THE ROLE OF NESTED INSTITUTIONS IN INTERNATIONAL WATER MANAGEMENT:

A GLOBAL PERSPECTIVE

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Abstract

In this paper we identify a number of critical water problems and discuss the key role institutions can play in their resolution. After the introduction, we develop our framework for analysis based on Williamson's (2000) four-levels of institutions. Next, we discuss the problems of designing institutions. This is followed by a section that argues we have, in the past, over invested in water infrastructure and under invested in water institutions. Fourth, we discuss some of the changes that have occurred in the developing world as it has become integrated into world markets and the implications this has for water. Fifth, we list five priority areas where new water institutions need to be developed and old ones discarded. Finally, we conclude with a call for international agencies to help foster the development of new and improved water institutions.

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INTRODUCTION

Water issues are characterized by complexity and conflicting interests. There are multiple uses for water: domestic, industrial and agricultural, but recently there is also increased emphasis on the environmental and recreational uses of water. Some of these uses are consumptive, diminishing the quantity of water available, while others are not. Some uses of water diminish the quality of the water to other users even if the quantity is not significantly affected. Quality itself is multi-dimensional and directly affects potential uses. In addition to toxic compounds, nutrients and sediment may also negatively affect water quality. Therefore, market failure due to externalities is an important issue, as is the fact that water quality and water management structures have public good aspects. Water use occurs at a particular time and place so contracts for water trades need to account for this. There may be issues with populations that are underserved, or whose interests are ignored, particularly women, the poor, and those who are illiterate or otherwise disadvantaged. There are also conflicting beliefs regarding water and whether it is an economic good or a basic right. There are also issues of surface versus groundwater management and the interactions between the two. Moreover, scale issues are important, water does not necessarily follow local, regional, or national political boundaries, and in fact, waterways are often the boundaries between political entities. This makes river basin management a particularly difficult task. An understanding of the sources of complexity and interdependence is the key to designing appropriate institutions (see figure 1). In addition, changes in technology, scarcity (relating to both supply and demand factors), or recognition of

environmental issues will often mean existing institutions are no longer adequate and new institutions need to be developed or old ones modified.

Institutions are often defined as the "rules of the game" while the "players" are organizations, firms, and individuals (North, 1990). Schmid (2004, p. 1) defines institutions as "human relationships that structure opportunities via constraints and enablement". They structure incentives and provide order and predictability. Vatn (2005) indicates that classical institutional economics also recognizes that institutions shape our preferences and views of the world. There is an increased focus on institutional analysis, both the classical institutional economics and the new institutional economics, which is more neoclassical. In each case, the view is more pragmatic than in formal neoclassical economics. Both the market and government are viewed as flawed, so all options will be imperfect. Livingston (2005, p.25) discusses the importance of institutional analysis regarding water: "Institutional arrangements are critical in creating incentives because they (1) define who has access to water resources, (2) establish the range of (legal) options open to legitimate water users, and (3) determine who can claim income from water use and who will bear the cost of water use". It is critical that effective institutional arrangements are in place before we ask potential water users to contribute to water development.

In what follows, we first describe our framework for analyzing institutions based on the work of Williamson (2000). We then briefly discuss the problem of designing institutions. This is followed by a section in which we argue that in the past there has been an overinvestment in dams and an underinvestment in developing institutions to guide water management. Fourth, we highlight changes in the developing world that call for new institutions or institutional reform. Fifth, we identify five priority areas where water institutional innovation is needed. Finally, we

conclude with some thoughts about the future and a list of the areas where institutional change will be needed.

ANALYTICAL FRAMEWORK

Williamson (2000) divides institutional inquiry into four levels of social analysis. At the *most basic level* are informal institutions such as norms, customs, mores, religion, etc., which are socially embedded and change only slowly (figure 2). This level establishes constraints for the next level of analysis. In the case of water, this may relate to the use of water and waterbodies in religious rituals. Also, people often have strongly held beliefs regarding water trading and access to water as a fundamental right. In addition, the physical environment and degree of water scarcity may have helped shape these basic institutions and explain why they differ among regions and states.

The *next level* of institutional analysis discussed by Williamson is the formal rules of the game or the institutional environment. This is the realm of constitutions that establish rules for making rules, as well as property rights, laws, and policies. These institutions are the result of both evolution and design. Change at this level occurs over decades. Economists recognize that the changes that occur may not meet either equity or efficiency goals. Livingston (2005) discusses the effect of interest group politics on water institutions and how this is affected by the transaction costs of organizing groups. This level of analysis includes both water law and water policy. Livingston indicates that water policy is nested within water law and is thus constrained by it. An example of a formal water institution is whether water rights follow the prior appropriation doctrine or riparian rights. The specific content of a water right would also be situated at this level of analysis. Can the water be sold separately from the land? Is there a right to a specific quantity or quality of water? What organization(s) adjudicate water disputes?

The *third level* of analysis focuses on governance structures for transactions, the focus of Williamson's work. He says "…governance is an effort to craft order, thereby to mitigate conflict and realize mutual gains" (p. 599). Timing for change at this level of institutional analysis is when contracts are renewed, typically in the range from yearly to once a decade. Contracts are incomplete since the contracting parties cannot anticipate all contingencies. In Williamson's framework, both bounded rationality (imperfect information) and opportunism exist, so contracts must involve enforcement and dispute resolution aspects. This differs from agency theory, which only focuses on the *ex-ante* aspects of a contract. One of the main issues in transaction cost economics is to determine in what dimensions transactions differ. Typically this literature focuses on frequency, asset specificity, and uncertainty as key attributes that determine which governance structure will minimize transaction costs (Williamson 1985). Frequency refers to how often a transaction occurs. Asset specificity refers to what extent there are assets that are dedicated to that specific transaction and partner. If the assets can easily be put to another use or be used in transactions with another agent, they are low in asset specificity which means lower transaction costs. In the case of irrigation projects, asset specificity would generally be high. Uncertainty may exist regarding costs or benefits of the product, such as the reliability of the water supply and the impact of reliability, or lack of it, on crop production.

