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A Place for Water Markets: Performance and Challenges

Ereney Hadjigeorgalis

The 2006 United Nations Human Development Report paints a dismal picture of global water scarcity and the increasing pressures on agricultural water supplies. While it acknowledges that demand-side policies are more effective than supply-side approaches, it remains skeptical of water markets as a means of managing scarce water supplies. This contrasts sharply with the successful implementation of water markets within the United States and other countries. To clarify the debate, this article evaluates the performance of established water markets. It also considers different challenges posed by water markets in developed and developing countries and discusses how countries can overcome these challenges.

> *"Viewed at the global level, there is more than enough water to go around and meet all of humanity's needs."*
>
> —*United Nations Human Development Report, 2006*

Seven hundred million people currently live in a state of water stress while an additional 1.4 billion worldwide live in river basins where water use exceeds sustainable levels. Approximately, one third of the world's population is water-short, and water use has been growing twice as fast as population for almost a century. These statistics, provided by the 2006 United Nations Human Development report (UNHDR), offer a compelling view of the state of global water scarcity and the sustainability of current extraction rates.

Interestingly, the UNDHR points out that the global water crisis is not caused by a physical deficiency of water, but rather is a result of a host of institutional and political failures in water resource management. They forward the hypothesis that in many countries water scarcity is a product of "public policies that have encouraged overuse of water through subsidies and underpricing" (p. 3).

Water scarcity and sustainable water use are by no means recent dilemmas. Traditional heavy reliance on irrigation, which was expanded to developing countries during the Green Revolution, increased water use in agriculture and led to

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supply-side approaches to manage scarcity. While these approaches have gone by the wayside in the United States, large-scale diversion projects in China and India point to the fact that they have not yet been abandoned in developing countries. The economic feasibility of such projects, even for developing countries, is questionable. China's South-North water diversion comes with a US$60 billion price tag, while India's Programme for Interlinking Rivers will generate costs equivalent to one-fourth of that country's gross national product (Hoerig). Both projects are expected to generate significant third-party impacts to surrounding areas, not least of which include the relocation of hundreds of thousands of residents (400,000 To Make Way).

Other supply side solutions include desalinization and virtual water imports. While perhaps cheaper than building new dams, desalinization still carries with it high energy costs, making it a viable option only for wealthy countries or those located on coastlines (UNDP; Gomez, Tirado, and Rey-Maquierira; El Fadel and Alameddine). Virtual water imports, on the other hand, are theoretically appealing but have many unresolved issues in practice. Emphasizing water to the exclusion of other productive factors neglects the importance of complementary factors of production such as land, labor, and capital (Wilchens, 2001, 2004, 2005), and virtual water often flows out of water-poor but land-rich countries to water-rich but land-poor countries (Kumar and Singh) .

As increasing water scarcity has rendered supply-side policies obsolete, demand-side policies have emerged as the panacea for the world water crisis. While the UN acknowledges that demand-side policies are likely to be more effective, they remain skeptical of private markets as a means of managing scarce water supplies. Citing examples of the impacts of water marketing on small farmers in the western United States and Chile (Meinzen-Dick and Ringler as cited in UNDP), they call private water markets a "questionable" solution that has not been shown to protect the interests of the poor and leads to inequitable distribution of water resources. The UNHDR concludes: "For developing countries, with weaker institutional capacity, there are distinct limits to the market" (p. 17).

While the UNHDR is correct in asserting that water markets are not the panacea to the world's water crisis, such markets have nonetheless been adopted and are proving successful in many areas, without significant impacts on equity and distribution. This article builds upon previous reviews by Kaiser and McFarland as well as Chong and Sunding to evaluate the performance of established water markets to date, the challenges posed by water marketing for both developed and developing countries, and how these challenges can be overcome. It concludes by considering the future of water marketing and future avenues for research.

The Performance of Established Water Markets

Only a small proportion of the planet's total water resource base is managed by markets. Most of the market mechanisms are employed in developed countries and chiefly concentrated in the western United States and Australia. In developing countries, only Chile has stood out in the extent to which it has developed formal markets, although informal groundwater markets have proliferated throughout Asia over the past fifteen years.

