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Chapter 15

Water – Can Property Rights and Markets replace Conflict?

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Introduction

According to the UN, 2.7 billion people will face severe water shortages by 2025 and it warns that there may be wars over water. Already, many disputes in the Middle East concern water. Former President Anwar Sadat of Egypt claimed in 1979 that 'the only matter that could take Egypt to war again is water'.[1] Where peace is achieved in the region, there is often much emphasis on the resolution of water conflicts.[2] Hydrology and politics are strongly interlinked.

The availability of fresh water varies widely from country to country. In 1995, Canada had over 105,000 cubic metres of fresh water per person; Tunisia had only 500, Algeria 625 and South Africa 1,400.

In semi-arid and arid regions, quantitative water scarcity is a serious concern. Precipitation is typically low and unevenly distributed, while evapotranspiration is high. Water scarcity is thus related to climate and is exacerbated by misuse, inefficiency, increasing populations and economic development. In these regions, pollution often constitutes an additional problem, but even if the pollution problem were resolved, water scarcity would remain.

In other parts of the world, where rainfall is abundant and evapotranspiration low, water scarcity still exists but is more typically a matter of quality than quantity. In North America, agricultural pollution alone is estimated to cost $9 billion every year.[3] However, water quality is an even bigger problem in low-income countries. According to the World Bank, poor quality water is responsible for around 3 million deaths a year in low-income countries, mostly from diseases such as dysentery, diarrhoea, hepatitis and cholera.[4] Industrial pollution is also a major problem in low-income countries.[5]

When a commodity is scarce, conflicts often arise over its use. This is especially true of commodities that are essential for human survival, such as water. Governance in general can be seen as an attempt to resolve such conflicts through the construction of allocation schemes. Methods of water allocation range from highly centralised governmental control,[6] to communal

[1] Quoted in Tadros (1996).
[2] The Israel-Jordan peace treaty, signed on 26th October 1994, devoted much attention to water allocation decision-making.
[3] Dinar and Xepapadeas (1998)
[4] World Bank (2001)
[5] Pearce (1992).
[6] Becker (1995).

allocation with internal self-regulation,[7] to private markets enforced by communal reputation and ostracism and/or national law.[8]

This chapter discusses alternative allocation mechanisms for water and evaluates their relative success in ensuring stable, high quality supplies at low cost to society. It also provides insights into what schemes might most successfully be employed in the future, especially considering the risk of international conflict.

Water Allocation by Central Government

In most semi-arid countries, water has been allocated by centralised government administration. The track record of such schemes has not been impressive. Despite growing water scarcity and the high costs of hydraulic infrastructure, "water is typically underpriced and used wastefully, the infrastructure is frequently poorly conceived, built and operated, and delivery is often unreliable."[9] At the same time, there are high fiscal costs stemming from the "construction of hydraulic infrastructure; from the institutional bureaucracy to support the design and execution of the projects and to set and collect water tariffs; and from the cost of operating and maintaining the system".[10]

Too little emphasis has been placed on the planning and design of water delivery projects. A major reason for this is the perverse incentives resulting from political allocation. As Elinor Ostrom puts it, "rent seeking and corruption" occur routinely in irrigation projects.[11,12] Indeed, irrigation projects, which are the largest water users in developing countries, have changed little since Helen Ingram found in 1973 that economic studies had been used to "clothe politically desirable projects in the figleaf of economic respectability."[13] In a similar vein, a comprehensive report for the World Bank in 1996 concludes that

> "Many large multipurpose hydraulic projects (irrigation, hydropower, flood control, urban use, etc.) were undertaken on political rather than economic grounds. Costs tend to be high because of: inappropriate design, stemming in part from poor studies done prior to start-up; long gestation periods resulting from funding shortfalls due to changing government priorities and poor capital programming and budgeting; few managerial incentives to control costs; and reported corruption that typically involves kickbacks from construction companies."[14]

An earlier World Bank report highlights some egregious examples of water mismanagement.[15] For instance, between 1974 and 1993 the Peruvian Government invested $3.4 billion (in constant 1993 dollars) in nine coastal multipurpose projects. These projects achieved only 6.6 percent of the planned expansion in supply and none of the planned hydroelectric generation capacity. The primary justification for the projects was irrigation and, while the estimated cost per hectare ranged from $10,000 to $56,000, at completion irrigated land in the area was selling for about

