Can Irrigation Water Use Be Guided by Market Forces? Theory and Practice

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ABSTRACT  This paper provides insight into the relevance of market forces to typical problems found in irrigated agriculture. It first considers the theoretical basis for the use of economic instruments, such as volumetric water charges and tradable water rights, then considers their usefulness in the context of five case studies of irrigated areas, in Egypt, India, Indonesia, Morocco and Ukraine. The case studies confirm that competition for scarce water and shortage of funds are widespread. To assess the suitability of economic instruments to achieve water management objectives, insight is provided into the current price paid for irrigation water, the cost of service provision and the value to irrigators. It becomes clear that there is a big gap between the price and value of irrigation water. This means that a considerable increase in the price of water is needed to balance supply and demand, which would reduce farm economic welfare substantially. This socio-political problem, plus the technical and administrative complexity of measuring water, make water pricing an unsuitable approach to balance supply and demand.

Introduction

Recent international conferences highlight the problems of competition for scarce water and shortage of funds for maintenance of irrigation facilities. Economic literature has extensively discussed the role of economics in irrigation water management (Merrett, 2002; Rogers et al., 2002; Tardieu & Préfol, 2002). However, at the operational and even the policy level there is still confusion about the meaning of treating irrigation water as an economic good. Some, mainly economists, want to treat water in the same way as other private goods, subject to allocation through competitive market pricing, while others want to treat water as a basic human need that should be largely exempted from competitive market pricing and allocation. So the main question is to what extent irrigation water use can be guided by free market forces or requires some extra management to serve social objectives and whether the complexity of market forces to address priority problems is worthwhile. Some ‘real world’ experiences in five case studies of irrigated areas will be used in this study to clarify the often-dogmatic positions set out by proponents of each perspective.

According to Perry et al. (1997) the answer lies in value judgements and their application to specific conditions of time and place as well as in the kind of objectives.
According to Savenije (2000) treating water as an economic good is about making the right choices, and not necessarily about setting the appropriate price for water. As there seems to be a gap between the role of market forces in theory and practice, not only the theoretical basis for the use of economic instruments will be studied here. The usefulness of policy instruments to achieve water management objectives in the context of issues faced in five case studies of irrigated areas will be studied as well, which is an extension of existing work in this field. Five case studies are selected, covering a range of problems with respect to competition for scarce water and shortage of funds. These are Kemry in Egypt, Tadla in Morroco, Haryana in India, the Brantas Basin in Indonesia and Crimea in the Ukraine.

The next section of this paper studies the theoretical basis for the use of policy instruments to typical problems found in irrigation water management—effective resource management and sustainable financial management. The suitability of policy instruments to achieve various irrigation water management objectives in the context of five case study areas is assessed and the preconditions for introduction of policy instruments are set out in the following section. Reasons why market forces are not widely applied in practice are then described. General conclusions are drawn in the final section.

**Theoretical Basis for the Use of Policy Instruments**

There are various water management objectives, some are connected with *effective resource management*, like balancing supply and demand of water, reallocating water to alternative uses (intra and/or inter-sectoral), increasing productivity of water consumed and avoiding wasteful use, while others are connected with *sustainable financial management*, like cost recovery and generating a stable income to the agency. The following policy instruments can be employed to meet water management objectives: rationing, volumetric water charges, tradable water rights, crop-based and area-based charges. Volumetric water charges and tradable water rights are market-based instruments.

The relevance of each tool to each objective is presented in a matrix (Table 1) and explained in more detail below. It is important to realize that objectives sought, and instruments available, must be evaluated in the context of a dynamic situation.

The suitability and applicability of policy instruments depends not only on water management objectives, but also on preconditions being in place. Required preconditions for the introduction of policy instruments are summarized in Table 2 and described in more detail below. The instruments are put in order of complexity of implementation. The first instrument is the most complex one, with highest transaction costs.