Governance structures can range from the spot market for groundwater at one end of the spectrum, for which there is little potential hazard (the "buy" decision), to annual contracts, the sale of permanent water rights, or more likely, public bureaus allocating the water (hierarchical).[1] Transaction cost economizing requires choosing the appropriate governance structure for the type of transaction that is under consideration. Williamson indicates that more complex governance structures are required as the hazards increase. The complexity of water governance

[1] In many cases in developing countries public agencies determine who gets water and when they get it.

structures is also likely to increase as water scarcity increases. These more complex structures entail costs both in the form of bureaucracy costs but also in attenuated incentives. Williamson indicates that public bureaus are often unfairly criticized since they may be useful for especially difficult types of transactions. Hybrid (public/private) forms of governance structures may also be possible.

Birner and Wittmer (2004) apply Williamson's concept of discriminating alignment to the issue of natural resource management institutions and the decentralization and devolution of both decision-making and implementation. Discriminating alignment refers to the idea that transactions with certain characteristics should be aligned with particular governance structures which may differ in their cost and competence. In addition to examining private and public sector options, Birner and Wittmer also discuss collective action and hybrid forms of governance in the developing country context. Besides the transaction attributes of frequency, asset specificity, and uncertainty, they add public relevance (to what extent are externalities or public goods an issue, and at what scale?) and care- or effort-intensity (to what extent does the outcome depend on the care or effort that agents exercise?). Public relevance is particularly pertinent for water resource issues. Birner and Wittmer also discuss contextual factors, such as state capability and social capital (which relates to the most basic level of analysis in Williamson's framework, that of informal institutions). They conclude that the most efficient form of governance will depend on the characteristics of the resource itself and the specific social and political characteristics of a country.

The set of governance structures discussed by Williamson has some relation to the water allocation mechanisms that are often discussed. Rosegrant and Binswanger (1994) indicate that there are three potential allocation mechanisms: 1) administrative allocation, 2) opportunity cost

pricing, and 3) tradable water rights. Both administrative allocation and opportunity cost pricing would represent hierarchical forms of governance. Tradeable water rights are a market-oriented form of governance, but for surface water, this would typically represent contracts rather than a spot market, while with groundwater, spot markets may be more common. Water trades would often involve a time component, such as water for a growing season (versus a permanent trade of the water right), and it may be necessary for contracts to specify the location and time of delivery as well as the quantity of the water or the share of the canal flow. In developing countries, spot markets for groundwater have grown as has the use of groundwater while markets for surface water are discouraged by law and irrigation agencies.

Perry and Easter (2004) discuss the difficulties involved with local decision-making in watersheds because those decisions have impacts elsewhere in the river basin. They give the example of crop practices in the Minnesota River Basin affecting water quality in the Gulf of Mexico and suggest some institutional arrangements that have been developed elsewhere to handle smaller but similar water quality problems. One institutional mechanism that could have been used to resolve such conflict was the river basin planning done under the U.S. Water Resources Council. However, as Howe points out, the Reagan administration abolished the agency and program. As a consequence, the U.S. "lost 50 years of bipartisan federal and state cooperation in water resource planning and pollution control" (Howe, p. 2).

Governance structures need to be able to account for these scale issues which may be difficult to do in the context of a private contract. It may be the case that hybrid forms of governance structures which incorporate both public bureaus and private contracting need to be developed as discussed by Birner and Wittner (2004). Decision-making could be separated from implementation so that impacts that extend beyond the local level are incorporated in the

decisions, but then decision-makers need to be concerned with the incentives for effective implementation at the local level. In a similar way, economists sometimes recommend that governments raise funds for public goods although they may hire private firms to actually produce the goods rather than producing them themselves. Governments also may need to raise funds for public water projects because of their size and scale, although this may be less important particularly in more advanced countries since large private water companies are now making similarly large investments.

Analogous to matching governance structures to characteristics of transactions, it is important to match incentives and impacts with rights. It may be that given the complex nature of water resources and beliefs held by certain communities concerning water access, that more complex governance forms are appropriate. For example, calls to privatize water may have been overly simplified, or even counterproductive, in some cases such as the privatization of the water system in the Cochabamba area of Bolivia. Pervasive externalities regarding both water quality and quantity that may extend to other localities, regions, or even nations, mean that local-level, private decision-making may not maximize social welfare. Complex physical interactions between surface and groundwater may involve time lags that mean the effects may not be directly observable by users, so there may be a need for scientific expertise in the decision-making process. There may also be cases where strongly held beliefs about who should control water access, work against efforts to privatize water, unless specific institutions are in place that assure water will be available for the poor and other disadvantaged groups.

The *final level* of analysis in Williamson's paper is the domain of neoclassical economics. The firm is seen as a production function and the issue of governance is ignored. Economic agents are assumed to optimize either utility or profits and respond to changes in

prices or constraints. Institutions are often ignored, or if they are addressed, they are incorporated as exogenous constraints. Adjustments at this level occur continuously. In the case of water, changes in water use due to price changes, or changes in technology, are examined. However, given the complex nature of water, analysis needs to be conducted at the deeper levels mentioned earlier. For example, Livingston and Garrido (2004) indicate that problems with groundwater go beyond pricing, since there are allocation issues as well as environmental issues involved.