[7] Ostrom (1990).
[8] Shah (1991); Rosegrant and Gazmuri (1994); Anderson and Snyder (1997).
[9] Holden and Thobani (1996), p.3
[10] ibid.
[11] Ostrom (1992), p. 32.
[12] Rent seeking is essentially the legal manipulation of the political process by individuals or groups for personal/group gain.
[13] Ingram (1973), p.34.
[14] Holden and Thobani (1996), pp.3–4.
[15] World Bank (1995a).

$3,000 per hectare. Similar statistics can be found elsewhere. Sri Lanka invested 6 percent of its GDP in a single project, the Mahaweli Development Programme, which was vastly inefficient and led to severe social tensions.[16]

Economic inefficiency of administered allocation

The main reason for such waste is that water is often purposely sold at a very low price or no price at all. Authorities in many arid areas in both developing and developed countries ration water to urban, industrial enterprise while subsidising farmers to grow low-value, water-intensive crops. The effect of under-priced water is that farmers use inefficient irrigation technologies to produce uneconomic goods at the expense of lucrative alternative economic activities. The opportunity costs of this misallocation can be vast.[17]

Furthermore, government control of water has often favoured the relatively wealthy and has not been effective at ensuring access to water for the poor.[18] The poor are often excluded from piped municipal water and must resort to expensive private water truckers to meet their daily consumption requirements. In its review of water vending, the World Bank showed that the unit cost of water supplied from water trucks to poor communities was between four and one hundred times more expensive than piped supplies.[19] In addition, the poor can rarely afford proper sewage arrangements. Similarly, government control has often failed to address environmental problems.[20] For example, 10 percent of the Pakistani irrigation system faces chronic salinity problems.[21]

Historically, administrative approaches to water allocation have tended to favour large-scale investments over water conservation. There are few rewards for administrators who make painstaking improvements in water efficiencies via better pricing policies. In addition, the glamour of large projects and the attendant publicity and power they bring provide strong incentives to both administrators and the primary agricultural users.[22] Meanwhile, administrators are often captured by interest groups.

Attempts to set prices that reflect the true cost of water provision are typically unpopular.[23] But the incentive to conserve water is weakened without appropriate prices. A key feature of successful allocation mechanisms is the financial connection between suppliers and users of irrigation systems. Elinor Ostrom explains that allocation mechanisms which build in the eventual users' interests work well because the users naturally want to monitor resource use among themselves – at a very low cost to the system. When the users' interests are not satisfied, expensive auditing systems become necessary, but are rarely supplied.[24]

Discussing the failure of political allocation schemes in Africa, Robert Bates argues that "inefficiencies persist *because* they are politically useful; economic inefficiencies afford

[16] Frederiksen, et al., (1993).
[17] Holden and Thobani (1996).
[18] Kemper (1997).
[19] The median cost was 12-fold greater.
[20] Kemper (1997).
[21] Frederiksen et al. (1993).
[22] Ostrom (1992); Kemper (1997)
[23] Anderson and Snyder (1997); Holden and Thobani (1996).
[24] Ostrom (1992)

governments means of retaining political power."[25] Bates explains that when a government artificially lowers the price of water, supply from private sources is reduced, users demand more and the result is excess demand. One result of this process is that other agricultural inputs, particularly land, become more valuable, and the administratively-created shortage creates an economic premium for those who own such assets. As the market cannot match supply and demand without prices, the existing supply has to be rationed – usually by those who operate the political market.

> "Public programmes which distribute farm credit, tractor-hire services, seeds and fertilizers and which bestow access to government-managed irrigation schemes and public land, thus become instruments of political organisation in the countryside of Africa."[26]

Furthermore, central control of irrigation schemes gives local users no incentive to maintain the engineering facilities, which inevitably deteriorate. The resulting fall in reliability of water supply stimulates greater government investment and central control, and farmers become even more reluctant to pay.[27]

Consultants, engineering firms and construction companies know this political process well, and understand the mechanism whereby the allocation of funds is politically negotiated. Feasibility studies for new investments rarely warn that the construction of storage dams or the upgrading of canals may be financially unattractive.[28]

When centralised administrative solutions fail – for example because supply augmentation is unsuccessful or simply leads to increased use – governments look for alternatives. The two most popular schemes are centrally administered quotas and prices.

