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Water Charging in Irrigated Agriculture

Lessons from the literature

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Report OD 145
December 2002

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Summary

Water Charging in Irrigated Agriculture

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This review has been prepared as part of a research project on Irrigation Charging, Water Saving and Sustainable Livelihoods, funded by the British Government's Department for International Development. The wider aim of the project is to draw together information that will allow critical assessment of irrigation water charging, either as a means to recover costs or to manage demand. Based on this assessment, the project will develop practical guidelines on water pricing policies and charging mechanisms which will take account of the costs and practical issues associated with charging and the wider policy aims that charging for water may seek to realise.

This document is the first output of the project and presents an overview of experiences in irrigation water charging, as reported in the literature. We believe it will be of value to policy makers and researchers who formulate or advise on irrigation policy. The need remains for practical and concise guidelines and this will be addressed in the subsequent stages of this project.

Chapter 1 gives brief definitions of some key terms and the scope of the review. Chapter 2 provides a brief synopsis of recent international policy development towards water pricing in general. The same chapter examines to what extent the experiences and lessons from the municipal and industrial supply sector may or may not be transferable to water use in agriculture. Chapter 3 reviews the objectives of irrigation water pricing, as described in the literature. In chapter 4 we set out the different methods for charging for water and the practical issues of implementation that are associated with each of them. We also underscore the importance of ensuring that the basis for charging is consistent with the overall policy objective. Chapter 5 sets out the main institutional and organisational issues affecting water charging and Chapter 6 describes some of the principal challenges that face any government or agency wishing to establish a viable water charging system. Chapter 7 sets out several countries' experience of water pricing in agriculture – illustrating a broad spectrum of experience from less-developed to more-developed countries. The final chapter sets out the principal findings of the review and identifies those areas where the published literature appears to be lacking. Annex 1 presents a synopsis of the quantitative data on irrigation pricing obtained from the literature together with a brief analysis of what those data indicate by way of price ranges, the use of different bases for charging, levels of fee recovery and reported levels of cost recovery.

Summary *continued*

The main conclusions of the review are summarised here.

Designing a charging system

a) In practice, the most widely pursued objectives are cost recovery and demand management. Macro-economic concerns of resource allocation between sectors, pollution charging and benefit taxation are recorded in the theoretical literature but they are seldom the key drivers of national policies.

b) There is often a lack of clarity in the objectives of water charging policies.

c) Where the objective is to recover some part of the cost of service delivery, the range of costs that may or may not be factored into the price calculation is large. In practice, most programmes seek only to recover annual operation and maintenance (O&M) costs and possibly some fraction of capital investment costs.

d) Non-volumetric water pricing can be used where the objective is cost recovery. It is much simpler to administer than volumetric pricing as there is no requirement for extensive measurement infrastructure and continuous field recording.

e) Volumetric water pricing or tradable water allocations are used where the objective is to reduce water demand in the agricultural sector. However, there is little practical evidence from the field to support the view that volumetric pricing changes farmers' water demand patterns. Even in Jordan, Israel and Morocco, countries facing extreme water scarcity, the aim of water pricing is to recover service delivery costs. Volumetric water allocations, rather than water price, are used to ensure that other sectors' needs are met. In all of these countries water is priced on a volumetric or approximate volumetric basis to indicate its value to users and discourage profligate use, but there is no attempt to use water pricing to achieve the balance between supply and the demand of competing sectors.

f) The most widely used price structure, which is adequate where the sole objective is cost recovery, is a fixed cost per hectare. In some cases this may vary according to crop type, with higher charges for more water demanding crops. Any price structure that contains a volumetric element is impractical where the infrastructure is lacking to routinely measure the volume used. Where this infrastructure exists a two part tariff (with a fixed element to cover O&M costs and a variable element to reflect consumption) may be simpler to administer than more complex rising block tariffs.

g) Water markets and tradable water rights could theoretically be more effective than water pricing as a means of achieving allocation efficiency. However, formal water markets may potentially lead to inequitable access to water resources and disadvantage poor farmers who lack resources to buy water. Unless safeguards are provided there is a risk that water will flow increasingly according to purchasing power. Formal markets for large transactions between sectors require a well-defined legal and regulatory framework and are mainly found in developed countries, with Australia and Spain being widely cited examples.

The effects of charging on water saving

a) The price response to volumetric water charging is widely shown to be minimal. Current prices are well below the range where water saving is a significant financial consideration for the farmer, so prices must be raised dramatically and generally well beyond estimates of the cost of the service, if volumetric charges are to have a significant impact on demand. Some authors suggest that volumetric prices would need to be 10 to 20 times the price needed for recovery of the full supply cost before demand was affected and this would have unacceptable political implications in most countries.

b) Water scarcity will continue to increase, leading to more competition for water between agricultural, municipal and industrial sectors. The agricultural sector is seen as wasteful in its use of water when, on large irrigation schemes with open channel conveyance, as much as 70% of water diverted from a source fails to arrive at the crop. However, three important points must be made concerning these 'losses':

- 'Lost' water often returns to an aquifer or river and can therefore be used by downstream users. It is only lost if it deteriorates in quality or drains to a sink from which it cannot be economically recovered. Thus switching to 'high tech' irrigation methods such as drip or sprinkler may not result in any overall savings of water if the previous losses were recaptured by others.
- The farmers' in-field management of water accounts for less than half of the losses. More than half the total losses occur in the conveyance and distribution canals. As individual farmers have no control of this infrastructure, pricing incentives cannot affect these losses.
- Withdrawal of water, which then returns to a river or an aquifer, will increase the cost of service delivery but may not affect overall levels of water scarcity.