DESIGNING INSTITUTIONS

While transaction cost economics suggests which governance structures may economize on transaction costs, transaction costs (TC) are not typically measured (McCann et al., 2005). In some cases, it may be important to know the magnitude of these costs so they can be directly compared to efficiency gains. This TC information may also be used to design improved institutional forms and policies (McCann et al., 2005). As pointed out by Birner and Wittner (2004), the usual methods used to empirically examine governance structures in the private sector are not relevant for water institutions since decisions depend on both politics and efficiency. In addition, lack of success by public sector governance forms may be a result of lack of state capacity and incentives in that country, rather than it being a fundamentally inferior form of governance for complicated issues.

Drawing from Williamson (2000), it is obvious that institutions are nested. Informal institutions such as norms and culture affect which laws and policies can be implemented. Fundamental formal institutions, such as property rights and judicial systems, affect which governance forms are efficient or even which forms are possible. Formal institutions, such as property rights and the distribution of property rights, as well as governance forms, affect market

prices (Vatn, 2005). It is also the case that changes in prices or technology may stimulate demand for institutional changes (Saleth and Dinar, 2004), as can basic changes in economic policy. One of the implications is that changes in formal institutions that contradict norms are unlikely to be successful. Institutions at different levels need to be coordinated, or at least taken into account, when designing new policies or choosing among governance forms. McCann and Easter (2004) examined the issue of transaction cost measurement and water allocation mechanisms and included figure 3 to indicate that transaction costs involved with changing institutions, such as laws, need to be taken into account when evaluating the transaction costs of a new policy, such as water trading, not just the market transaction costs once the policy is established. In this figure they show level two divided into two parts, to illustrate how enabling market institutions are dependent on the legal system.

While somewhat related, the concept of path dependence is also relevant for the analysis of institutional change. Nestedness refers to the impact that different levels of institutions have on each other. Path dependency relates to the constraints and opportunities that previous institutional choices pose as far as future choices. In general though, this term relates to institutions that are at the same level. North (1990) says that history matters because transaction costs matter. In the case of water, formal and informal property rights that are in place will affect the cost of reallocating those rights or their value. Challen (2000) found that once water rights are devolved to lower levels, it is very difficult for the state to reclaim those rights. Furthermore, in developing countries, such as India, it is very difficult to get irrigation agencies to devolve any level of irrigation water control to farmers. This has been one of the key reasons why establishing water user organizations (WUO) has not resulted in large improvements in water management, as had been expected.

The new institutional economists seem to ignore the important impact that the physical environment may have on both formal and informal institutions as well as on prices. The classical institutional economists seem to be more aware of this. Livingston (2005) discusses the fact that there has been greater institutional change, and different institutions have evolved, in the dry western United States as compared to the wet eastern United States. This clearly shows how institutions are developed in response to water scarcity. If water is not scarce, water institutions can be quite simple. It then pays to develop more complex institutions as water becomes scarce.

The analysis, evaluation, and design of water institutions are complex, and each policy and governance form usually has some drawbacks. The physical, social, and political realities need to be considered in the design of institutions if they are to be successful. Instead of searching for perfection, we need to be pragmatic. If a feasible alternative can't be developed that produces positive net benefits, then we should wait until changes in the physical, social, or political conditions raise the potential benefits. This now brings us to a discussion of current institutional challenges and questions concerning which changes in international water institutions offer high returns.

UNDERINVESTMENT IN INSTITUTIONS

Our experience with rapid irrigation investment in Asia strongly suggests that we overinvested in dams and irrigation canals and failed to make complementary investments to change or develop the institutions needed to better utilize and manage the water made available. This is not surprising since we knew how to build dams but had not really thought much about building water institutions. In places such as India and Pakistan we followed the old heavy handed top-down approach adopted from the former British Raj where the peasants were dependent on government water managers and district collectors. It was only in the 70's that the

lack of water institutions was first put on the research agenda. Poor water distribution at the local level was one of the first institutional gaps identified. Several of the early studies discussed how Taiwan had solved the problem by establishing Irrigation Associations (IA) to manage the water for the farmers (Abel, 1976). The key in this case was that the IA's were corporate entities owned by the farmers and financed partially by the farmers' water fees (Wai-Fang Lam, 2005, p. 346).

Secondly, in many countries the lack of Williamson's second level of institutions, or the institutional environment and legal system, hindered the development of new water institutions. If the rule of law doesn't work in a country, how can a government establish formal water rights? In small, localized, irrigation systems water users, in a few cases, have gotten around the problem by organizing and allocating water shares among members such as was done in the Cariri region of Brazil (Easter and Liu, 2005).

The third problem involved the existing institutions and organizations. Many countries such as India and Pakistan have very centralized national irrigation agencies which are overstaffed with low-paid employees. This results in rent-seeking behavior by staff and a misallocation of water resources. The end result is overirrigation, usually at the head of the canals, while other parts of the same irrigation system seldom receive any irrigation water. These same overstaffed and inefficiently operated irrigation agencies have been very effective in preventing institutional or organizational change. This illustrates the path dependence problem in trying to change institutions. As Vermillion (2005) points out, virtually all countries in Asia with irrigation have gone through an improvement stage which involved some form of increased user participation. This phase left the existing institutions in place and failed to transfer any water control to farmers, let alone give them any water rights. This is what Vermillion calls

"participation with patronage." What he says is needed is "empowerment with accountability," which he sees just in a few cases. This means restructuring irrigation agencies, giving farmers water rights and establishing WUO that are strong legal entities with the authority to make and enforce service contracts; a task he says that has been started, but is very difficult to implement.