Pricing

In principle, pricing enables public authorities set user fees for water at levels that reflect the opportunity cost of provision, thereby inducing water conservation and making more water available to higher value uses.[29] In practice, no central government has set water prices in this way and pricing is primarily used to recover costs of water delivery.[30,31] Nevertheless, where demand is sensitive to pricing it can have a considerable influence on the long run quantity demanded.

Some countries with low water capacity per person have higher tariffs, such as Tunisia, but others, such as South Africa, do not. Countries with naturally-high water levels have varied tariffs – in other words, scarcity of water is not a strong determinant of higher tariffs.[32] Farmers are the main users of water in semi-arid areas and oppose raising water prices because it

[25] Bates (1983) p.128 (emphasis in original).
[26] Bates (1983), p.130.
[27] Bates (1983).
[28] Shanks (1981).
[29] Thobani (1998)
[30] Note that a policy of pricing water to cover the full cost of building and managing the infrastructure (the long-run marginal cost) is not optimal if the infrastructure was ill-conceived and built at high cost. If full cost pricing could be enforced, most farmers, who typically account for the bulk of water use, would find irrigation farming unprofitable (Thobani, 1998).
[31] Water prices can also be used to reflect external costs, and this approach has been applied in some locations (see Howitt, 1998).
[32] Dinar & Subramanian (1997)

increases their variable costs. Their assets also depreciate as higher water prices reduce the value of their land. Farmers' resistance to increased fees is therefore grounded in their incentives. If the fees charged for water on some projects were to be raised (and enforced) sufficiently to recover both the recurrent and capital costs, many farmers would be better off not irrigating. Robert Repetto found this to be the case for five of the six countries he analysed in Asia.[33] However, a common problem for pricing schemes is that increases in fees usually accrue to the central treasury and will only rarely be re-invested in better institutional facilities, unless bribes are paid. Farmers thus often have good reason to oppose price rises.

Occasionally, governments will allow local associations to keep water fees for reinvestment and farmer opposition to fees is lowered.[34] Repetto found in only one country out of six (the Philippines) did the fees collected cover the operating and maintenance costs of the systems (this was probably because in the Philippines revenues were hypothecated); in no country were the capital costs covered.[35] In several of the countries surveyed, Repetto found that the amount of bribes and fees paid to private tube-well operators demonstrated the farmers' willingness to pay far more than the subsidised price for reliably available water.

Ironically, it is poor farmers who suffer most from the under-pricing of water. Low prices inflate demand, so authorities have to impose limits on water use. When this happens, the politically insignificant poor are excluded from receiving supply, while better-off, politically relevant farmers obtain water at highly subsidised prices.[36]

Quotas

Quotas can constrain demand for water (if they are set lower than the quantity demanded).[37] Indeed, if demand is relatively unresponsive to changes in price (as is likely to be the case in places where water is extremely scarce),[38] quotas are more successful at constraining demand than water pricing.[39] This may be important if limiting water use to a specific maximum is vital to ensure sufficient water for ecosystems or subsistence users. Similarly, if demand for water increases due to economic development, quotas limit supply to a specific, ostensibly sustainable amount. Compared to water pricing, however, fixed, un-tradable quotas provide less of an incentive to increase the efficiency of water usage.

In addition to the above factors, quotas provide official recognition of access rights and can be given for free. In addition, if supply is augmented through dam development and irrigation canals, farmers are more likely to escape paying for developments from which they alone benefit under a quota scheme.[40] It is thus not surprising that of the two schemes, farmers in less

[33] Repetto (1986).
[34] See the case study on the Philippines National Irrigation Association by Bagadion (1988).
[35] Repetto (1986).
[36] Thobani (1998).
[37] Quotas are quantitative limits on water use and can be based on time, volume, or can be use-specific (such as per crop).
[38] Technically, the price elasticity of water demand is equal or close to zero.
[39] Baumol and Oates (1988).
[40] Bate et al. (1999).