Implementing charging policies

a) Even the theoretically simple objective of full supply cost recovery has been difficult to achieve in practice. Japan, France, Australia, Spain and the Netherlands stand out as achieving full recovery of annual O&M costs and some recovery of capital costs in certain schemes. However, in the overwhelming number of cases, water charging is not covering even annual O&M costs. The literature refers to various institutional and political factors that hamper full cost recovery in different countries, including:

- The lack of political will to impose higher costs on farmers.
- Unwillingness to reduce costs by slimming down overstaffed government agencies.
- Lack of motivation on the part of agencies charged with fee collection, as fees return to the treasury and recovery is not linked to funding.
- A vicious cycle of low O&M expenditure leading to poor performance and increasing reluctance on the part of farmers to pay when they see no benefit.
- Insufficient resources – time, money, training – given to planning and implementing cost-effective charging mechanisms.

Summary continued

- Practical and political difficulties associated with enforcement of pricing policies.

b) The widespread policy of irrigation management transfer does not necessarily ensure recovery of full supply costs. The literature indicates that whilst turnover often leads to an increase in levels of cost recovery, revenues are still generally insufficient to cover full supply costs as tariffs are set too low.

c) Where volumetric charging is applied to limit consumption, delivery must be measured and controlled to the individual user. The nature of most irrigation systems in developing countries, often serving thousands of small farmers, requires that the service is provided to an aggregated group of farmers. Massive investments in re-engineering would be required to even theoretically provide for "volumetric" delivery and pricing to each farmer, and given the poor level of "aggregated" service now observed, the challenge to administration and management would be unrealistic.

d) It is important that the objectives of a water pricing programme are clearly articulated in any discussion. Cost recovery and water demand management are two distinct objectives which require different types of intervention. It is surprisingly common to find substantial documents where these different objectives are apparently interchanged at random. This confusion, or blurring, of objective must be avoided so that policy makers, and those who advise them, have a clear understanding of what they are seeking to achieve and the tools that are relevant to that objective.

e) The introduction of a water charging policy should not be viewed as a 'silver bullet' that can deliver all. Rather, water charging should be part of a larger package of measures designed to move from the vicious circle of deteriorating service, user reluctance to pay leading to further decline, to a virtuous circle where farmers are willing to pay for a good service with the revenue collected invested in sustained and improved service delivery. In the case of demand management the literature again indicates that pricing is only one element. Legally recognised water rights and allocations and the use of tradable water rights are other common elements in such a programme.

Information gaps

a) Much of the literature focuses on economic water pricing and its contribution to more efficient water use. There is little information on the 'social good' aspects of water charges. As a result there is a divide between the theory of water pricing and reality, where subsidies in providing irrigation services are common and have even increased. Given budgetary constraints such subsidy is commonly regarded as unsustainable but there is a need to better understand actual subsidy levels and ask what subsidies can or should be used to achieve.

b) There is much written material on water pricing but far less on effective collection mechanisms. In many countries the issue is not one of how to determine the level of water prices, but how to implement and enforce any pricing policy. Without due consideration of the revenue collection and enforcement systems, policy makers may design pricing policies that are theoretically sound but unmanageable in practice.

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1. INTRODUCTION

1.1 Aim and purpose of present study

This review has been prepared as part of a research project on Irrigation Charging, Water Saving and Sustainable Livelihoods, funded by the British Government's Department for International Development. The wider aim of the project is to draw together quantitative data that will allow critical assessment of the claims that are now being made with regard to irrigation water charging, either as a tool for cost recovery or demand management. Based on this assessment, the project will develop practical guidelines on water pricing policies and charging mechanisms which will take account of the costs and practical issues associated with charging and the wider political aims that charging for water may seek to realise. This document is the first output of the project and presents an overview of experiences in irrigation water charging, as reported in the literature.

The purpose of the literature review was initially to ensure that the research team was fully aware of the current state of knowledge and debate. However, as the work continued it became apparent that although there was a large amount of literature available covering certain aspects of water charging in the irrigation sector, there were other aspects, particularly relating to the practical issues of the mechanisms to levy and collect water charges, that were less well documented. Furthermore, although there is a considerable body of literature, there are few recent, analytical reviews that address the practice as well as theory. For these reasons, this review aims to highlight the gaps in the literature and to make our own findings more widely available. We believe it will be of value to researchers and policy makers but this report does not fulfil the need for practical and concise guidelines for those who formulate and implement policy. That need remains and will be addressed in the subsequent stages of this project.

1.2 Terms and definitions

1.2.1 Water charging

This document uses the term "water charging" as an inclusive term embracing all of the policies, practical actions and mechanisms required to set a price for water, decide the basis on which a charge will be levied, levy the charge and collect the revenue.