Table 1. Water transfer mechanisms

Water Bank	A water bank is a central institution that acts as a clearinghouse for users who wish to purchase or sell water. Water is sold at cost with a margin added to cover the operating costs of the bank, which are typically borne by the buyer. Water banks may be temporary or permanent institutions.
Bulletin Board Markets	are often called water banks but price is not set by a central institution. Bulletin board markets allow buyers and sellers to post offers and requests for water or water rights at a centrally located bulletin board, typically through the irrigation district central offices, or through an electronic platform.
Double-Auction Markets	require buyers and sellers to submit sealed bids for specific volumes of water or permanent entitlements. The exchange operator aggregates all of the bid and offer prices to determine a pool price at which the market will clear the most water.
Derivative Markets	involve the use of options or forward contracts to transact water on a temporary basis. Forward contracts require the buyer to purchase the water from the seller on the contract date at a previously agreed upon price. Options contracts allow the buyer to forgo the purchase of the water before the expiration date, at which point the options deposit is forfeited to the seller.
Environmental Leasing and Purchase Programs	access water from irrigators to increase in-stream flows for the protection of fish and wildlife and environmental amenity. They include water trusts, governmental leasing and purchase of irrigator rights and buyback programs.

A variety of mechanisms have been designed to transfer water both on a temporary and permanent basis. These include water banks, bulletin board and double-auction markets, options and forward contracts, and environmental leasing and purchase programs (table 1). In the past decade, Australia has emerged as a particularly innovative force in water marketing, devising a number of hybrid water markets that combine two or more of these mechanisms within a central clearinghouse known as a water exchange. Additionally, both informal and formal spot water markets, which may or may not be brokered, have emerged in developed and developing countries for the transfer of surface water and groundwater resources (table 2).

Western United States

In the western United States, most formal market transfers are handled through water banks, bulletin board markets, options markets, and water trusts. A water bank is a central institution that acts as a clearinghouse for users who wish to purchase or sell water. Water is sold at cost with a margin added to cover the operating costs of the bank, which are typically borne by the buyer. Water banks may be temporary or permanent institutions. Temporary water banks, such as the California Emergency Drought Water Bank, aim to reallocate scarce supplies under conditions of severe drought, whereas permanent water banks, such as the Idaho water bank, facilitate the movement of water over many growing seasons.

Table 2. Where the markets are

	Water Bank	Spot Water/ Bulletin Board Markets	Double-Auction Markets	Derivative Markets (Options/Forward Contracts)	Environmental Leasing and Purchase Programs
United States					
California	•	•		•	•
Colorado	•	•			•
Idaho	•	•			
Kansas		•			
Montana					•
New Mexico	•				•
Oregon					•
Texas		•		•	•
Washington		•			•
Other Countries					
Australia		•	•	•	•
Canada[a]		•			
Chile		•			
China[b]		•			
India[b]		•			
Pakistan[b]		•			
South Africa[c]					
Spain[d]	•				

Sources: Australia (2007b, 2007c, 2006b); Blomquist et al., Briscoe, Bureau of Land Management, California Department of Water Resources, Campos and Stuart; Clifford, Landry, and Larsen-Hayden; Colorado Water Trust; Defenders of Wildlife; Easter et al., 1998a, Garrido (2005), Gelt, Hadjigeorgalis (2000), Hearne and Easter, Hickman, Milla, Montana Water Trust, Nicol, Nieuwoudt and Armitage, Oregon Water Trust, Saleth and Dinar, Sturgess, Texas Commission on Environmental Quality, Wang et al., 2007a, 2007b; Washington Water Trust, Zhang et al.

[a]Formal water markets have been established in Southern Alberta; only six market transfers occurred from 1999–2005 (Nicol). Informal market transfers are considerably more numerous.

[b]Groundwater markets.

[c]South Africa passed a new Water Law in 1998 that allowed for tradable entitlements, but market activity has been limited to small numbers of permanent water rights transfers.

[d]Spain passed a reform to the 1985 Water Law in 1999 that allowed for the creation of water exchange centers, which are described to be similar to water banks (Milla). The law addresses only permanent water rights trades and imposes substantial restrictions on transfers (Garrido). To date, there has been no analysis of actual water market trades in Spain, although interesting analysis has been performed using simulation models and experimental economics (Garrido, 2000; Calatrava and Garrido, 2005a, 2005b).

Water banks that are permanent institutions may be preferred to temporary institutions that are only instituted in case of drought, since whether and when a drought water bank will be established introduces an aspect of uncertainty into farmers' decision making.