developed countries seem to prefer water quotas over pricing regimes,[41] and quotas have been the favoured solution to restraining demand in LDCs.[42]

Quota systems have proven insufficient to constrain demand. Often new quotas given to farmers (either incumbents or new arrivals) following supply augmentation eventually increase pressure on supply. Nevertheless, it is now the norm in LDCs to use quotas, coupled with low levels of pricing, to limit demand.[43]

Water Markets

Quotas and prices, separately or in combination, have been criticised for not allowing sufficient flexibility in allocation.[44] Inflexible allocation usually leads to inequity and inefficiency, because as prices remain low, the value of quotas increases, with latent demand unfulfilled, which leads to economic stagnation, increased power to quota holders and even illegal exchanges of quotas. There are exceptions: where there is the administrative capability regularly to calculate shadow prices and change water usage, as in countries such as France, pricing and quota strategies have been relatively flexible. But most developing countries do not have such administrative capacity. Scholars therefore suggest a third option, water markets, where quotas are legally traded among users.

Market allocation requires well-defined and freely exchangeable property rights. Unfortunately, transaction costs, which include the costs of creating, monitoring, and enforcing such rights, are often large compared with the value of the water, making it difficult to establish market systems. Problems of externalities, inequity, and devolution of power to local users also make markets politically unpopular.[45] Furthermore, water use is legally linked to land in most countries of the world, making the legal creation of tradable rights to water technically complex. Meanwhile, at least one solution to this problem, tradable quotas, tends to result in hostility.[46] Yet the flexibility and efficiency that come from the decentralised knowledge held in water markets has made them popular in many developing countries.

Tradeable water rights allow the price of water to reflect the value of its alternative uses, which creates incentives to put it to more productive use. For example, if farmers were able to sell their water rights at freely negotiated prices, some might sell surplus water to a neighbouring farm where it has a higher value. Often, farmers can generate a surplus by using more efficient irrigation techniques or by switching to less water-intensive crops. In addition, buyers of water rights are likely to conserve water more efficiently.

Tradeable water rights can often shift water to higher value uses more cheaply and equitably than alternatives such as building hydraulic infrastructure, confiscating water from farmers, or raising water charges sufficiently to force farmers to conserve water. Although the conveyance

[41] Repetto (1986).
[42] Easter (1998).
[43] Deacon (1997).
[44] Anderson and Snyder (1997).
[45] Strosser (1997).
[46] Quotas may in fact change this legal linkage by exchanging a legal concept of 'reasonable use' of water with a stipulation of an exact amount of water. But this legal change is rarely obvious since water is still used on the same riparian land. However, trading in quotas gives a much stronger impression of alienation of water use from land. So, while establishing quotas is the key change to the legal status of the rights, hostility to quotas only occurs when they are exchanged.

infrastructure to transfer traded water must be built if it does not exist already, the cost of doing so may be less than that of generating new water rights[47].

Trading water rights is particularly beneficial for small farmers, who are often excluded from the political process and have therefore been most vulnerable to reductions in their water allocation over time, and have few other sources of collateral. Poor farmers are assured of sufficient water by their tradeable rights, which also help to reduce the abuses of administrative allocation. As rights are divisible, farmers can mortgage some part of their water rights for small loans, rather than their entire farm holdings.[48] Although the experience in some countries is that small farmers are generally bought out completely when they trade,[49] the more efficient ones that remain are able to expand by purchasing water use rights.[50]

Finally, when comparing the transactions costs of water markets with alternative allocation mechanisms, the 'hidden' transactions costs of the latter must also be taken into account. There are very high costs due to private rent-seeking by the managers of publicly administered irrigation systems. Allocation through markets in well-defined property rights in water will economise on rent-seeking costs.[51]

Case Studies

So far the discussion has mostly focussed on the problems of government control and the theoretical alternative of water markets. We now turn to a brief discussion of the practical implications of water trading, looking at various schemes that exist around the world, both formal and informal.

Informal Markets

Failure of governments to allocate water to the satisfaction of users has led to informal, but often illegal, markets in water transfers in many countries of the world.