*Rationing* will not raise any money to cover the costs. Rationing can be applied to meet any specified overall level of usage (where supply equals demand). It can be arranged to assign usage in ways that may be socially desirable. Farmers who previously received excess water will realize the opportunity cost of water. This may lead to those formerly growing a crop with a high value of production per hectare, like sugar cane, to switch to a crop with a higher value of production per unit of water consumed. To this extent, usage will be reduced in the most efficient way, but at a wider scale there is no transfer of use from the less productive to more productive users or sectors.

*Volumetric water charges* give clear incentives to reduce water consumption, provided the charges are significant in relation to the value of water and the cost of management.
Charges not only affect demand, but may also encourage increased supply. Volumetric charges are poorly suited to cost recovery: in a drought, where the agency has limited water to sell, revenues will fall proportionately; in a year of high rainfall, demand for irrigation water will be limited, again leading to revenue shortfalls. Volumetric water charges require means of accurate volumetric measurement, so that supplier and user agree on the service that has been provided. Most existing irrigation systems do not allow accurate measurement and disaggregate supply of water.

**Tradable water rights** require first that allocations of water by user are defined, monitorable and enforceable. This step is a major challenge in most water short countries. Once established, tradable water rights then can be bought either on a short-term (seasonal) or long-term (permanent) basis. The price of such rights is usually market-based, that is, there is no interference by government to affect prices, with a component to cover the administrative costs of the trading system (which must also include analysis of third-party impacts). As such, payments made in this market are unrelated to cost recovery.

### Table 1. Whether the objective can be achieved by the tool (Yes, means that it is suitable)

<table>
<thead>
<tr>
<th>Tool objectives</th>
<th>Rationing</th>
<th>Volumetric water charges</th>
<th>Tradable water rights</th>
<th>Crop-based charge</th>
<th>Area-based charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective resource management:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Balance supply and demand</td>
<td>Yes</td>
<td>Possibly</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>– Reallocate to alternative uses</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>– Increase productivity of water consumed</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>Possibly</td>
<td>No</td>
</tr>
<tr>
<td>– Avoid wasteful use</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Sustainable financial management:</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Cost recovery</td>
<td>No</td>
<td>Possibly</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>– Stable income to the agency</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

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### Table 2. Shows which of the preconditions required for implementation of the tools have to be met

<table>
<thead>
<tr>
<th>Tool preconditions</th>
<th>Tradable water rights</th>
<th>Volumetric water charges</th>
<th>Rationing</th>
<th>Crop-based charge</th>
<th>Area-based charge</th>
</tr>
</thead>
<tbody>
<tr>
<td>– Volumetric measurement at farm level</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Disaggregated supply at farm level</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Defined water rights</td>
<td>X</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>– A legal framework to charge for water</td>
<td></td>
<td>X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Disaggregated supply means that adjacent farms can be supplied at different rates and schedules.*
for the provision of the irrigation service itself. In any case, since the trade in water rights will be irregular, depending on hydrological and agricultural market conditions, and prices will similarly vary unpredictably, the income stream from such a system is not well suited to cost recovery objectives. Since the rights available for use of trade will be defined in relation to the known supply of water, tradable water rights must control demand at a certain level, even if new parties enter the market. Like rationing, tradable water rights provide incentives to concentrate usage on the most profitable crops, and since water that is not used can be sold, this traded water will be reassigned to more productive users, thus achieving an additional productivity benefit.

*Crop-based charges* generate a relatively predictable revenue stream to recover costs, especially where irrigation supplements rainfall, because the revenues are independent of the volume of water applied. Since the farmer is left free to select his cropping pattern, there is no particular reason to expect supply and demand to be equalized. It will not reallocate water to more productive users or sectors. It will increase production per unit of water consumed by the individual user if the level of the crop-based charge is sufficiently high to switch from high to low water consuming crops.