Water banks have generally performed well in the western United States and have been successful in moving substantial amounts of water without significant third party impacts (Howitt, Moore, and Smith). The California Drought Water

Bank facilitated the reallocation of 389,970 acre feet of water in 1991, mostly from agriculture to urban areas (Israel and Lund); whereas in 1992 and 1994 the Bank transacted 208,000 acre-feet, due to less severe drought conditions. The Snake River Rental Pool in Idaho, which represents over 90% of transactions in all rental pools in Idaho, moved over 200,000 acre feet per year on average from 1990 to 2002 (Clifford, Landry, and Larsen-Hayden).

Many established water banks in the western United States are actually bulletin board markets. Bulletin board markets allow buyers and sellers to post offers and requests for water at a centrally located bulletin board, typically through the irrigation district central offices or an electronic platform. Examples include the Northern Colorado Water Conservancy District (NCWCD), Idaho State Water Supply Bank, the Texas Water Bank, and the New Mexico Water Bank on the Pecos River. In addition, pilot bulletin board markets have been established in Colorado (Arkansas River Pilot Water Bank) and Washington (Yakima Basin Pilot Water Bank) (Clifford, Landry, and Larsen-Hayden).

The performance of bulletin board markets has been mixed. The most active bulletin board market is the NCWCD in Colorado, where about 30% of the water allocated to the CB-T project is involved in rental transactions (Howe, Schurmeier, and Shaw; Michelsen). Other bulletin board markets have been less successful. The Arkansas River Basin Bank, established as a pilot program in Colorado, and the water bank on the Pecos River in New Mexico had generated no transactions of water as of 2006. The Edwards Aquifer Groundwater trust established in 2001 also remains inactive, while the Texas Water Bank has conducted only one transaction since its establishment in 1993 (Clifford, Landry, and Larsen-Hayden).

An alternative to traditional water leasing through water banks and bulletin board markets is the use of dry-year options. In an options trade, a water user purchases an option to buy a specified volume of water at a pre-arranged price. The buyer may exercise the option by purchasing the agreed volume by the expiration date or let the option expire, thereby forfeiting the option deposit to the seller. Options are attractive because they allow sellers to retain ownership of the permanent water right while permitting buyers to reduce their risk during droughts by securing access to future water supplies early in the season.

California experimented with option markets in its 1995 water bank program. In anticipation of a potentially dry year in 1995, the Department of Water Resources (DWR) purchased water supply options on 29,000 acre-feet of water at $3.50 per acre-foot for water bank members. The negotiated exercise price on these options varied between $36.50 and $41.50 per acre-foot. Abundant rainfall in 1995 negated the need to exercise the options, which expired in May 1995 (Jercich).

Texas also experimented with a dry-year option in the Edwards Aquifer in 1997. Farmers were paid $116 to $300 per acre to suspend irrigation. Funding for the options came from thirty-two water utilities and other large pumpers and it was dominated by the San Antonio Water system. Although the region experienced a wet spring, estimates showed that had dry conditions persisted, suspending irrigation would have substantially reduced pumping and increased springflow (Keplinger and McCarl).

In a move toward the use of markets for environmental flows, water trusts have gained momentum over the past decade. Water trusts are typically nonprofit

organizations that transact with irrigators to procure water for the protection of fish habitat and wildlife. Oregon was the first state to establish a water trust in 1993. It was followed by Texas in 1997, Washington in 1998, and Montana and Colorado in 2001. The Columbia Basin Water Transactions Program, which spans several states, was established in 2002.

Water trusts have been particularly active in acquiring water for in-stream flows. Since its inception, the Oregon water trust has purchased or leased more than 160 cubic feet per second (cfs) of water for in-stream use in collaboration with over 200 landowners with a substantial increase in rentals in 2001 (Oregon Water Trust). The Washington Water Trust has put eighty-four cfs back into streams (Washington Water Trust) whereas the Montana Water Trust has negotiated eighteen agreements totaling sixty-three cfs for in-stream use (Montana Water Trust). Most transactions conducted by water trusts are short-term leases with durations under ten years, although some transactions involve purchases of permanent water rights. Water trusts also work with irrigators to assist them in conserving water that can then be leased back to the trusts.

While not a water trust, California's Environmental Water Account (EWA) also buys and leases water rights with the aim of providing water for fishery protection and recovery while maintaining supplies to agricultural and urban areas. Implemented in 2000, the EWA released 290,000 acre-feet of water at key times to protect winter-run salmon, Delta smelt and splittail in 2001 (California Department of Water Resources).

