The Potential Role of Economic Instruments in River Basin Management

Increased economic efficiency through paying farmers to use less water

Better rules for sharing water could make a large difference for equity and productivity outcomes. Economic incentives for water management, including prices, taxes, subsidies, quotas, and use or ownership rights can affect the decisions of water users and motivate them to conserve and use water more efficiently.
Von Claudia Ringler

Water uses and developments in one part of a hydrologic or river basin will affect outcomes in other parts. Similarly, pollutants introduced in one part of a river basin will eventually affect outcomes elsewhere in the system. The often invisible but strong inter-connection of water users within a river basin can be seen in multiple (re)uses of water. Water in the Danube basin, for example, is drunk and used for different productive and ecosystem activities by 14 riparian countries along its flow into the Black Sea. The basin context is also important as actual water savings at the basin level might be less than savings at individual irrigation systems might indicate. For example, in the Nile basin of Egypt, it has been estimated that while irrigation efficiencies for individual systems are only 30 percent, the overall irrigation efficiency for Egypt's Nile irrigation use is 80 percent, as irrigation water is reused several times (Keller 1992).

With growing water demands exerted by increasing and more affluent populations, efficient, sustainable, and equitable water allocation policies are rapidly increasing in importance both in large, transboundary basins but also in smaller catchment areas. In the past, supply augmentation of water through new water development has been common to address water shortages experienced in one part of a basin. In so-called maturing water economies, characterized by increasing scarcity values for water, demand management increases in importance. Thus, the focus on engineering, technical, and agronomic solutions declines (Randall 1981). The task of demand management is to generate both physical savings of water and economic savings by increasing output per unit of evaporative loss of water, by reducing water pollution, and by reducing non-beneficial water uses. This can be supported through a variety of policy measures, including economic incentives to conserve water use. These measures can comprise pricing reform and elimination of wasteful subsidies, but also complementary regulations on water use rights, and policies targeting poor and vulnerable groups, education campaigns, water recycling, enhanced pollution monitoring, and quota, licensing, and locale-specific or basin-wide water trading systems. In addition to water conservation, economic incentives can also help recover investment costs, and can help internalize costs imposed on third parties and on the environment. And while many demand management measures have targeted irrigation as the largest water user, municipal and industrial water use cannot grow unchecked; regulation and economic incentives are needed to reduce the negative ecological, economic, and social impacts of these uses, especially on water quality.

Modeling Framework Used

The modeling framework used here for analyzing economic incentives is a combination of hydrologic simulation with economic optimization maximizing economic benefits to water use subject to physical, system control, and policy constraints. The conceptual and technical basis for this type of integrated basin-scale modeling is described in a state-of-the-art review by McKinney (1999).

The node-link network, which is an abstracted representation of the spatial relationships between the physical entities in the river basin, underlies the modeling system. Nodes represent river reaches, reservoirs, and water demand sites, and links represent the physical linkages between these entities, such as natural and artificial channels, canals and drains. Inflows to these nodes include surface discharge from the headwaters of the river basin, as well as local rainfall drainage. Flow balances are calculated for each node and for each time period, and flows are calculated based on the spatial linkages in the river basin network.

Thematically, the basin model includes three components. Firstly, hydrologic components, including the water balance in reservoirs, river reaches, and irrigated cropland; secondly economic components, including the calculation of benefits from water used by sector, demand site, and province and thirdly institutional rules and economic incentives that impact upon the hydrologic and economic components. Water supply is determined through the hydrologic water balance in the river system and reflects exogenously determined inflows and precipitation inputs. Water demand is determined endogenously within the model based on functional relationships between water and productivity in irrigated agriculture, domestic and industrial uses, and hydropower. Water supply and demand are balanced based on the objective of maximizing economic benefits to water →

use. Environmental requirements to dilute waste streams and to control saltwater intrusion are included as minimum flow constraints. In addition, reasonable values for minimum flow are preserved on all river reaches. This modeling framework thus preserves the hydrologic integrity of a river basin system while supporting the analysis of tradeoffs and complementarities among alternative water uses, and the impact of alternative water allocation policies and strategies on these water users.

Analysis of Economic Incentives in a River Basin Context

Economic incentives can play a role in many water and water-impacting policies, and can include direct water use rights for environmental flows, payments for environmental services, such as upstream watershed protection for downstream municipal water supplies, payments to irrigators to use less water, the elimination of subsidies for agricultural input and output prices and the elimination of trade subsidies and non-efficient trading arrangements, those affecting climate change, and the enforcement of water quality regulations.