INSTITUTIONS TO ADDRESS CHANGING GLOBAL CONDITIONS

Globalization has had a major impact on Asia and to a much lesser extent, Africa. We see the growth in new jobs and incomes and a shift in demands. We now find rice prices at historically low levels which puts farmers in Asia under financial pressure since rice is the staple crop for most irrigated areas in Asia and to a lesser extent Africa. Thus, farmers are less able to pay water fees and irrigation systems deteriorate as maintenance keeps being deferred. In addition, small scale farmers are less interested in collective action to improve irrigation as the younger members of the household find jobs in the service or industrial sector.

With the availability of improved technology, farmers have also shifted to groundwater irrigation. This gives them much better control over the water and allows them to grow high valued crops. Groundwater availability gives them further reason to not be interested in collective action and may also directly compete with surface water. Increased pumping along stream banks or canals will draw down groundwater tables and cause the surface water to infiltrate much more rapidly into the ground and recharge the groundwater.

In countries such as India that have laws that prevent or discourage any private development of surface water, groundwater development may be the farmers only private irrigation alternative. These laws, developed to prevent excess surface water development, may be indirectly encouraging groundwater development and discouraging collective action to develop and maintain surface water systems. Thus, we need new institutions that encourage the

conjunctive management of surface and groundwater as well as modification of old institutions that are restricting private collective action. The days when governments need only to be concerned about surface water development are over. They now need to be equally concerned about groundwater and the joint management of the two sources.

An equally important change that hit developed countries several decades ago has now entered the agenda of developing countries. This is the concern for the environmental uses of water, primarily in-stream uses. Chief engineers in Asia have heard the message and are now much less likely to argue that any water reaching the ocean from a river or stream is wasted water. Grudgingly they are realizing that water discharging into the ocean is providing valuable environmental services, including giving fish access to the ocean.

Citizens in a number of developing countries are asking questions about reserving water rights for the environment. This has become a key issue for coastal zones and for the fishing industry. Both ocean fishing and coastal fish farming are concerned about decisions involving water use and diversions upstream on many rivers. Recreationalists and those in the tourism industry have similar concerns about water resources. They are asking questions about water use as well as the regulation of pollution discharged from cities and industries. Beaches that used to be pristine are no longer used by foreign visitors and reefs are being destroyed by pollution and exploitive fishing practices.

To deal with these problems we need to develop innovative institutions such as those reported by Perry and Easter (2004). For example, those being damaged by water pollution need institutions that allow them to alter upstream activities, either through bargaining or some form of regulation. This type of institutional arrangement was developed in Japan with the help of well-functioning downstream water organizations and an active land market.

> "Before 1920, Japanese irrigation associations and municipalities which were located downstream in the river basin were very active in trying to reduce water pollution and erosion in their basin. Several different approaches were used. First, they purchased land in critical areas in the upper basin and cost-shared on management of upland forested areas. Later, municipalities and power companies shared the cost of purchasing upland forested areas. Finally, with the increase in water use, the prefectural government assumed more responsibility and leased privately owned land in the upper basin and planted trees. This was done in cooperation with the downstream water users and included a cost-sharing arrangement between the water users and the government in terms of both costs and revenue (Nickum and Easter, 1990). Existing irrigation and municipal government helped hold down transaction costs. However, to do the same thing in another area might involve high transaction costs if existing local organizations are not interested or are inactive in dealing with river basin problems" (Perry and Easter, 2004, p. 5).

This example shows that if effective level-two institutions are in place, formal and informal, privately induced collective action can be the primary impetus to protect water quality and water supplies. As government agencies become technically more skilled and efficient they can play a larger governance role in protecting water resources. In the absence of level-two institutions, such collective action will be difficult because the local downstream water organizations have no way of influencing land and water use activities upstream.

INSTITUTIONS OF PRIORITY CONCERN

Given the past water investment and the changing economic conditions around the globe, there are five key areas where it is important to devise new institutions, or adjust old ones, to address the global changes (discussed in the last section) and our growing water scarcity. The five key areas are: (1) institutions to resolve and reconcile conflicts between local water decisions and the broader basin-wide impacts (Perry and Easter, 2004); (2) institutions that allow cost-recovery and water pricing to be effective as well as "fair" (Easter, 1993 and Easter and Liu, 2005); (3) institutions to foster the granting of water rights or use rights and facilitate their exchange among water users (Easter and Renwick, 2003); (4) institutions to help manage groundwater extraction and conjunctive water use; and (5) finally, institutions to coordinate and

foster cooperation and negotiation over transboundary water resources as opposed to conflict and water misuse (Easter and Zeitouni, 2005).

For the first area, reconciling local decisions with regional concerns, it is not hard to identify the issue close to home. I live in Minnesota and my co-author grew up in Minnesota, which is where the Mississippi originates and where it picks up anywhere from 6 to 10 percent of the nitrates that are carried down river and deposited in the Gulf of Mexico where it creates a huge dead zone (no oxygen). Individual decisions by farmers in the upper Mississippi River basin involving drainage, crops, livestock, and fertilizer are made to maximize their profits. Many don't even know that their decisions are having an impact on the Gulf. What we need to develop are institutions that inform farmers and landowners about their downstream impacts and give them incentives to reduce their negative externalities caused by heavy use of nitrogen fertilizer and/or manure along with tile drainage. Here existing farm programs, and the strong belief that farmers should not be burdened by government restrictions, have prevented any effective changes.