Australia

A number of water exchanges that transact temporary water trades as well as trades in permanent entitlements, have emerged in Australia since 1997. The largest of these, the National Water Exchange, began to transact forward contracts in water in 2007 (Australia, 2007b). While official statistics do not exist, a recent report commissioned by the Australian National Water Commission estimated that approximately 80% of all trades in irrigation water in Australia occur through water exchanges or private brokers with the remaining amount handled between private parties (Australia, 2007b). The National Water Exchange alone serves 20,000 clients spanning approximately 2 million hectares of irrigated land in the Murray-Darling Basin (Sydney Morning Herald).

Water exchanges generally use two mechanisms: bulletin boards and/or sealed double-auctions. The bulletin board approach requires buyers and sellers to post offers and requests for water, typically through an electronic platform. Trades are executed by matching individual offers with bids. The bulletin board approach is used by Murray Irrigation Limited in New South Wales as well as the privately operated exchanges Waterfind (South Australia, Victoria and New South Wales), Murray Irrigation Exchange (New South Wales), and the National Water Exchange. (Australia, 2007b).

Under the sealed double-auction approach, buyers and sellers submit sealed bids and offers for specific volumes of water or permanent entitlements. The exchange operator aggregates all of the bid and offer prices to determine a pool price at which the market will clear the most water. Sellers with offers above the pool price as well as buyers with bids below the pool price are left unsatisfied

(Bjornlund, 2003a). The sealed double-auction approach is used by the publicly run exchanges Watermove, in Victoria, SunWater Exchange in Queensland, and the non-profit-run Murrumbidgee Water Exchange in New South Wales (Australia, 2007b).

During the 2004–2005 season, 36.8 GL of water was traded on the temporary market in Australia, which represented 3.5% of the total volume of water allocated that season. Less than 1% of total permanent entitlements changed hands (Australia, 2006b). Trading varied by state, with the most active trading in Victoria where 38% of entitlements were leased in the temporary market, representing 6.7% of the total volume allocated for that state. Approximately, 3% of total entitlements were transferred permanently in Victoria in 2004–5 (Australia, 2006b).

A case study in the state of Victoria found several positive economic impacts resulting from water trading over the past decade (Australia, 2007a). For example, many mixed farms managed drought conditions by selling water in the temporary market, which gave them a higher income than would have been possible growing crops. Trading of permanent entitlements contributed to large-scale horticultural development in the state as well as the almond and wine booms. While many Australian dairy enterprises faced collapse during the decade's droughts, many more would have fared much worse in the absence of permanent entitlement trading. Additionally, those who exited agriculture were able to sell their permanent entitlements, which left them with a higher level of capital than in the absence of water markets.

Developing Countries

In developing countries, most water market activity is concentrated in Chile and Asia. In Chile, the market has performed best in basins with high water scarcity, adequate infrastructure, and few competing uses. Trading in temporary water is only active in the semi-arid Limarí river basin, which boasts the country's only inter-seasonal reservoir storage network. During the 1994–97 drought informal spot market trades accounted for 6% to 34% of the basin's allocations on an annual basis (Hadjigeorgalis, 2000). Market transfer of water-use rights also produced substantial economic gains-from-trade in the Limarí and Elqui basins over the 1986 to 1993 period (Hearne and Easter, 1997). Institutional constraints to water market trades, a lack of adequate infrastructure for transferring rights, and conflicts over priority have inhibited the market in other basins (Hadjigeorgalis, 2000 and Lillywhite; Bauer, 1997).

In Asia, informal groundwater markets have spontaneously emerged in response to growing land and water scarcity. In China, groundwater markets doubled in rural areas of Northern China between 1995 and 2004 and are currently functioning in approximately 100,000 villages (Wang et al., 2007a, 2007b). In India, informal markets in groundwater date back to the 1920s (Shah). In China and India, as well as Pakistan, these markets have been particularly successful in transferring water from large tubewell owners to smaller producers who do not have the capital or land area to justify their own investments in private tubewells (Wang et al., 2007a; Zhang et al.; Shah; Meinzen-Dick, 1996, 1998).

Challenges to Water Marketing

Externalities

Widespread opposition to the establishment of water markets has stemmed primarily from the fact that water markets may generate negative externalities due to the interdependent nature of water supply (Jordan; Hartman and Seastone). Surface water extractions affect groundwater supply and vice versa. Diversions upstream affect flows downstream (Merrett). Changes in consumptive use alter the amount of water that percolates back into the ground and is available for other uses. A change in a point of diversion can reduce return flows and upset the water supply of a farmer who is not party to a transaction within their basin (Merett). Similarly, excessive withdrawals from a river can reduce in-stream flows and harm fish habitat.