Economic incentives play out differently under differing enabling institutions. The most important among these are water rights for farmers and other water users to facilitate investment in water-conserving irrigation technologies, to share both benefits and responsibilities from water use and create incentives for cooperation, to increase the reliability and thus reduce uncertainty and wasteful use, to facilitate compensation of water users when water is reallocated from one part of the basin to another – typically from rural irrigation uses to urban industrial and domestic uses, and to facilitate water rights trading among users within the river basin.

Other basic enabling institutions that influence the use of economic incentives include the rule of law and good governance, for example, through the use of stakeholder negotiation platforms that are increasingly being implemented. Also important is the relative focus on public systems versus private development. The impact of mostly private groundwater expansion in many developing countries on water availability for other users and the environment has yet to be addressed. Equally important, to alleviate budget constraints and management challenges, several developing country governments have embarked on decentralization or devolution of management and operational functions of irrigation systems to the province or district levels or directly to farmer groups, which can both hinder or enhance water management.

Water Pricing

Water pricing is the most common economic instrument used for basin water uses. In a review of the World Bank irrigation and drainage portfolio covering 68 projects water pricing was most common, with 52 out of 68 projects using it (Dinar, 2001). Administrative water prices generally work well for municipal and industrial water usage, particularly if subsidies are targeted towards poor domestic users, and revenues generated through water charges are invested into expanding water supply services to lower-income areas.

Administrative water prices are generally less effective in saving significant quantities of irrigation water, particularly in developing countries where farmers have limited control over water supply. In these settings supplies are seldom reliable and large systems serve many small farmers, rendering measuring devices and monitoring deliveries often too costly. Analyses have shown that increases in direct water tariffs only release small quantities of water from agriculture for other uses, at a high cost to the irrigation sector as farm incomes drop significantly (Perry 2001, Berbel 2000, Rosegrant 2000, Löfgren 1996). In addition, in existing irrigation systems, prevailing, formal or informal, water rights significantly increase the value of irrigated land. Water rights holders correctly perceive the imposition of water prices, or an increase in existing prices, as expropriation of those rights, reducing the value of land in established irrigation farms. Attempts to establish or increase water prices are thus met with strong opposition from irrigators (Rosegrant 1994). Moreover, current water fees are generally low – limiting the potential for water savings. When water fees increase, adverse impacts on farmer incomes can be large. However, water fees can work well if they are implemented appropriately. Water pricing helps to maximize social welfare by creating incentives to move water to the most productive uses, while less productive applications reduce water use.

An analysis in the Brantas basin in Indonesia revealed water values ranging from 0.02 to 0.11 Dollar per cubic meter while the full water supply cost was 0.006 Dollar per cubic meter and water fees ranged from 4.5 to 13.3 Dollar per hectare or 0.001 Dollar per cubic meter (Rodgers 2005). A river basin model analysis for the Dong Nai River showed that under increasing irrigation service fees, both area and yield for lower-value crops decline rapidly, translating into sharp declines in farmer incomes, while water withdrawals are reduced more slowly, and water savings concomitantly are small (Ringler 2005).

Water Trading in River Basins

The implementation of water use rights together with a brokerage mechanisms or market clearing mechanism at the basin scale, on the other hand, can protect farmer incomes while saving water and supporting water moving into higher-value uses. This will be examined based on three alternative model scenarios using the basin model introduced previously for the Dong Nai River basin in southern Vietnam. Under the Water Use Rights (WRI) scenario, water use rights are allocated to all water-using sectors following historic usage. In the brokerage mechanism or clearinghouse scenario (CH), individual water demand sites can sell unused or purchase additional water use Rights from an agency at the fixed price of 0.02 Dollar and 0.06 Dollar per cubic meter every month. Under the Market Clearing (MC) scenario, in addition, the volume of water use rights sold and bought need to equal.

Under the clearinghouse mechanism, all water-using sectors in the Dong Nai River basin are net buyers of water when the water price is set at 0.02 Dollar per cubic meter, and a total of 1690 million cubic meters are traded providing the agency a net income of 34 million Dollar from water sales for the river basin as a whole (see Figure 2). At the same time, gross irrigation withdrawals increase to 8.7 cubic kilometer. On the other hand, benefits to instream uses like hydropower and environmental uses decline, as they do not have water use rights accorded based on the water law. Moreover, although total profits in the irrigation sector increase, these profits are spread over a much wider irrigation area, and more low-value, water-intensive crops are