The second problem area, cost-recovery and water pricing in developing countries, is an issue that the World Bank and others have been working on for years with only limited success. What Yang Liu and I found in our recent study of successful cost-recovery efforts was that a complex set of institutions and incentives, which governments create or fail to create, are critical to obtaining high levels of cost-recovery (Easter and Liu, 2005). As one might expect, effective institutions and incentives were not the same in all cases, since the details of implementation and existing institutions matter. However, several changes seem to have big payoffs (see tables 1 and 2). First, giving farmers more authority and responsibility over water control is critical. Second, water fees collected from farmers and other water users should be used to operate and

maintain their water system in an open and transparent manner. Third, making the water supply entity financially autonomous with close ties to the farmers has been a very effective way to force water supply entities to provide good service. Finally, the fee structure has to be equitable, administratively simple and easy for all users to understand. As part of the process, the full range of services and benefits produced by the system needs to be identified, and the cost shares allocated, based on the distribution of these benefits (table 3). Irrigators should not have to pay all the project costs, particularly for multipurpose projects or projects that primarily increase grain production and thus lower the grain prices farmers receive.

The third area, establishing water rights and water markets, requires a number of key institutions. One of these is a mechanism to resolve conflicts that might arise from return flows, water pollution, or over-pumping of groundwater. An additional concern may be to devise institutions that assure low income families, and women, they will have access to reasonably priced water for their basic needs. This may be necessary because of the concern that someone will buy up all the water and charge excessive water prices.

The fourth area of concern involves both the developed and developing world and how they use groundwater. It has been the major source for increased irrigation over the past quarter century. At first this created few problems, but that is no longer the case. Groundwater levels are dropping rapidly. Salt water intrusion is getting worse in coastal areas and cities, such as Bangkok, Thailand, have been sinking because of excessive private groundwater pumping.

Little has been done in most cases to arrest this over-exploitation. One exception is along the Platte River in Colorado, where surface water rights have been ruled to be senior to groundwater rights when pumping groundwater affects surface water uses. In response to adverse impacts on the Platte River, the state ordered the shutoff of more than 2,000 wells in

2005 and 2006 along the Platte River. They are also pursuing legal action against at least 50 who didn't shut off their wells in 2006. This is also an efficient program for conjunctive water management since water trading is allowed and well owners can buy more senior surface water rights if they want to continue pumping.

Another option is to establish groundwater districts that have the authority to establish limits or quotas on pumping based on recharge rates in the district and to allow quotas to be traded. This was done in several areas in southern California in response to salt water intrusion (Blomquist, 1995). Other options include license requirements that impose pumping restrictions, or require the would-be pumper to show that the proposed well will not affect other wells in the area. If they do affect neighboring wells, then the pumper is liable to pay damages to those who are damaged. In developing countries the problem is not only establishing the law but being able to enforce it. In some cases the lack of an effective legal system prevents enforcement since damaged well owners can't seek damages, or can't afford the court costs or the long waiting period before receiving any compensation. Thus, to control over-exploitation of groundwater these developing countries will need to change institutions at both Williamson's level two and three. This will take time since changes at level two occurs over decades while the level three changes can take up to a decade to enact.

The final important set of water institutions that are needed, involve transboundary water resources and the need to foster coordination, cooperation, and negotiation over their use. This involves surface and groundwater as well as water quality and quantity. With the growth in population and economic activity, water, which used to flow across borders without creating any concern over its use, is now causing serious debates among countries all along such rivers.

Transboundary surface water issues are visible around the world but particularly in Africa

where almost all the rivers cross one or more countries. Europe, of course, has been dealing with this problem for years, as have the U.S. and Mexico. The U.S.-Mexico experience suggests that establishing water rights and allowing trading of these rights across the boarder can help reduce potential conflicts over water use and pollution. A study by Hilery Sigmen (2004) shows that trade between countries that share rivers, promotes environmental coordination in the use of the rivers. In other words, increased trade was correlated with increased environmental coordination on the international rivers. Only the countries in the European Union (EU) did not show this relationship. This she argues is because the EU uses other mechanisms to foster environmental coordination and cooperation in the use of its international rivers.

In the case of groundwater, the competition between Jordan and Saudi Arabia over the Disi Aquifer is a good example of the lack of cooperation. Jordan would like to keep the aquifer as a strategic reserve for municipal and industrial water use and has stopped agricultural uses. However, Saudi Arabia is subsidizing farmers who pump from the same aquifer to grow wheat. Again, an international agreement is needed which may need to include a third party, such as the U.S., which would guarantee wheat supplies for Saudi Arabia to replace production from the groundwater (World Bank, 1993).

An example of such an agreement with surface water was brokered between India and Pakistan by the World Bank and involved the sharing of rivers after the partitioning of former British India cut right through large irrigation systems in the northwest part of the subcontinent (see Box 1). The agreement took over ten years to broker but it has lasted for almost half a century and through three wars between India and Pakistan. The agreement involved investments by a number of western countries to build storage dams in Pakistan which would replace the water (rivers) that were allocated to India. It also required some investment by India,

as well as continued water delivery, until the new dams could begin supplying water to Pakistan. The Indus Water Treaty suggests both the difficulty of negotiating international water agreements and the need for greater involvement of international agencies in helping countries to negotiate agreements for managing international water resources.