*Area-based charges* generate a predictable revenue stream that can recover costs. Such a system will not usually ensure a balance between supply and demand. If the water available is almost always adequate to meet demand, so that all the farmers in a scheme are served equally well, this system can directly allocate the desired level of service charge over the area served, and provide a simple and effective means of charging. There are no incentives in such a scheme to save water or encourage productive use beyond the incentive that every farmer has to farm profitably.

Table 1 shows that none of the instruments meets all of the water management objectives, so that a combination of instruments will usually be required. Instruments can be combined in such a way that they reinforce or complement each other. Although these policy mixes are complex to develop, the most successful experiences show that they are viable and perhaps the only way to achieve multiple-objectives.

**The Role of Market-based Instruments in the Case Study Areas**

The case studies identify the issues faced in each area, confirming that competition for scarce water and shortage of funds are widespread (see Table 3). All study areas except Ukraine are water-short. In Ukraine demand for water is less than the available supply, as poorly maintained equipment deter farmers from irrigating. Two of the study areas (India and Morocco) allocate surface water successfully through quotas, but face problems of uncontrolled and excessive groundwater use.

To assess the suitability of economic instruments to achieve water management objectives, insight is provided into the current price paid for irrigation water, the operation and maintenance (O&M) cost of service provision, and the value to irrigators of the water they receive (see Table 4). The price and costs of water are derived from financial data. The value of water, by contrast, is estimated, since farmers do not bid for water under competitive market conditions involving other economic sectors. Here, the value of irrigation water is taken as the net income received by the farmer per unit of water applied. A simple framework for collecting data related to farm incomes, water and labour use is used in Egypt, Morocco and India to calculate the residual income of crop production (set out in Hellegers & Perry, 2004). By subtracting the cost of other production factors
from the gross production value, the net value added per unit of water is calculated. However, the residual value may also include other values, such as returns to farmer’s management and land. According to the literature such estimated values are, however, consistent with values observed in transactions in water banks (NRC, 2004). The value of water in the Ukraine is based on the difference in benefits minus costs of crop production between irrigated and rainfed land divided by the quantity of water applied (Zhovtonog et al., 2004), which gives a value in the same order of magnitude.

Table 4 shows that the value of water to farmers is considerably higher, usually a multiple of the O&M costs, while the O&M costs are in most cases not fully recovered by water charges. Given the big gap between the price and value of irrigation water, a considerable increase in the price of water would be needed to balance supply and demand, which seems socially undesirable as it imposes a substantial burden on farm economic welfare. This socio-political problem, plus the technical and administrative complexity of measuring and accounting for water, make pricing an unsuitable approach to balancing supply and demand. Table 5 shows that important preconditions for the introduction of market-based instruments are absent in most study areas.

The objective of managing scarcity is most readily achieved through quotas, which also encourage farmers to seek the most productive use of water. Beyond quotas, tradable water rights offer additional gains through the potential for water reallocation.

Simple crop- or area-based charging systems with low administrative costs and a high degree of transparency are most suited to achieving cost recovery objectives.

<table>
<thead>
<tr>
<th>Study area</th>
<th>Kemry</th>
<th>Haryana saline</th>
<th>Haryana fresh</th>
<th>Brantas</th>
<th>Tadla</th>
<th>Crimea</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effective resource management:</td>
<td>X</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>– Balance supply and demand</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>– Reallocate to alternative uses</td>
<td>X</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>– Increase productivity of water consumed</td>
<td>X</td>
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<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sustainable financial management</td>
<td>X</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Sustainable environmental management</td>
<td>X</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
<td>X&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

<sup>a</sup>Supply and demand of canal water are balanced, but there is excessive groundwater use
Reasons Why Market Forces Are Not Widely Applied in Practice

In theory, market-pricing and tradable water rights can lead to an efficient allocation, but neither instrument has been applied successfully in the case studies due to (i) preferences of society to allocate water according to politically defined priorities; (ii) market failure; and (iii) implementation problems. Experiences from the study areas are reviewed below.