Where groundwater use is predominant, overextraction in the absence of groundwater management can lead to land subsidence, salt water intrusion and drawdown of the aquifer (Knap et al.; Lefkoff and Gorelick; Shah et al.; Chen, Pei, and Jiao as cited in Wang et al., 2007a; Sakura et al. as cited in Wang et al., 2007a. While these phenomena are not exclusive to water markets, they can be exacerbated by the substitution of pumped groundwater for surface water sales (Lefkoff and Gorelick).

In the western United States, such problems tend to occur in rural areas whereas in developing countries the problems associated with groundwater overdraft are much more pronounced in urban areas. In northern China, for example, despite the massive expansion of groundwater markets in rural villages over the past ten years, there is little evidence of groundwater overdraft or other groundwater-extraction induced problems (Wang et al., 2007a, 2007b). In contrast, in many of China's cities, groundwater tables are either in overdraft or in serious over draft (Ministry of Land Resources, 2005 as cited in Wang et al., 2007a, 2007b).

While externalities tend to be a common ailment of water markets, they are not without remedy. Externalities, whether affecting the environment or other users, can be incorporated into market prices to compensate for the social costs associated with market transactions. Water transfers could be taxed (Colby, 1990; Milliman; Easter, Rosegrant, and Dinar, 1998c) or the area of origin of the transfer could be compensated for secondary effects through transitional assistance (Howe, Lazo, and Weber). In Australia, for example, exit fees are imposed on out-of-district permanent water trades to compensate those irrigators who remain in the system for their increased share of total operation and maintenance costs (Goesch et al.; Australia, 2006a).

Incorporating externalities into market prices compensates for the social costs of a transaction, but it does not prevent them. Some externalities, such as in-stream flow reductions, can be prevented by incorporating the environment into the market. The environment, represented by environmental interests, becomes a market participant and competes for resources with other uses. Traditionally, this has been slow to occur because institutionally nondiversionary interests such as in-stream flows have been accorded a lower status in water allocation and rights than diversionary interests such as agriculture (Colby, 1990; Griffin and Hsu). Legislation in many areas is changing to accommodate these environmental interests as evidenced by the emergence of water trusts and other market-based environmental instruments over the past fifteen years.

Environmental externalities can also be managed through government intervention. The U.S. federal government has required that water contract renewal for federal irrigation projects in the Central Valley of California comply with the National Environmental Policy Act, while the Bureau of Reclamation has leased water rights from irrigators in times of drought to increase in-stream flows and protect fish habitat (Colby, McGinnis, and Rait; Clifford, Landry, and Larsen-Hayden). In early 2007, the Australian Government announced a National Plan for Water Security to address overuse of water and overallocation of permanent entitlements in the Murray-Darling Basin. The plan earmarked $3.1 billion for buyback of entitlements and assistance for irrigators in unviable or inefficient irrigation schemes to exit agriculture (Australia, 2007c). Ministerial intervention was also used in 1997 when a cap on total water withdrawals was instituted in the Murray-Darling Basin (Australia, 2004).

In Australia, a number of mechanisms are currently being trialed to prevent negative impacts on third parties and environmental flows that may be generated by water market trades. Chief among these are unbundling of water access rights and tagged entitlements. Unbundling prevents pecuniary impacts on other irrigators within a system by decoupling the right to extract and use the water from the right to access infrastructure and delivery services (Goesch and Beare). In this way, permanent water rights trades out of the system will not generate increased operation and maintenance costs for the remaining irrigators. The right to access infrastructure services can subsequently be sold in a separate market or maintained by the irrigator.

Impacts on environmental flows from water market trades can be avoided through a system of tagged entitlements. Tagged entitlements permit permanent water rights trade only between irrigators who can extract water from the same source, thereby preventing trades that affect water availability for other users (Goesch and Beare). They also guarantee that the amount of water extracted by the purchaser on a perpetual basis is no greater than what could have been extracted by the seller had they maintained their right. In the Murray-Darling Basin of Australia, tagged entitlement trading was established between New South Wales, Victoria, South Australia, and Queensland in 2007.

Institutional Frameworks—Formal versus Informal Markets

Water markets can generally take two forms. Formal water markets are those that are supported by a legal system that fosters efficient market exchanges and acts to enforce contracts. Informal markets are those where contracts are enforced based on social ties rather than legal constructs (Easter, Rosegrant, and Dinar, 1998c).

