potential and Performance. Kluwer Academic Publishers, Boston.

Savenije, H.H.G. (2001). Why water is not an ordinary economic good. IHE Delft Value of Water Research Report Series No. 9.

Scanlon, J., Cassar, A. and Nemes, N. (2004). Water as a Human Right? IUCN Environmental Policy and Law Paper No. 51.

Shah, T. (1993). Groundwater Markets and Irrigation Development: Political Economy and Practical Policy. Oxford University Press, Bombay.

World Water Commission Report (2000). Earthscan Publications Ltd, London.