Box 1. The Indus Waters Treaty

When the subcontinent was partitioned in 1947, the political boundary abruptly cut off two of Pakistan's irrigation canals from their source water in India. The dispute started in 1948 when India stopped the supplies and claimed propriety rights over the waters flowing through its territory. In 1951 the former chairman of the TVA warned that the dispute was a dangerous powder keg that could explode anytime. He suggested that the World Bank help the countries to develop the Indus system as a unit along the lines of the TVA. The Bank president promptly offered assistance, and delegations from the two countries met in Washington in May 1952 to prepare a joint plan. They differed too sharply in their views, however, to pursue joint planning. The Bank suggested that each side should present a plan of its own. Again, their plans were too far apart to be reconciled. Finally, they agreed to the Bank's offer to present its own proposal.

In February 1954, the Bank presented a proposal that allocated the eastern rivers (the Ravi, Beas and Sutlej) to India and the western rivers (the Indus, Jhelum and Chenab) to Pakistan. This proposal envisaged construction of a system of link canals from the western rivers to replace Pakistan's uses on the eastern rivers, a transition period to allow Pakistan to complete these projects, and the need for India to pay the project costs and to continue sending water supplies during the transition period. This division would meet the uses of both sides and leave each free to develop new supplies. India accepted the proposal. Pakistan's acceptance was conditional; it contended that there was not enough surplus in the western rivers to replace its uses on the eastern rivers.

The delegations met again in Washington in December 1954 to work on the Bank's proposal. After extensive studies of the available river flows, losses and gains, the Bank issued an aide-memoire in May 1956 that confirmed that the surplus supplies in the western rivers would be insufficient to meet Pakistan's replacement needs in certain periods and that its original proposal had to be modified to include storage works. Pakistan accepted the modified proposal, but India said its financial liability should be limited to the original Bank proposal.

The next four years of negotiations to reconcile differences on several issues were difficult. The Bank continued its efforts and threatened on several occasions to discontinue its assistance if the parties maintained their uncompromising positions. Simultaneously, recognizing that the countries could not afford the large project costs, the Bank mobilized the support of Australia, Canada, New Zealand, the United Kingdom, and the United States for financial assistance. Finally, the Indus Water Treaty was signed on September 19, 1960. The Bank's success was due to its recognized technical expertise and neutrality along with its ability to provide financial assistance.

CONCLUSION

If the necessary changes and innovations in institutions can be put in place, then the next 20 years will experience a growth in water markets and water trading. What is surprising is why water markets did not spread much earlier. This may be because water hasn't been scarce in many areas. Yet, considering the very early successful development of water markets in southern Spain and Oman (still operating effectively today), why did it take Australia, Chile and the western U.S. so long to develop their water markets? Another explanation for this arrested development is that water market development has never been a state policy and the existing markets have developed locally as villagers, facing water shortage, worked together to develop their water resources and make their irrigation systems sustainable.

Future investment in irrigation infrastructure is very uncertain, particularly given the issues of climate change and global warming. With climate change and growing water demands, a number of countries, such as China, will feel or are feeling the need to develop more water storage and conveyance capacity. The one continent where past investment in dams and canals has been quite limited is Sub-Saharan Africa (figure 4). This is the one area where donors are talking about the underinvestment in irrigation and the need for new capital investments in irrigation. Hopefully, donors have learned from past mistakes in irrigation development in other regions of the world and will worry a lot more about the institutions that will be needed in Africa if they are to effectively use any new irrigation systems.

Asia poses a different set of questions and constraints because the dams and canals are already in place. What may be needed is a major economic or government administrative change, such as occurred in Chile and China. In Chile, after a major change in government economic policy, they gave water users tradable water rights, and in China, they are

experimenting with different management models that use innovative ways to provide positive incentives. Irrigation staff is given incentives to provide better service and farmers are given incentives to pay their water fees and conserve water (Easter and Liu, 2005). The problem is to get other countries to develop ways to "fairly" grant water rights to users and develop incentives that encourage water managers to provide better service.

Another key question will be, can innovative ways be devised to coordinate and encourage cooperation in the use of international waters? This is clearly an area where international agencies, such as the World Bank and International Water Management Institute (IWMI), need to put a bigger effort in terms of research and investment. On the positive side, the expansion of world trade may be a vehicle which encourages greater cooperation, at least, on international water quality.

Our past experience with developing institutions to coordinate between local decisions and their basin-wide impacts suggests that it is easier to do when the basin is primarily within one country. However, other countries should not follow the U.S.'s example of throwing out the basin-coordinating institution after 50 years of effective work. France's model of river basin management, with six river basin committees, is a much better model for other countries to follow (World Bank, 1993).

With the growth in unregulated groundwater development, many countries are moving closer towards a point where the external cost being imposed on other water users requires some broad-based collective action. The problem is that most developing countries don't have the level-two and three institutions in place to implement such collective action. The large number of wells makes it very difficult to enforce restrictions on water extraction or to collect fees for the water pumped, or for the electricity used in pumping in countries, such as India and Pakistan.

Overall, our great fear is that we will continue to muddle along until the above water problems become so serious that our options are severely limited. This will result in serious hardships for many dry regions and poor people. As researchers we need to help policy makers develop improved water institutions that can be implemented in a reasonable amount of time to help deal with those problems. Eventually, climate change may be the shock that gets us out of the muddle.