The Pakistan Water and Power Development Authority found active water trading on 70 percent of the water courses it studied.[52] Although trades were not officially sanctioned, it was found that where water had been traded agricultural incomes had increased by 40 percent due to greater control by farmers over their water supply.[53]

Similarly in India, over half the area irrigated by tubewells belonged to farmers who bought water.[54] The estimated gains from trading water in the whole of India were $1.38 billion per year. Yet the only policy statements and governmental actions on water markets in India have been to discourage them because they were illegally using electricity for pumping.[55]

[47] Provision of conveyance infrastructure is almost certainly a job government will underwrite, if it does not fund it completely. Private finance is used in many schemes at the moment (IFC, 1998 – Private Sector Bulletin).
[48] Holden and Thobani (1996).
[49] Holtzhausen (1997).
[50] Thobani (1998).
[51] Rosegrant and Binswanger (1994).
[52] Pakistan Water and Development Authority (1990).
[53] Strosser (1997).
[54] Shah (1991).
[55] Saleth (1998).

Markets in India and Pakistan, and others like them, helped to resolve short run water shortages. Scarcity drove the institutions to make the most efficient use of the available water.[56] But because informal water markets are not supported by existing laws, contracts are not enforceable. Agreements are only struck by users (usually farmers) who know and trust each other well. The lack of legal title also limits transactions to spot sales of water for brief periods of time, and never permanently, and so trades do not fully capture the benefits of an organised market in secure tradeable rights. Unfortunately in many informal water markets (such as those in India and Pakistan) groundwater is depleted because of concerns that markets may be curtailed at any time. Nevertheless, informal markets can occasionally provide the benefits expected from legal markets, such as maintenance of canal delivery systems, because the canals transport purchased water.[57]

Chile

Chile has the most developed and one of the oldest regimes of water-use trading in the world.[58] All water rights were expropriated by the Chilean Government in 1966 and transferred to the State. But Chile's 1981 Water Code re-established tradeable water rights where existing water users (farms, industries, municipalities and power utilities) were granted rights to surface and groundwater.[59] New or unallocated water rights were auctioned. Except for a few restrictions, the allocated rights could be transferred or sold to anyone for any purpose at freely negotiated prices.

The agricultural sector accounts for 89 percent of the estimated 300,000 owners of water rights.[60] Administration is highly decentralised with the monitoring, distribution and enforcement of water rights carried out by water user associations at the local level – river basin, underground aquifer (for groundwater), primary canal and secondary or tertiary canal. Except for a few large dams and their associated main canals, all hydraulic infrastructure is owned and operated by water users themselves.

Water users enjoy flexibility and control over water rights. In the arid areas north of Santiago there have been many mutually beneficial sales and leases of water, resulting in a voluntary transfer of water to more productive uses. By contrast, in the higher rainfall area south of Santiago, there have been few trades, since the transaction costs of registering the rights and conveying water is greater than the gains from transferring the water.[61]

Chile's transfer of water to more productive uses was carried out voluntarily and without having to raise water charges. In fact, water charges fell following the introduction of tradeable water rights. The decrease occurred because the Chilean Government facilitated the transfer to user groups of the responsibility for carrying out operations and maintenance activities and for setting water tariffs. User groups were able to conduct these activities at a much lower cost than government. Despite the lower water charges, the opportunity to sell water reduces waste.[62]

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[56] Anderson (1994).
[57] Easter et al. (1998).
[58] Livingston (1995).
[59] Anderson and Snyder (1997:192) quote from the Chilean Constitution which translated states that "the rights to private individuals, or enterprises, over water, recognised or established by law, grant their holders the property over them".
[60] Ríos and Quiroz (1995).
[61] Hearne and Easter (1997).
[62] Rosegrant and Gazmuri (1994).

Perhaps the greatest benefit of the trading approach has been that demands for environmentally destructive dam building have been dropped. The city of La Serena in Chile is able to meet its rapidly growing demand for water by purchasing water rights from farmers at a lower cost, rather than contributing to the construction of a dam. Farmers received an acceptable price for the water and were induced to use more efficient irrigation techniques.[63] Similarly, when Chile's main water company, Empresa Municipal de Obreros Sanitarios (EMOS), realised that it could no longer obtain free water rights, it invested in a programme to significantly reduce physical water losses.