1.2.2 Water pricing

Water pricing is used in a restricted way to refer to the process of defining the monetary value or values that will be levied. It is thus only a part of the wider process of water charging. In some cultural or political contexts it is unacceptable to place a price on water and therefore other terms such as irrigation service fee (ISF) are used, with the emphasis being that the charge is made for the *service* of supplying water to the user, not for the water itself. We have used "water pricing" to include both concepts – a price set on the water or on the infrastructure and services required to manage and delivery it.

1.2.3 Water use efficiency

"Water use efficiency" is a common phrase in the literature, often meant to convey two quite different concepts: the first relates the volume of water diverted from a source to the volume consumed in the target activity – with "losses" such as seepage counting as an inefficiency in the system. The second meaning of "water use efficiency" is actually a productivity concept – how much is produced per unit of water consumed (or indeed, sometimes per unit of water diverted – thus embodying both "efficiency" concepts in one rather confused measurement). These two distinct meanings have carried through on occasions where we have used quotations from the literature.

1.2.4 The cost of water

The general principles for the "cost of water" as set out by the GWP (Global Water Partnership) (2000a) present a full analysis of the different cost elements that may be factored into a calculation of the cost of supplying water. Whilst the GWP definitions are helpful, they are not always adhered to and some authors may use the same terms but with different definitions. Even when terms correspond there is certainly no universal agreement on what level of cost it may be practical to recover through water charging. In some OECD (Organisation for Economic Co-operation and Development) countries, "full cost recovery" refers to operation and maintenance (O&M) costs only, whereas in others it is the recovery of O&M and capital costs (OECD, 1999). In the European Union, the term incorporates scarcity values and environmental externalities (European Union, internet; OECD, 1999), which is similar to the Global Water Partnership definition. In the definition of capital costs it is unclear whether this should include the costs of replacing equipment at today's prices or the historic costs of existing equipment. Both approaches are adopted in the literature, depending on the situation. In cases of asset transfer from public to private ownership, asset capital values may often be written down by using their historic building costs rather than present day replacement value.

GWP (2000a) distinguish three types of costs: Full Supply Costs, Full Economic Costs and Full Costs as shown in Figure 1.

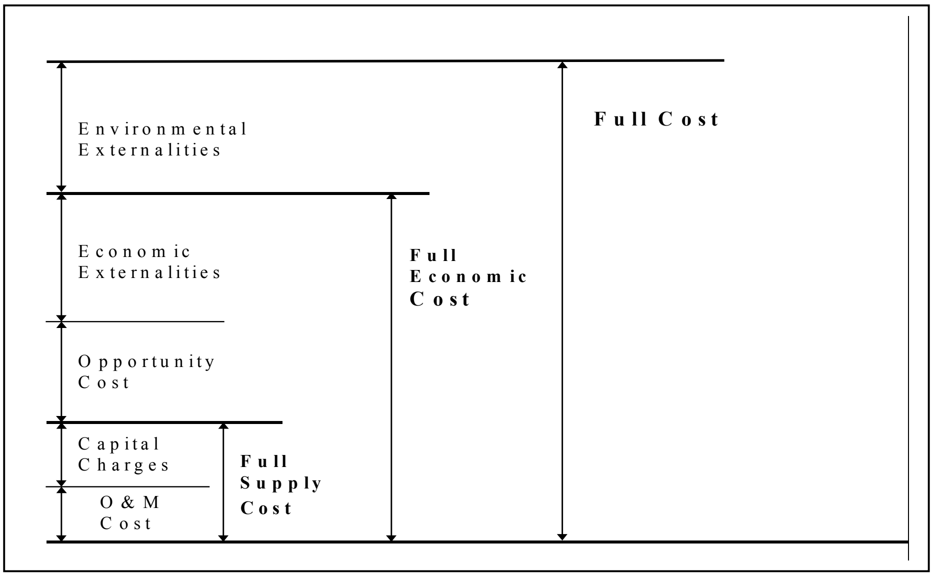

Figure 1 General principles for the cost of water

The Full *Supply* Cost includes the cost associated with the supply of water without consideration of externalities (externalities are the indirect consequences or side effects of supplying water to a particular user or sector). It includes the operation and maintenance of irrigation infrastructure and capital investment. Full Economic Costs include the full supply costs plus opportunity costs and economic externalities. Opportunity costs acknowledge that by using the water, another user is deprived of it. If the other use has a higher socio-economic value, then there are some costs to society due to 'misallocation' of resources or inefficient use, from a pure, or classical, economic point of view. Full Costs include full economic costs plus economic and environmental externalities. Externalities arise when costs or benefits associated with extraction and use of the resource are imposed on third parties. Externalities, both positive and negative, are an important component in costs related to irrigation water use.

Cost recovery concerns full supply costs only, costs that can be fairly readily defined, whereas efficient water allocation within a country or basin context requires consideration of opportunity costs and externalities. These are valid concepts but agreeing a numerical value for them is notoriously difficult. In the words of one ICID report, "information concerning opportunity costs is difficult to obtain, they vary by place and season, and even sophisticated research studies cannot estimate them in a way that is universally accepted" (ICID, 1997). Given the difficulties associated with quantifying these components of the full economic cost, they are unlikely to play a useful role in discussion of the actual price or price structure that applies to a given group of water users – they guide sectoral allocation, not detailed pricing.