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Table 1. Factors Influencing Fee Collection Rate

Cases	Financial autonomy	Incentives to pay		User participation	System transparency	Collection rate (%)
		Penalty for non payment	Improved irrigation service			
Awati, China	Yes	N.A.	N.A.	Yes	N.A.	98
Bayi ID, China	Yes	Yes	Yes	Yes	Yes	100
Nanyao ID China	Yes	N.A.	N.A.	Yes	N.A.	95
Shangdong China	N.A.	Yes	Yes	N.A.	Yes	100
Yangtze Basin, China	Yes	N.A.	Yes	Yes	N.A.	N.A.
Gujarat, India	Yes	Yes	Yes	Yes	N.A.	100
Haryana, India	Partly	Yes	N.A.	Yes	N.A.	85–95
Mexico	Yes	Yes	Yes	Yes	N.A.	90
Alto Rio Lerma, Mexico	Yes	N.A.	Yes	Yes	Yes	100

Source: Easter and Liu, 2005.

Table 2. Factors Influencing Water Use Efficiency

Cases	Switch to volumetric metering	Pricing structure	Water-saving technology availability	Assurance of water delivery	Education		Annual saving
					Public awareness	Technical assistance	
Awati, China	Yes	Increasing block	N.A.	N.A.	Yes	N.A.	50m^3 /mu
Shangdong, China	Yes	Volumetric	N.A.	Yes	N.A.	N.A.	5 Bm^3
Yangtze Basin, China	Yes	Volumetric	N.A.	Yes	Yes	N.A.	1.18 M m^3 in WUA
Katepurna, India	Yes	Volumetric	Yes	Yes	Yes	Yes	7.71 M m^3
Tunisia	Already used	Volumetric	Yes	N.A.	Yes	N.A.	N.A.
Mula area, Spain	N.A.	N.A.	Yes	Yes	N.A.	Yes	101 Mm^3

Source: Easter and Liu, 2005.

Table 3. Alternative Cost Allocation for Three Water Projects in Andra Pradesh, India

Part A. Cost Allocation for Three Consumptive Uses Based on Water Delivery

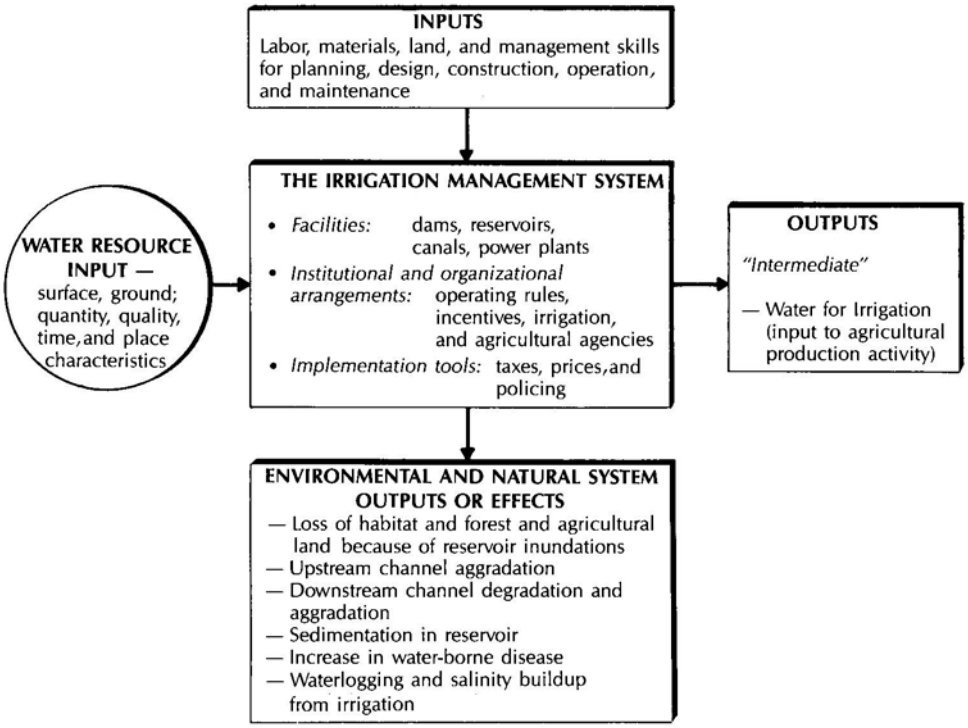
Three water projects	Domestic water supply (%)	Industrial (%)	Irrigation (%)
Nagarjursagar	2	0	98
Tungabhadra	1	4	95
Sriram Sagar	2	3	95

Part B. Cost Allocation among Three Projects Based on Direct Benefits

Purpose or use	*Three Water Projects*		
	Nagarjursagar (%)	Tungabhadra (%)	Sriram Sagar (%)
Irrigation	94.3	91.3	88.1
Hydropower	4.0	4.2	3.0
Domestic	1.6	2.1	3.0
Industry	0.1	2.3	4.3
Fisheries	0.1	0.1	1.6

Source: Easter and Liu, 2005.