The distinction between formal and informal markets is important and has implications for the use of water markets in developing countries with weak institutional capacities. Formal water markets are the mechanism of choice for the legal transfer of permanent water rights, where intersectoral transfers are needed, or where there may be substantial negative environmental impacts resulting from transfers of water or water rights (Easter, Rosegrant, and Dinar, 1998b, 1998c). Informal water markets, on the other hand, may work better where the transaction

costs of establishing formal water markets are high or where the predominant interest in transfers involves short-term rentals for a growing season within agriculture (Easter, Rosegrant, and Dinar, 1998b, 1998c).

While the success of formal water markets depends critically on the institutional framework that supports them (Hadjigeorgalis and Lillywhite; Huffaker; McCormick; Thompson; Gould; Gardner; Mann), informal water markets endogenously develop institutional frameworks suited to the needs of their users. For example, in China, Thailand, India, and Pakistan, informal markets in groundwater in the agricultural sector have spontaneously emerged in response to increasing scarcity and remain unregulated (Wang et al., 2007a; Zhang et al.; Molle, 2001; Saleth; Meinzen-Dick, 1996; Shah). In Thailand, informal markets are both flexibly and socially controlled (Molle, 2001). In India, government agencies exert neither influence on the operation of groundwater markets nor do they impose restrictions on the manner in which transactions are executed (Shah). In Pakistan, groundwater markets have been recognized as spontaneously developed institutions for water resource management that do not represent either government-sanctioned or state-regulated sales of tradable water rights (Saleth).

Property Rights

Coase forwarded the idea many years prior to the proliferation of water marketing that given an appropriate institutional framework market externalities will resolve themselves through individual bargaining. Only when the costs of such bargaining are too high is government intervention warranted, and even then, it may not produce an economically efficient solution due to its susceptibility to political pressures. Included in Coase's ideal institutional framework were well-defined property rights and the absence of transaction costs.

The issue of property rights is particularly germane to the debate surrounding the establishment of market mechanisms to allocate water in developing countries. Molle (2001) forwards the idea that subsidizing agriculture is easier than the daunting task of defining water rights, while Rosegrant and Binswanger point out that usufructuary rights to water already exist in most developing countries, either implicitly (though custom) or explicitly (though bodies of law or regulation). Nevertheless, Molle (2004) submits that the definition, or perhaps formalization, of such rights is complicated by two phenomena. The first is the tendency for water users to organize collectively, which makes it difficult to define individual rights. The second stems from the fact that in many developing countries, water rights have often remained undefined with a regime of open access to resources or administered through a more or less informal system of riparian use.

While subsidizing agriculture may be easier than formalizing water rights in developing countries, it comes at the expense of reduced economic growth and a more inefficient agricultural sector (Rosegrant and Binswanger). A potential solution to the definition of water rights in developing countries may lie in a decentralized procedure that includes participation and input from all stakeholders as opposed to the centrally managed top-down approach to water rights prescription often recommended by donor agencies (Molle, 2004). Rosegrant and

Binswanger echo this approach, noting that if farms are small [and numerous] tradable water rights can be assigned to communal groups of water users, which in turn can assign rights internally. This would perhaps avoid the complication of inadequately defining water rights due to a lack of information on particular users' needs.

Property rights could also be defined collectively rather than individually to mirror the organization of agricultural production (Rosegrant and Binswanger). In Chile, while the legislation provides for individual property rights, in many cases, rights are defined collectively for cooperative agricultural communities (Hadjigeorgalis, 2000). In Northern China, the emergence of private groundwater markets replaced the previously established collective system of water management, but in many cases, tubewells are owned jointly by a group of farmers (Zhang et al.).

Private water markets are rarely characterized by an absence of transaction costs in the pure Coasian sense. Transactions costs associated with water markets, however, have not been shown to be greater than those associated with other water allocation methods. What sets a water market apart is who bears responsibility for transaction costs. Whereas in centralized allocation and opportunity cost pricing the state or water authority bear the costs of water allocation, in a water market these costs are passed on to water market participants—those who engage in transfers of water or water rights (Rosegrant and Binswanger). Since private individuals have a greater incentive to minimize costs than governmental organizations, it is possible that transaction costs are actually lower in a water market than under state-controlled allocation methods (Rosegrant and Binswanger).