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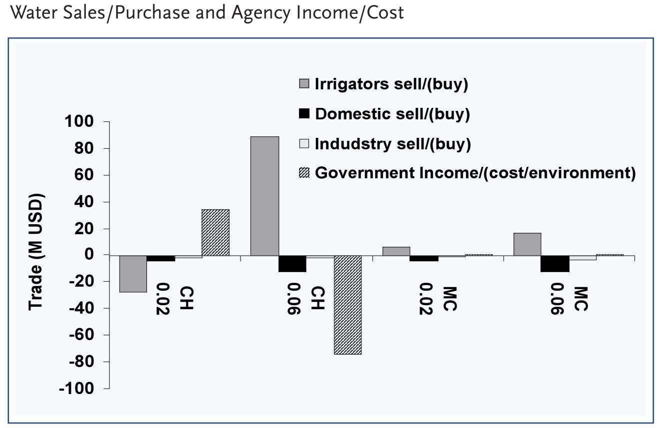
brought into production. As a result, profits decline on a per hectare basis compared to the system with fixed water rights from 591 Dollar per hectare to 538 Dollar per hectare. If the water price in the CH mechanism is set at a higher level, here 0.06 Dollar per cubic meter, it is more profitable for many irrigation systems to sell part of their water use right to the water agency than to continue using the full share of allocated use rights. Due to the large sales of water out of irrigated agriculture, the volume of gross agricultural water withdrawals declines to 3.1 cubic kilometer and irrigated area drops to 0.497 million hectares. As a result, profits from irrigated agriculture alone under the higher water price of 0.06 Dollar per cubic meter are lower compared to the irrigation profits at the agency-set price of 0.02 Dollar per cubic meter. However, the important result is that under the higher water price, profit from irrigated agriculture on a per hectare basis is with 779 Dollar per hectar significantly higher compared to the WRI scenario with 591 Dollar per hectar and the CH scenario at the lower agency-set price with 538 Dollar per hectar. At the price offered for the water use right, irrigating farmers make a substantial share of their use rights available to other off-stream users or the environment, while investing their remaining water resources into crops that are more profitable per cubic meter of water. Thus, water moves to higher-valued uses without income losses to the irrigation sector.

In addition to the brokerage mechanism a market clearing mechanism can be introduced under which net purchases of water need to equal net sales. This ensures that instream water

Figure 2: Clearinghouse and Market Clearing Scenarios – Water Sales/Purchase and Agency Income/Cost



Source: Developed by author

uses are not significantly harmed through large additional water withdrawals. Under this MC scenario, consequently the volume of purchases and sales drops compared to the CH scenarios. At the water price of 0.02 Dollar per cubic meter, irrigation demand sites are unable to purchase water as domestic and industrial sectors themselves strive to purchase water from lower-value irrigation. At the higher water price, trade is even more limited, as domestic and industrial sectors purchase less water than the irrigation sector might be willing to free up at this price. While the quantity of water traded was 1690 MCM under BRK 0.02 Dollar and 1485 MCM under BRK 0.06 Dollar, the corresponding volumes under the market clearing mechanism drop to 284 MCM under MC 0.02 Dollar and 275 MCM under MC 0.06 Dollar, respectively. Although net farm income per hectare under market clearing does not reach brokerage mechanism levels – at which the agency supports water sales from irrigated areas even if no one purchases this water – net profits per hectare irrigated are still greater than under the WRI case.

Conclusion

The implementation of economic incentives depends on the socioeconomic, institutional, physical, and political conditions at the site. And on the relationship between property and pricing regimes, and on the level of transaction costs. Results from many case studies show that increased irrigation service fees would impose a substantial burden on farm economic welfare, while water savings at the basin level would be relatively modest. Simple water trading instruments, including a clearing-house mechanism, and informal or formal water marketing, on the other hand, can induce conservation of water while maintaining farmer incomes. Issues to contemplate during the implementation of a brokerage mechanism include: (a) third-party effects including impacts on the quantity or quality of return flows or reduced economic activity in the water-supplying region, (b) the difficulty of trading water over long distances, (c) the potential for monopoly control over water resources, and (d) the danger of over-exploitation of open-access water resources such as groundwater.

However, despite the beneficial outcomes presented here for a river basin in southern Vietnam for both the irrigation sector and the overall basin economy, economic incentive approaches outside of irrigation service fee payments have seldom been implemented. Such implementation would require (a) strong water use rights systems, (b) careful fitting of instruments to the particular water use and development situation and (c) pilot testing at a smaller scale before attempting large-scale implementation. Much work remains to be done in this area. Important new research areas for economic incentives include their application for water quality control in a river basin context, the assessment of distributional impacts of economic incentives by income class and gender and the linkage of basin-level economic incentives with computable general equilibrium models to assess economy-wide impacts of changing basin water allocations. Also further analysis of the impacts of input and output price support and trade policies on basin water allocation and use as well as research into the political economy of the policy adoption process of economic incentives is needed.

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