1.3 Scope and limits of the review

First, the focus here is on charging for *irrigation* water. Some might argue that this is an excessively narrow perspective because agencies that provide irrigation water often provide closely related services – agricultural and storm drainage, domestic and commercial water supply, sewage disposal, flood control and groundwater management to name the most common. Each of these services has its own financial dimensions if that service is to be efficient and sustainable. Often, however, the nature of these services and their beneficiary groups are different, so that trying to compile an integrated description of the water charging issues across these various activities would encompass too many variables. Interest in irrigation charging is often directly focused on the two issues of *financial sustainability* of irrigation systems, and the problem of *perceived excessive water consumption* in irrigation. We therefore focus narrowly on the issue of irrigation water charging and do not address charging for non-irrigation services, although we recognise that charging for these services may be a legitimate means of achieving financial sustainability.

Second, the current interest in private sector participation in water service delivery *in general* depends, for much of its rationale, on the recent trend towards various forms of private management of municipal and industrial (M&I) water supply utilities. This literature review addresses water use in agriculture – the dominant consumer of water in most developing countries – but it is important to understand the approach that has been taken in the M&I sectors, distinguishing between those issues that are relevant to the irrigation sector, and those that are not.

Following this introduction, chapter 2 provides a brief synopsis of recent international policy development towards water pricing in general. The same chapter examines to what extent the experiences and lessons from the municipal and industrial supply sector may or may not be transferable to water use in agriculture. Chapter 3 reviews the objectives of irrigation water charging, as described in the literature. In chapter 4 we set out the different methods for charging for water and the practical issues of implementation that are associated with each of them. We also underscore the importance of ensuring that the basis for charging is consistent with the overall policy objective. Chapter 5 sets out the main institutional and organisational issues affecting water charging and Chapter 6 describes some of the principal challenges that face any government or agency wishing to establish a viable water charging system. Chapter 7 sets out several countries' experience of water charging in agriculture – illustrating a broad spectrum of experience from less-developed to more-developed countries. The final chapter sets out the principal findings of the review and identifies those areas where the published literature appears to be lacking.

2. BACKGROUND

2.1 Trends in international policy development

Water charging began to feature prominently as a policy issue following the Dublin International Conference on Water and the Environment in 1992. Whereas the call for self-financing and cost recovery of operation and maintenance costs has a longer history, the Dublin Conference established the concept that water itself is an 'economic good'. The principle, one of the four agreed at the Conference, suggested that full cost charging, however defined, besides being a sound business principle, could be a potent instrument in water management (see Box 1).

> **Box 1. Dublin Principle No 4**
>
> "Managing water as an economic good is an important way of achieving efficient and equitable use, and of encouraging conservation and protection of water resources"

Since the Dublin Conference, water charging has been on the agenda. It has been reinforced in documents such as the World Bank's Water Resource Management Policy Paper (1993) and the Asian Development Bank's Water Policy Paper (Arriens *et al.,* 1996). The Dublin Principles made explicit reference to water as a social good only with regard to domestic water supply, viz., *'…within this principle, it is vital to recognise first the basic right of all human beings to have access to clean water and sanitation at an affordable price.'* However, at the UN Conference on Environment and Development, Rio de Janeiro, 1992, the social emphasis was added to give 'water is an economic and social good'.

The notion of water pricing as an effective management instrument was further promoted at the Second World Water Forum in The Hague, in March 2000. The Declaration of the Ministerial Conference, attended by over 100 ministerial delegations, made "full cost water pricing" a prominent recommendation and one of the seven challenges to resolve the water crisis. On the same occasion, full cost pricing of water, based on the "user pays" principle, was highlighted as being one of the most important issues in the World Water Vision (Cosgrove and Rijsberman, 2000; World Commission on Water, 2000). The "Framework for Action" presented at the Forum recommended the introduction of pricing to facilitate full cost recovery and to encourage careful use. It further stressed the need to link pricing to benefits in improved services and the need to establish effective charging systems and mechanisms to protect the poor (GWP, 2000b).

The Bonn International Conference on Freshwater, held in December 2001, was more cautious, playing down the possible contribution of water pricing to water management, and instead focusing on the recovery of operational and financial costs. This caution was partly caused by the 'water as a human right' debate that had gained importance in the previous two years and which advocated that no-one should be denied access to water. This suggests that agricultural water users (the customers who use most water) should be charged fully for operational and financial costs, whereas financial support to poor domestic users could continue (see Box 2).

> **Box 2. Statement from the Bonn International Conference on Freshwater**
>
> "Water service providers should aim for financial sustainability through receiving sufficient income from their customers to finance operation, maintenance and capital costs. Balancing this, however, cost recovery objectives should not be a barrier to poor people's access to water supply and sanitation…Efforts to recover cost should focus on those customers who use most water. The authorities that set tariffs should be willing to charge the full cost to users that can afford to pay…Transparent subsidies can be applied where appropriate and necessary to preserve ecosystems."