Stakeholder Participation

Even if externalities can be successfully incorporated and institutions modified, water markets will only be successful with stakeholder acceptance and participation. A looming challenge to water marketing is the aversion, particularly on the part of farmers who typically control the largest share of water resources, to the sale of water rights (Easter, Rosegrant, and Dinar, 1998b). Much research has been done in Australia concerning farmers' reluctance to separate water rights from land and commercialize them (Tisdell and Ward; Bjornlund, 2003a, 2003b; Bjornlund and McKay; Chatterton and Chatterton; Crase, O'Reilly, and Dollery; Crase, Pagan, and Dollery; Turral et al.). Many farmers consider water integral to the land that they farm and not for sale. In Chile, many farmers have expressed an aversion to selling water rights or leasing their water in lieu of farming (Bauer, 1998; Hadjigeorgalis, 2000). For these farmers, farming may have its own economic value independent of income produced.

Ag to Urban Transfers and Area of Origin Impacts

This aversion to breaking the land–water nexus has worked against the movement of water rights from agriculture to municipalities (Solis; Molle, 2001). Intersectoral transfers usually involve either outright sales to municipalities, thus permanently removing water from agriculture, or long-term leasing, which for

all practical purposes has the same effect, although legally the water use right remains with the farmer. Few can forget the acrimonious struggle to transfer water from the Owens Valley to the City of Los Angeles, in the early part of the twentieth century (Libecap).

The prevalent cause of conflict in rural to urban transfers stems from the fear of economic impacts on the area of origin. Large transfers of water out of agriculture can have negative effects on rural economies, particularly if the transfer involves permanent water rights in lieu of leased water (Merrett). Oggins and Ingram showed that communities in areas of origin expected to be severely destabilized by the effects of the transfer of local water supplies to entities outside the community. Over 88% of the leaders of communities located in an area of origin agreed that the communities' losses were such that they could not be monetarily recompensed.

As Libecap points out, however, it is important to consider the social benefits generated by urban areas and to consider how water transfers from agriculture to urban areas serve the public interest:

> In general, cities stimulate much of the economic development and technological innovation that occurs in any society. Cities typically offer the highest real wages, and provide increased opportunities for productivity growth, employment, and upward mobility for all economic groups, *including the poor* [emphasis added].

Equity

Finally, water markets are often criticized for skewing a perhaps already skewed distribution of resources from the poor to the higher income (Brajer et al.; McEntire; Cummings and Nercissiantz; Metzger; Syme, Nancarrow, and McCreddin; Molle, 2001). This criticism arises from the observation that, in many developing countries where water markets have been established, there is a substantial resource gap between buyers and sellers. In these markets, many of the transactions take place within agriculture. Buyers of water and water rights tend to be larger-scale producers with greater on-farm irrigation technology (Hearne and Easter; Bauer, 1998, 2004b; Armitage et al.; Hadjigeorgalis, 2000, 2008; Nieuwoudt and Armitage). Sellers tend to be smaller farmers with limited resources, limited access to technology and poor access to credit or liquidity constrained (Hearne and Easter; Bauer, 1998, 2004b; Hadjigeorgalis, 2000, 2008; Bjornlund, 2003b, 2006). In groundwater markets, this pattern is reversed, but the stark gap in resources between buyers and sellers remains (Saleth, Braden, and Eheart; Saleth; Shah and Ballabh; Meinzen-Dick, 1998).

The movement of water and water rights from poor farmers to wealthier farmers, municipalities, or industrial interests often leads to the perhaps premature conclusion that small farmers are being stripped of their access to irrigation water (UNDP). Molle (2001) notes many small farmers are pushed to sell their rights because of debt. Indeed distress sales of water rights, while perhaps not common, were not infrequent in the Chilean water market (Hearne and Easter; Hadjigeorgalis, 2000, 2008; Bauer, 2004a, 2004b).

While this pattern of trade is not disputed, two important questions remain. Are water markets to blame for the small farmer's plight in developing countries, and do alternative water allocation mechanisms fare any better in protecting the

poor? Water markets do not create debt in and of themselves. If the "small peasant distinguishes himself by a lack of choices, or rather the alternative which is quitting, willingly or not, the farm sector" (Molle, 2001), this lack of choice is not the result of the establishment of a water market. The perception that peasants are "forced to sell because a water market exists" (Molle, 2001) may actually be the observation that a peasant now has the option to sell because a water market exists. Additionally, the case has been made that alternative water allocation regimes in developing countries have not fared better at protecting the rights of poor farmers or impeding third party impacts in many cases (Rosegrant and Binswanger). It is also not clear that the resolution of issues related to equity and conflicts between water users is easier to achieve under alternative water allocation methods (Rosegrant and Binswanger).