Figure 1. Irrigation management system with inputs and outputs



SOURCE: Adapted from Bower and Hufschmidt (1984)

Figure 2. Levels of Institutional Analysis (developed from Williamson, 2000)

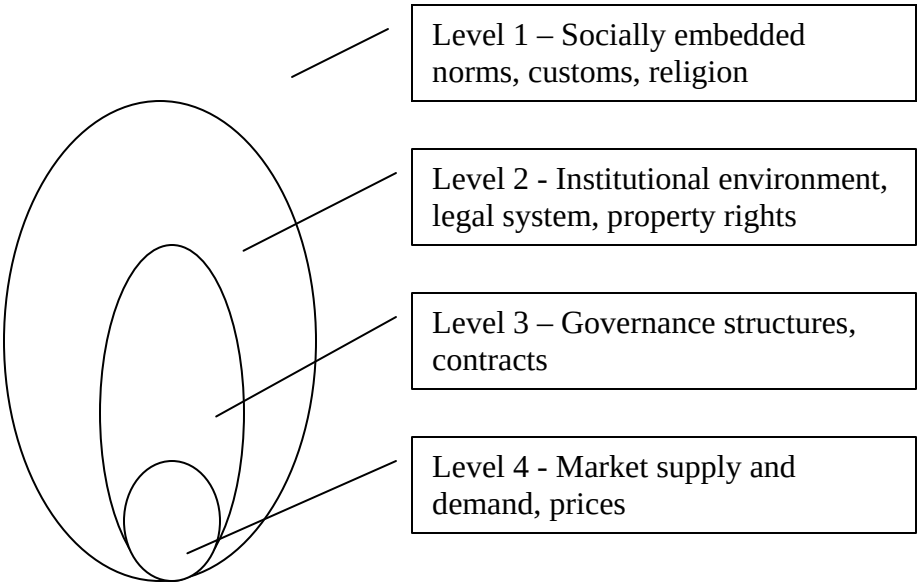
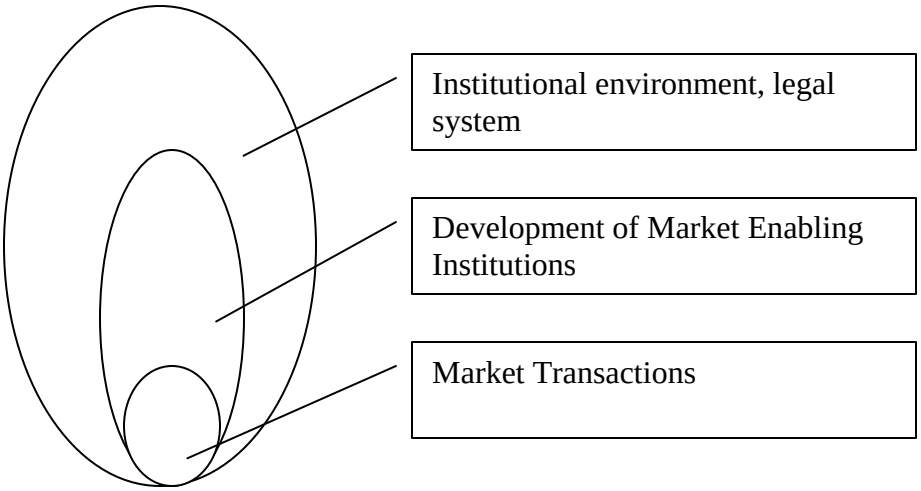
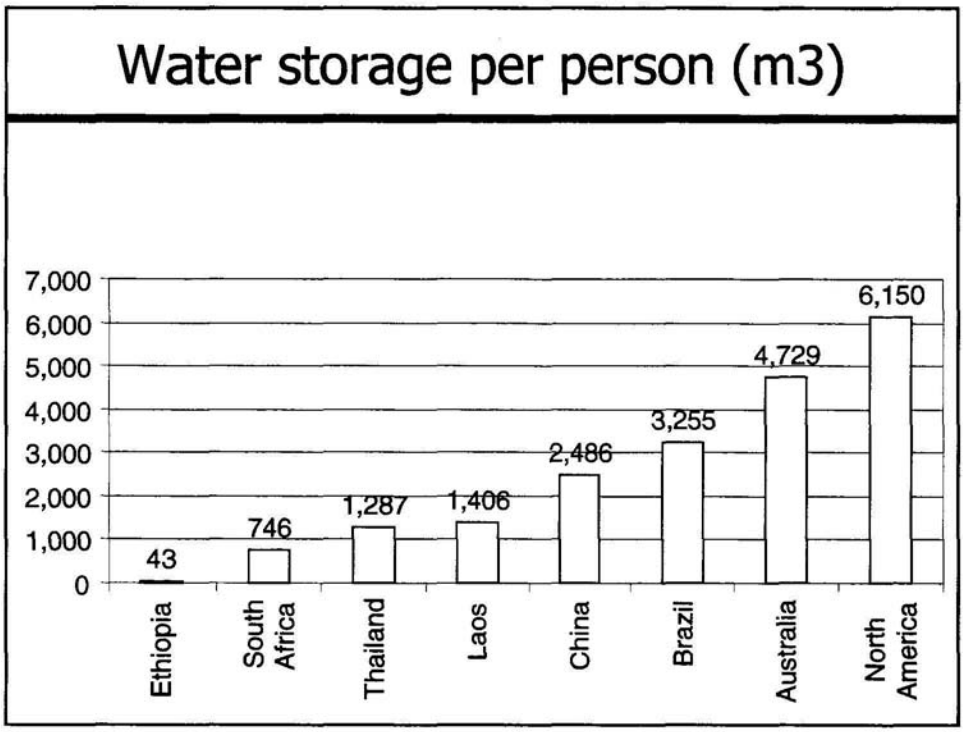


Figure 3. Boundary Issues Regarding Transaction Costs.



Source: McCann and Easter, 2004.

Figure 4.


Water storage per person (m3)
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
43
746
1,287
1,406
2,486
3,255
4,729
6,150
Ethiopia
South Africa
Thailand
Laos
China
Brazil
Australia
North America