It is worthwhile to contrast the global policy discussion from Dublin onwards with actual water charging policies in practice. It appears that most headway has been made towards self-financing of domestic water supply. Less has been achieved in cost recovery and water pricing in irrigation services, or for that matter in financing of other water services, such as wastewater treatment, drainage, flood protection or river basin management.

There has been substantive discussion in several major irrigated countries, such as India, Pakistan, Egypt, Thailand, Vietnam, China and Indonesia, on the introduction of full cost irrigation charging, but there has been little effective implementation as yet. Rather, in some countries, there has been a reverse trend, where water charges have been abolished (Taiwan, Poland, Punjab India), recovery rates have decreased (Eastern Europe, Pakistan) or the introduction of irrigation charges has stalled (Indonesia). A major exception to this development is the EU Water Framework Directive that aims at full cost water pricing in all member states by 2010 (see Box 3).

Box 3. EU Water Framework Directive, Article 9

Member states shall ensure that by 2010:
- Water pricing policies provide adequate incentives for users to use water resources efficiently, and thereby contribute to the environmental objectives of this Directive.
- There will be an adequate contribution from the different water uses, disaggregated into at least industry, households and agriculture, to the recovery of the costs of water services, based on economic analysis…

EU (2000), Directive 2000, Establishing a framework for Community action in the field of water policy

Finally, Savenije and van der Zaag (2002) argue that the interpretation of the Dublin Principle and subsequent statements has led to great confusion over what actions follow from the understanding of water as a economic good. They identify two schools of thought, aligning themselves firmly with the second: "The first school maintains that water should be priced at its economic value. The market will then ensure that the water is allocated to its best uses. The second school interprets 'water as an economic good' to mean the process of integrated decision making on the allocation of scarce resources, which does not necessarily involve financial transactions." They argue that economics, properly understood, is about how best to meet all human wants (Gaffney, 1997, cited by Savenije and van der Zaag, 2002). They urge that to treat water as an economic good is to be concerned with more than its allocation to a highest value use.

2.2 Experience from municipal and industrial water services

Before looking into irrigation water charging it is worth examining the water services for municipal and industrial uses where there is more experience with water pricing issues. The following gives a brief review of the water supply sector, informed largely by the experience in England and Wales since privatisation in 1989. Clearly, there will be many different experiences but this highlights the general areas of similarity and difference between the domestic water sector and agriculture [1].

The regulatory process for water supply companies in the UK defines three categories of costs:

- Operating costs, such as plant, labour, materials and buildings.
- Capital costs of building new and replacement works.
- The cost of obtaining the capital needed to build the works.

1 This review of M&I charging policies is based on exchanges with John Brindley, an expert who was intimately involved in the privatisation process in England and Wales, and who continues to work within the regulatory process.

Operating costs form at least half the costs of the water service[2] in the water companies of England and Wales. Some of these costs, such as chemicals for treatment, fuel for pumping, and abstraction fees, are related to the amount of product supplied and some are more fixed, such as buildings, administration staff and mobile plant.

Capital costs: Throughout the continuing life of a utility business, capital works are needed to replace and enhance the assets to maintain the required performance. Creating these works incurs the costs of planning, designing, building and commissioning the works. There are two categories of capital works: those that are needed to maintain the existing performance, *Capital Maintenance*, and those that raise the performance to a new level, *Capital Enhancements.* To maintain existing performance, assets require piecemeal refurbishment and replacement to ensure that the whole integrated infrastructure continues to provide the same level of serviceability. To raise performance to a new level, existing assets are improved or new assets are added and the value of the infrastructure is then increased by the cost of those works.

Cost of capital is the remuneration to the providers of capital, both equity shareholders and lenders. The actual capital base on which this return has to be provided depends on the history of the utility. For a new, green-field site utility, the capital base is the cost of procuring the works. More usually, the works have grown over time and under a variety of ownership, often in the public sector. In such cases, the value of the business is defined by the value of the expected income stream rather than by the original cost of the assets or their replacement cost.

A water utility charges a tariff that brings in income that matches the total of the operating and maintenance costs, the capital maintenance costs and a proper return on capital. The tariff can be structured to distribute the burden of the costs across the users as required. But cost recovery must be more than just allowing a (monopoly) utility to recover whatever costs it chooses to incur and whatever profit it chooses to make – hence the need for an external regulator to ensure that:

- Costs are no more than those that a “reasonably efficient” utility would incur.
- Return on capital is no more than the market would accept at that level of investment risk.
- Performance is maintained at the proper levels, with proper stewardship of the assets.

In an unregulated monopoly, there will be the dangers of insufficient capital maintenance (allowing short-term deterioration of the assets) and excessive return on capital. Water is very seldom a competitive ‘commodity’ and some form of regulation has to be brought to bear to ensure that the performance standards are maintained, the tariffs are reasonable and the utility continues to be able to fund its function. A regulator therefore has to police the proper performance, decide what reasonable but challenging costs should be, ensure that the capital value remains appropriate and decide the appropriate level of return for investors.

Within those tight relationships between costs and charges, there is limited scope for providing signals that might influence the behaviour of the water users. This can occur where water is expensive in the context of the user’s total costs. As water prices began to rise in the UK in the 1990s, many manufacturing and process businesses commissioned water audits and reduced their consumption significantly. However, domestic customers take two-thirds of the water supplied and are less inclined to cut consumption; water is not generally a large part of the household bill.