Additionally, there is evidence to suggest that sales between poorer and wealthier farmers may generate benefits for smaller farmers. One notable case is groundwater markets in Asia, which have emerged spontaneously in response to the needs of both large and small farmers in the region. Groundwater markets in India, Pakistan, and China give small farmers access to irrigation water through temporary rentals (Saleth, Braden, and Eheart; Saleth; Shah and Ballabh; Meinzen-Dick, 1998; Wang et al., 2005, 2006, 2007a, 2007b). In villages that have groundwater markets in northern China, these markets play an important role in transferring large volumes of water to a large number of households (Wang et al., 2007a). Molle (2001) describes such markets as arrangements devised by farmers and other operators to allow a degree of reallocation of production factors and economies of scale. He goes on to say such arrangements mediate the transfer of scarce public or common-pool resources to private individuals, resulting in benefits for both buyers and sellers.

In groundwater markets, small farmers tend to be buyers of water and water rights. In many instances, however, small farmers tend to be on the selling side of the market, and this is where the debate surrounding the negative effects of water markets on these farmers emerges (Hadjigeorgalis, 2008). Sales of water and water rights by small farmers are interpreted as disenfranchisement. In reality, however, there is insufficient data or evidence to support that selling water rights is a categorically bad position in the market. While we assume that the sale of a productive asset by a poor farmer will make them worse off, this has not been supported empirically.

Concluding Remarks on the Future of Water Marketing

Water use on a global scale is outpacing population growth and the productive use to which water is being put is shifting from agriculture to municipal, industrial, and energy uses. Construction of new dams and large-scale diversion projects are an expensive measure to meet these growing and changing needs. As pointed out by the United Nations Human Development Report (UNHDR), the issue is not a physical deficiency of water but institutional and political failures in water management. Markets could address these failures as a demand-side approach to managing water scarcity.

Markets, however, can also be plagued by political and institutional failures, which may explain the skepticism on the part of the United Nations to advocate them as a solution to the crisis in water availability for productive uses. While not

a panacea to the world's water crisis, however, they have been adopted and are proving successful in many areas in developed and developing countries. There is increasing evidence that many of the shortcomings of water markets are being resolved as we gain more experience with this mechanism and begin to employ it in increasingly wider circumstances.

What does the future hold for water marketing? Evidence suggests that water marketing is here to stay and will likely be expanded and refined over the coming decades to correct institutional inadequacies and issues that generate costs on third parties. Once seen as deadly to environmental interests, markets will begin to play an increasingly greater role in the protection of in-stream flows and wildlife. Innovative market arrangements, such as futures markets for water, and greater use of dry-year options to transfer water to municipalities while protecting areas of origin are likely to become more popular.

Increased use of markets is also likely to support increased water conservation. Reducing water use in agriculture through transfers to urban, hydropower and environmental interests will generate incentives for increased efficiency in agricultural water use. Raising the price of water to scarcity levels will also lead to changes in behavior as water users become better aware of the true costs of water provision. The market, in this sense, could substitute for what the UNHDR acknowledged were "public policies that have encouraged overuse of water through subsidies and underpricing" [p. 3].

The institutional framework within which formal water markets operate is crucial to their success, and the UNHDR raises the right question in expressing caution toward the establishment of water markets in developing countries with weak institutional capacities. The solution, however, may not lie in abandoning water markets as a long-term solution to the problem. Rather efforts should be focused on strengthening institutional capacities in developing countries and providing broader support for market mechanisms appropriate to the level of institutional development, such as user-generated informal markets. Additionally, policies that improve access to credit for poorer farmers can go a long way toward alleviating equity concerns by providing an alternative to water rights sales for debt relief.

Finally, research needs to be directed toward more interdisciplinary approaches to water resource management. Managing scarce water involves physical science, social science, law, and culture. Economists cannot solve the problem alone, as the issue cannot be reduced to one of net costs and benefits. There are broader implications for society in terms of laws, institutions, cultures, and the hard science of the sustainability of resource extraction and replenishment. While water markets alone may not be the panacea to the world's water crisis, a collaborative, multidisciplinary approach, with a significant role for water markets, has considerable potential to play a contributing role.

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