Preferences of Society

Society may prefer to allocate water in ways that are inconsistent with the likely outcome of a free market. There are often multiple-objectives. Generally, the basic allocation of water among sectors is a political decision, since allocation has so many implications that it can often not be left to the free market. It may for instance trigger socially undesirable changes in income distribution. Water availability will serve the greater benefit of society as a whole, and has thus as many possible values as there are perspectives on what is ‘right’ for society. Water used for irrigation can, for instance, be a powerful means of reducing food costs to poor people; support economic development in rural areas, providing jobs and supporting agro-food industries in areas, which should otherwise become depopulated.

- Market prices will not be used to balance supply and demand in case it will impose a socially undesirable big burden on farm economic welfare.
- Diverting water away in Egypt from long-developed areas with high productivity to newer less productive areas may reduce overall production. Nevertheless it is a political priority to expand the irrigated area in backward areas.
- Historical, social, cultural and religious barriers often exist. Water is a basic human need. Charging agriculture for water may therefore be a politically sensitive issue. In principle, charging for the service of providing water is acceptable, but charging for the water is not; making volumetric charging a contentious issue.

Market Failure

Irrigation may cause environmental externalities, such as waterlogging and exploitation of aquifers beyond its sustainable yield in fresh groundwater areas in Haryana and Tadla, due
to the common-pool nature of aquifers. When the market does not internalize such externalities, it will not allocate resources appropriately.

Implementation Problems

Important preconditions for the introduction of market prices and tradable water rights are absent in most study areas (see Table 5). The design of the irrigation system makes volumetric measurement and disaggregated supply impossible in Haryana and Brantas. The British irrigation system, as in Egypt, is, for instance, less well designed for the use of volumetric charges and tradable water rights than the French system, as in Morocco, as the latter has more accurate distribution and measuring structures. It is determining whether the concept of scarcity was dominant in the original design, like in Morocco. Volumetric measurement and disaggregate supply are especially problematic in field-to-field irrigation. In Crimea there are problems with respect to disaggregated water supply at the much smaller scale of future privatized farms. There are currently also no defined rights for groundwater use in Haryana and Tadla. A legal framework to charge for water is not in place yet in Kemry and Haryana. Because some of the preconditions, such as the design of the irrigation system, cannot be easily changed in the short run, they can be considered as given. However, in the long run actions can be taken to put the required preconditions in place. Whether preconditions will be met, depends consequently on the time horizon.

The transaction costs might block the introduction of market-pricing and tradable water rights, since introduction is usually conditional upon the size of additional benefits—efficiency gains—relative to extra costs involved.

When it is hard to internalize social preferences or externalities, public intervention is often needed. Such required 'adjustments' to free market outcomes explain why market solutions are rarely found in water management. This conclusion is identical to that reached by Merrett (2003), who concludes that the market approach is rarely applicable.

Conclusions

At the beginning of this paper the question was raised to what extent irrigation water use can be guided by free market forces or requires some extra management to serve social objectives, and whether the complexity of free market forces to address priority problems in the study areas is worthwhile. The experiences from the case studies show that if the objective of managing scarcity is achieved through rationing, which is the most common instrument currently in effect in most study areas, the potential role of market-prices and tradable water rights is limited.

Although market-pricing and tradable water rights can lead to an efficient allocation in theory, they are rarely found in practice, as outcomes of the market do not often result in a water allocation that meets the legitimate concerns about environmental, social and other factors. In part this is because outcomes of the market do not often result in an allocation that meets preferences of society. Besides, there is market failure. Furthermore, there are implementation problems. This explains the observed absence of market solutions and the potentially limited role of market-pricing and tradable water rights in water management, which is probably typical of many developing country situations.
Nevertheless, economics provides the means of analysing the implications of water use and allocation on the basis of trade-off analyses that show the financial, environmental and economic implications for those directly concerned, and for society more generally.

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References