If the water utility is seen as a public service organisation, customers might be expected to respond by reducing demand. In England and Wales, although this perception is dwindling, the regulators and the industry are promoting water efficient devices, such as smaller cisterns and washing machines. Much research has been done on the components of water use and many appliances are now more water efficient. Thames Water, who supply 2,000 Ml/day, claimed savings last year of just 0.1 Ml/day from the

2 Water service means supply of water and collection and treatment of sewerage and drainage water.

introduction of efficiency measures (a saving of 0.005%). This is small but it is difficult to assess whether it has halted any increase that may have occurred without the measures.

The surest way to make customers use less water is to turn it off. First, hosepipes are banned and then water is made available only through standpipes. Experiences in Yorkshire in 1995 show that this approach is only acceptable in the rarest of circumstances - rarer than once in a hundred years or so. Apart from these rather drastic measures, effective signals can only be given through the cost of the volume of water taken. This needs reliable meters on every consumer connection, which is not universally seen as an economic cost.

Tariffs can be arranged, spread, distorted or targeted within the total revenue profile to give signals to high users or protection to the needy. This is particularly true in a monopoly, where competitors will not undermine the structure with opportunistic bids. It is notable that competition for commercial customers starts from where the new supplier has the lower costs; competition is strictly cost-based and there is no scope for artificial signals. The scope for changing people's habits by redistribution of the tariff is still limited if the aim is only to recover costs. It is likely that effective inhibition of use will result only from the introduction of extra costs. Any such extra costs would be expected to be related to volume and would therefore be, in effect, an additional abstraction charge. In England and Wales the abstraction charges are limited to the administration charges of the regulator and are small – less than US$ 5.7 per property per year, corresponding to a small percentage of the total cost of operations (5% or so), and equating to perhaps 5.5 US cents per cubic metre (US$ 55 per 1000 cubic metres).

Rising block tariffs do send signals but there are problems. More sophisticated meters would be needed to measure higher use over any periods other than the present reading frequency (which is normally 6 months in the UK) and meters would have to be read every time, not just estimated, as at present. Unfortunately, in domestic supply it is difficult to distinguish between profligate high consumption and high consumption through need, say for large families or medical reasons. A simple option would charge punitively for every cubic metre taken during any reading period that exceeds the annual average, thereby penalising anything but steady consumption. Some pilot studies were carried out in the UK ten or twelve years ago to establish use patterns and some rising block tariffs and seasonal tariffs were included. However, the main conclusion was that households use some 5% to 15% less water if they are put on a meter for the first time; the impact of other tariff systems was less conclusive.

Generally, the utility, as well as the customer, is under pressure from increased abstraction charges. Losses in the distribution system are costly to find and fix. Short-term profits are to be gained from delaying infrastructure maintenance. High marginal cost of water would encourage the utility to economise in its water use. Here again, it is complicated to link the marginal costs of specific resource works to specific marginal use at any time. Losses are, in effect, use by the utility. As long as leaks are easy to find and repair, leakage reduction is cheaper than finding more water. However, ageing networks in large, crowded cities may be more expensive to fix and it can be cheaper to introduce new sources.

If prices are not used artificially to bring demand and supply into balance, demand is met by building successively more expensive schemes to produce more water. Utilities are obliged to have enough water available to supply likely demand with some agreed amount of headroom. The economic regulator is obliged to ensure that the utilities can fund their function but is not obliged to see that the extra charges are distributed in any specific pattern.

This brief overview of the M&I sector highlights important and intuitively predictable similarities with irrigation services:

- The components of the service cost – O&M, rehabilitation and improvement, capital costs.
- The need to clearly identify appropriate levels of expenditure.
- The need to identify sources of funds for these costs, and appropriate charging strategies.
- Demand is not very price-sensitive as long as the service charge is small in relation to overall budgets.

Less intuitive outcomes, which relate closely to general experiences in irrigation, are:

- In the UK at least, meter use is presently limited to just 23% of households nationally.
- Metering is politically sensitive and not enforced even at the "regional" level of a large residential complex.
- Sophisticated metering for a commodity priced at about US$ 1.4 / m^3 is not financially viable. (The corresponding value in irrigation is 1-10% of this figure.)
- The "capital cost recovery" in M&I is nominal and is based on an estimate of the value of the revenue stream (which in turn is based closely on previous, subsidised revenue streams). This means that the implicit capital subsidy in relation to asset values at the time of privatisation was some 85%, and by now is 96%, although some of this increase relates to interim capital improvements which are recovered.

A critical difference between M&I services and irrigation is that (if we take the cost of abstraction as constant at, for example, 5.5 US cents / m^3) the dominant proportion of the cost of providing the M&I service is treatment and operational costs, capital maintenance and replacement. In irrigation, an abstraction cost of 5.5 US cents / m^3 would be the dominant element in the overall cost – because treatment costs are essentially zero, and other costs – given the very large volumes of water delivered, are low per cubic metre.