Remarkably, Chile's sustained annual growth of 6 percent in agriculture during the 1980s was managed without public investments in new hydraulic infrastructure. While this was due in part to heavy investment in water infrastructure in previous decades, the tradeable water rights regime enabled new water uses, including the rapid expansion of fruit production.[64]

Chile has also been successful in increasing access of the poor to potable water, as 99 percent of urban residents and 94 percent of rural residents are supplied typically for 24 hours a day. This contrasts sharply with comparable rates of coverage of 63 percent and 27 percent in Chile in 1970 and with developing countries elsewhere in the world.[65] While this was due to several factors, such as ensuring that regulated water tariffs reflect the true cost of water, allowing competition among water companies (Santiago alone has seven private companies), and subsidising water consumption for those with low incomes, the ability of water companies to buy water from farmers played a significant role.

Chile still has some problems in water use, particularly with quality. The obligations on holders of non-consumptive rights to release water for public consumption in times of shortage were not clearly defined, so dilution for effluent was occasionally low. This reduced water quality and led to conflict between the recently-privatised hydropower companies and farmers. Some shortcomings in the law have also enabled one hydropower company to obtain huge blocks of non-consumptive rights without charge. Despite these problems, Chile has fewer conflicts and makes better use of its water than its neighbours.[66,67]

Mexico.

In the past few years, the Mexican agricultural sector, and the economy as a whole, have become more market-oriented, and policy makers have increased security of water rights. According to the 1992 Water Law, and its 1994 regulations, users may convert their existing precarious water rights into more secure tradeable 'concessions' with a maturity of between 5 and 50 years (most are about 30 years), to ensure security of tenure.[68] However, the rights are not as secure as in Chile. Under the Mexican Constitution, all water belongs to the nation, and the Water Law also mentions the possibility of forfeiture of water rights for the public interest if water is not being used efficiently, or if it has not been used for three years.

[63] Hearne and Easter (1997).
[64] Hearne and Easter (1997).
[65] Rosegrant and Gazmuri (1994).
[66] Hearne and Easter (1997).
[67] Bauer (1997) claims that some of the gains from markets have not been as substantial as originally claimed, and external costs had not been widely acknowledged in early studies. Nevertheless, these claims have been contested, particularly that external costs were relatively slight (Easter et al., 1998).
[68] Hearne (1998).

By 1995, 85 percent by volume of available water in Mexico had been allocated as water use rights and there was widespread leasing and selling of both surface and groundwater rights.[69] Water trades had been common before 1994, but, as in India and Pakistan, these trades were limited, informal and illegal. Apparently, the authorities tolerated the trades but did nothing to monitor any externalities from them, so, unfortunately, aquifers were drained. The new law recognised and encouraged trade (on either a permanent or temporary basis), which reduced total consumption and alleviated externalities (for example, slowing aquifer depletion).[70]

Most of the recent trades involve farmers selling to industries, water companies or more efficient farms, thereby encouraging investment in more productive activities. Water trading has also allowed unprofitable farmers to reduce their farming debts and to work as labourers on more efficient farms or to seek alternative employment. Although it may not be an ideal solution, having a tradeable asset in water rights gives an inefficient farmer some flexibility.

The Western United States

Shortage of water in the Western United States led to a system of property rights to water based on the prior appropriation doctrine;[71] whoever first diverted water and established beneficial use, obtained primary rights. Successive claimants could only obtain rights that were contingent upon those with prior rights having received their allocations.

Although water rights regimes vary widely between states, their common characteristic is that water use cannot be changed without authorisation of state water authorities. Obtaining authorisation to change water use is often a lengthy and costly business, requiring consent from the relevant governing body after public hearings.

Perhaps the most extreme example of restricting transfer between uses occurs in California. The agricultural sector makes up only 4 percent of GDP of the state; yet it receives about 44 percent of the water. Environmental use is allotted 44 percent, while urban and industrial users receive only 11 percent. Agricultural water rights vary widely, from cheap, inherited sources to highly subsidised ones. The anomalies that these restrictions cause are extreme; water is so cheap to some users (as low as $2.50 per acre-foot) that rice is cultivated in the desert, while some municipalities have built desalinisation plants to supplement their supplies of water at a cost of $2,000 per acre-foot.[72] Even worse are the perverse incentives in conserving water. Farmers are forced to operate under a ‘use it or lose it’ rule, while in towns, rationing during periods of drought is based on family use during periods of plentiful water, which encourages profligacy.