The implication of this is that placing an abstraction (or resource) charge on water that would be sufficient to influence M&I demand would render irrigated agriculture completely unprofitable. Essentially these are two markets which barely intersect – one a high cost, low volume market, the other low cost and high volume. In sum, the lessons from the M&I sector are clear as regards recovery of costs, and indeed which costs can be recovered, but they offer no great insights in relation to demand management.

3. OBJECTIVES OF IRRIGATION WATER CHARGING

"Everyone involved in irrigation and water resource issues claims to recognise that institutional, policy, and political issues are central causes of poor performance. But it has proven difficult to focus governments' and donors' attention on these matters, and develop long-term solutions that can be implemented" (Merrey, 1997, cited in Johansson, 2000, p.44).

This chapter provides an overview of water charging objectives mentioned in the literature. Chapter 4 then reviews the implementation of different charging mechanisms and the links that should exist between objectives and charging mechanisms.

Water policies and strategies now often require the implementation of some form of water charging. In many cases, attempts at reforming water pricing stem from financial crisis, low recovery of costs, deteriorating infrastructure, and increasing water demand (Johansson, 2000). Policy makers tend to pursue a variety of objectives through pricing (Dinar and Subramanian, 1998). However, it is crucial to clearly distinguish between different policy objectives and implementation modalities, because, in practice, stated objectives and implemented methods are not always compatible.

In practice, the objectives of charging for irrigation water are often confused. Each objective can have different implications for the method of charging (Meinzen-Dick, 2001). There may be some overlap between them (Molle, 2001a) but some objectives will be incompatible with some charging methods. Box 4 provides an overview of water charging objectives for agriculture that are cited in the literature and the following sub-sections discuss these in more detail.

Box 4. Possible objectives of irrigation water charging

<u>Service delivery – cost and accountability</u>

- To cover the costs of providing the service – ranging from operation and maintenance (O&M) costs to full supply cost, including capital expenses
  (Ahmad, 2000; Meinzen-Dick, 2001; Molle, 2001a; Perry, 2001a, 2001b; Svendsen, 2001a).
- To improve accountability of the water provider to users (Gerards *et al*., 1991).

<u>Water allocation and quality</u>

- To provide an incentive for the efficient use of scarce water resources
  (Ahmad, 2000; Meinzen-Dick, 2001; Molle, 2001a; OECD, 1999; Perry, 2001a; Svendsen, 2001a).
- To allocate water to the highest priority uses (Meinzen-Dick, 2001; Molle, 2001a; Svendsen, 2001a).
- To improve water quality/reduce pollution levels/protect the environment (Ahmad, 2000; Johansson, 2000).

<u>Fairness</u>

- To encourage wise investment decisions by public and private organisations (Meinzen-Dick, 2001; Svendsen, 2001a).
- To create a benefit tax (Perry, 2001a).
- To ensure equity of access to water or the benefits of its use (Johansson, 2000; IWMI web site)

3.1 Service delivery – cost and accountability

3.1.1 To cover service costs

Water pricing reform is often driven by pressure on government budgets, rising costs to provide water delivery services and governments' desire to recover all or part of their costs (Svendsen, 2001a). For several years the World Bank has encouraged governments to employ a policy of cost recovery in the belief that users should pay fees to cover O&M costs and *some* of the capital costs (del Castillo, 1997).

Cost recovery requires a politically sensitive choice as to the extent of cost recovery – full recovery of capital and O&M costs at realistic interest rates, or partial recovery, implying some level of explicit or hidden subsidy (Perry, 2001a). Where capital costs and O&M costs are not recovered, governments pay the difference, thus subsidising the agricultural sector, which is a politically sensitive area (Johansson, 2000; Perry, 2001a). IWMI (2002) suggests that levels of subsidy generally declined during the 1990s as governments sought to implement cost recovery programmes. Nonetheless, Dinar *et al.,* (1998) report that in the Pakistan Punjab the cost recovery ratio (ratio of income from water pricing to O&M expenditure) was just 0.38 in 1994-95, falling to just 0.26 in 1995-96.

Small *et al*. (1986) (cited in Johnson, 1990) express concern about a narrow focus on cost recovery. Based on their studies of water pricing in Asia, they conclude that cost recovery is only one of four key processes in irrigation pricing policy and that these other processes need to be considered as well. These include:

1. Allocating resources to irrigation.
2. Using these resources to implement irrigation services.
3. Controlling the resources obtained from irrigation beneficiaries.

Although the authors cited in this section generally use the term "cost recovery", Small and Carruthers (1991) distinguish "cost recovery" and "irrigation financing" as having separate implications for water pricing. In "cost recovery", all funds collected go to the government treasury department, and in "irrigation financing", funds are retained within or returned to the irrigation agency to meet actual irrigation costs. This distinction is another way of underscoring the need to go beyond the "simple" calculation of the level of cost to be recovered and to make explicit the way in which any funds raised are used to benefit either the irrigation department or the individual scheme where they were acquired.

3.1.2 To improve service delivery

Ray (in press) emphasises the fact that irrigation departments in many countries need to improve the management and operation and maintenance of the main canal and that "incentives for their staff members to operate efficiently are at least as urgently needed as those for farmers". According to some writers, water charging can accelerate this. In Indonesia, Gerards *et al*. (1991) state that "the real question for ISF success is whether the Irrigation Service is willing to redefine its role and function… Rather than an attitude of instruction, managers and field personnel of the Irrigation Service have to reassess their role, and have to accept water users as counterparts, almost as co-system managers" (p.11).