Reform is often discussed (Anderson and Snyder, 1997; Holden and Thobani, 1996; Kemper, 1997) but assigning to farmers the ability to simply sell their rights would give them millions of dollars in windfall gains on top of the large subsidies that they already receive – a politically unpopular result. On the other hand, farmers fear that their allocation will be reduced over time and with no compensation. Therefore, even in a country with well-developed institutions, there is poor administration of water allocation. The solutions used often defy logic and waste resources, and reform is slow.

[69] Holden and Thobani (1996)
[70] Hearne (1998).
[71] Anderson and Snyder (1997).
[72] Holden and Thobani (1996).

A notable contrast to the various restricted water right regimes which exist in the western United States is provided by the Big Thompson water trading scheme of 310,000 acre-feet of water in Colorado.[73] This scheme, which brings headwaters from the Colorado River through a tunnel in the Rocky Mountains to north-eastern Colorado, was partially funded by subscribers in return for use rights. Soon after the scheme was fully operational it became apparent that water demand varied significantly between users and areas within the district. The Northern Colorado Water Conservancy therefore established a system that allowed permanent water right trades. Trades had to demonstrate 'beneficial use' and no sales were allowed to areas outside the District. A central registry records ownership and transfers. The system has become so refined that a simple postcard is used to notify the Conservancy of a transfer.

An extremely sophisticated market has evolved for this water and many types of contracts are used, from straight transfers to the purchase and sale of options to water. Within the Conservancy District all the complex infrastructure is in private hands. The Conservancy's role is to record transactions and to check that there is no cheating. The system appears to be operating efficiently within the water District, with supplies going to their highest valued use, although there is undoubtedly an opportunity cost to owners of water rights in not being able to sell their water outside the District.

Australia

Sturgess and Wright studied water transfers along the Murray-Darling River Basin, which stretches 2,530km from the Snowy Mountains of eastern Australia to its mouth in South Australia.[74] In the worst drought years of 1987/8 there were 687 transfers, totalling 340 million cubic metres, with gains estimated at $17 million. In better years, a great deal of trading still took place but the total gains were lower: in 1988/9, the corresponding figures were 280 transfers, 85 million cubic metres and $5.6 million; in 1990/91 the figures were 435 transfers, 120 million cubic metres and $10 million. The researchers concluded that "if benefits of this scale can be obtained by a system of water transfers circumscribed by regional barriers, the benefits that would flow from redefinition of water property rights to allow the free transfer of water between regions....would be greater still."[75]

Spain

Maass and Anderson examined the centuries old water market of the farmers of Alicante in Spain.[76] The irregularity of water supply in the region led the Alicante farmers to build the Tibi Dam in the late sixteenth century, which became one of the most admired hydraulic works in Europe. Although this temporarily improved supply, it encouraged population growth and demand increased again. A flexible system of allocation developed to improve water use. Over the years, flexibility was achieved when the use of water was split from ownership of land and permanent and temporary transfers of water became legal. Although the water rights were based on allotted irrigation time from a canal, the rights were translated into volumetric units. By the 1970s the market was sophisticated enough to have temporary transfers, measured in minutes or fractions of minutes per day, up to entire seasons.

[73] Kemper and Simpson (1995).
[74] Sturgess and Wright (1993).
[75] Sturgess and Wright (1993), pp. 23–4
[76] Maas and Anderson (1978).

For the most part, water prices were freely negotiated and agreed at local taverns by the farmers themselves, although brokers did arrange some transactions. In spite of this very free system, concern was raised by officials and non-trading farmers that trades would lead to speculation and higher prices, and eventually a reduction in farming. These opponents of the system demanded a return to the time when water rights were legally tied to land sales, to ensure that water was always used on local farms. These demands were not acted upon. However, attempts to communalise private rights to water were enshrined in the 1985 Water Law, under which rights considered private in 1985 remain so until 2060, when the right will revert to the State, and no new rights will be allocated. Under the 1985 Law, water use will be maintained by the issuance of licenses, the right remaining with the State.[77]

Other Examples

Water markets exist in other countries, including parts of North Africa,[78] South Africa,[79] and Brazil.[80,81] These markets have similarities with other markets discussed above and will not therefore be given detailed consideration here. Other markets also probably exist, but are yet to be documented, and many other countries are contemplating trading, for obvious reasons. In all the countries discussed in this chapter, allocative improvements have been made from trading and in some cases, such as Chile and India, significant economic gains have been made.

Summary and Conclusions

Governments have sought to control water allocation in most countries of the world, often giving water to politically important users, such as farmers. The usual response to the inevitable insatiable demand for free water, has been construction of supply augmentation facilities, such as dams. As demand has continued to rise, governments have attempted to reduce water use by setting quotas and then imposing a tariff on the quota.

For the most part, governments have resisted handing over allocative control to the market. Often political restrictions to trading have reduced the possibilities for better allocation. Many of these restrictions have emanated from concerns that over-depletion of water resources and environmental damage might occur. Concerns about concentration of power in the water market are also common but the literature is not clear on either point.

Negative externalities (such as from pollution) have increased under certain trading conditions (usually informal markets), and reduced under others. Where formal markets have been permitted, overall environmental costs have been reduced, even where trading has reduced dilution for pollution.[82] On balance, water trading countries in arid areas have a better than average environmental performance.[83] There have been problems in Chile with concentration of power, but this was because of a mistake in allocating (non-consumptive) use rights to power

[77] Anderson and Snyder (1997)
[78] Landry (1999).
[79] Bate (2000).
[80] Kemper (1997).
[81] They are also allegedly forthcoming in Israel (Dinar and Subramanian, 1997) and Peru (Easter et al., 1998).
[82] Landry (1999).
[83] Dinar and Subramanian (1997).

companies. The companies (sometimes inadvertently) lowered the possibility of consumptive use trades by reducing flows in specific locations, although they never actually reduced net flow in the river taken as a whole. As the first to establish comprehensive modern water markets, Chile was bound to make mistakes, but now it and other countries have learnt lessons and are resolving problems through regulation of non-consumptive use rights (ensuring that non-consumptive users return water to the same location from which they withdrew it, to ensure no 'dry' spots).

Furthermore, much of the literature shows that existing allocation systems favour special interests, such as water bureaucracies. These interests differ from those that may dominate in a market, such as major farm estates or power companies.

Water, like gas, electricity and telecommunication utilities, is probably best allocated by private provision with government regulation.[84] This combination brings the flexibility and dispersed knowledge of the market, while leaving sufficient power in government hands to set maximum abstraction limits and control abuses of monopoly power.

The theory and practice of water markets, as outlined in this chapter, provide a potential solution to inflexible allocations of water. As water scarcity increases around the globe, it is surely time to see more widespread use of such flexible solutions, not only because of their greater efficiency but also as a means of reducing conflict.

The Six Day War was fought partially over water. Israel refuses to leave the Golan Heights or West Bank in part because doing so would reduce the headwaters they control, putting thousands of Israelis at significant risk. Tensions are rising in Egypt about Ethiopian plans to expand water abstraction from the Blue Nile – Egypt draws over 85% of its fresh water from the Nile and any reduction in flow would harm its massive farming enterprises. Will it go to war over water, as Sadat suggested it might in 1979?

Similar problems are occurring elsewhere on the globe. In the past decade, armed conflicts have been fought over water in Bangladesh, Tajikistan, Malaysia, Yugoslavia, Angola, East Timor, Namibia, Botswana, Zambia, Equador and Peru.[85]

Of course, water markets and good property rights systems would not by themselves resolve these tensions. But by improving efficiency of water use they would lower effective demand and hence the need to increase abstraction – the cause of the tension. Water markets in India and Pakistan stopped fighting among farmers and engendered cooperation. Markets replaced conflict.

Water markets will not settle historic border grievances such as the disputed territory of Kashmir, nor will they stop terrorism driven by religious fanaticism. But water markets can stop water wars. Just as Chile and Mexico have adopted markets to allocate water, so too can Israel and other parts of the world where tensions run high over dihydrogen monoxide.

[84] Anderson and Snyder (1997).
[85] Gleick (1993).

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