The same argument has been used in the irrigation sector reforms in Pakistan, where water delivery contracts would include a penalty to the irrigation provider, in case it did not live up to its commitments, except in extenuating circumstances (Euroconsult, 1997). A similar discussion has started in Thailand – where the introduction of cost recovery would come with responsibilities from both service provider and customer. Despite these indications of intent, the literature lacks substantive evidence of water pricing leading to better service delivery to farmers.

3.2 Water allocation and quality

3.2.1 To provide an incentive for efficient use (demand management)

It is widely argued that low water prices in a water scarce environment send the wrong signal to water users. Farmers do not have any incentive to reduce water diversion or adopt water efficient crops; indeed they may adopt water-intensive crops and over-irrigate their fields. Under-pricing leads to overexploitation of scarce water resources. Where charges are not a direct function of the volume diverted or consumed – for example, where charges are fixed per hectare of crop – overall charges may be high, but there is no direct incentive to decrease consumption at the margin.

Some argue that the introduction of volumetric water pricing reduces water wastage and generates revenue to continue essential services for the future, thereby combining the objectives of demand management and cost recovery (Briscoe, 1996; Rosegrant, 1997; Kumar and Singh, 2001). However, other researchers question the general validity and practical implications of these statements. In order to meet this objective (reduced demand), a charging system is required that makes a farmer assess marginal water use against its marginal cost (Svendsen, 2001a) or, in other words, makes the user aware of an incremental charge related to incremental use. To achieve this objective, the cost to the user must be significant in relation to the benefit incurred. In many circumstances, this may require that the effective charge levied is greater than the full supply cost (O&M plus capital charges). Some argue that the use of rising block tariffs can ensure a high marginal cost while keeping the average cost to many users below or around the full supply cost.

3.2.2 To allocate water to highest priority uses

In Johansson (2000), it is stated that water allocation efficiency "is that which maximises the total net benefit able to be generated under the existing technologies and available quantities of that resource" (p.6). Without quantitative regulations to cap excessive water extraction, subsidised water leads to resource depletion and a loss to future society. Net benefits to society are maximised when costs of extraction (including environmental and opportunity costs) and value, balance. "Getting the prices right", i.e. reflecting the social value of the resource, is a desirable way to allocate water efficiently (Dinar and Subramanian, 1997; Johansson, 2000). According to Ahmad (2000), "the economic or political dimension of water scarcity and its low price mean that agriculture should release water to other uses, because the economic value of water is much lower in farming than for domestic or industrial use" (p.233). However, as Svendsen (2001a) comments, this may not be a viable option for governments to take where there are no alternative forms of employment for farmers. Savenije and van der Zaag (2002) also caution that the difference in value between using water for irrigation and using it to meet municipal and industrial needs, i.e. the opportunity cost of irrigation, may not be as high as some argue. They suggest that the multiplier effect of ancillary industries, reliant on irrigated agriculture, is often ignored. They also point out that once M&I demand is fully met, the supply of further water to that sector brings no value at all. Although overexploited catchments and water short areas now receive considerable attention, they point out that in many countries urban demands can be satisfied using just 20 – 50% of available supply in all but the driest years. In these situations the permanent transfer of water from agriculture to other sectors would be counter-productive. They argue that legal provisions ensuring that agriculture would surrender water to urban needs in the occasional dry years, using a system of seasonal allocations, would be a simpler approach than one reliant on the vagaries and complexities of the market. In over-committed catchments they favour negotiated reallocation rather than water pricing.

Another approach is that of water markets where farmers are able to sell their water shares to higher value uses both within and outside the agricultural sector (Ray, in press). However, this requires that the farmers have a clear legal entitlement to a water right which they are able to trade. Furthermore, some view it as a "strategic mistake" not to maintain a productive agricultural sector, and to allow irrigated agriculture to decline, "would make dry areas very vulnerable in the long run, regardless of the level of economic development" (cited in Bakker, 1999, p.28).

3.2.3 To improve water quality

Environmental quality is usually viewed as a public good and therefore controlled by means of regulation. Johansson (2000) remarks that, when considering some form of water pricing to deal with water quality problems, two issues stand out: (i) the effects of water use vary [across time and space] and (ii) non-point source pollution where the source of pollution is typically unknown. These issues make charging a difficult tool to apply in practice. Dinar and Letey (1996) explore possible economic incentives to reduce polluted effluents from farms, with examples from California. The direct way is to tax the disposal of polluted drainage water on a per volume basis but this imposes high costs for monitoring. Some argue that raising the irrigation water price induces improved irrigation efficiency and hence reduces drainage flow as the gap between the volume diverted and that consumed reduces, but the link between price and volume diverted is not always apparent or easy to manage. Young and Karkoski (2000) describe a successful scheme of tradable discharge rights in California to abate agricultural pollution from non-point sources. It is noteworthy that all papers related to agricultural water pricing for pollution control focus on the US situation where the principle of “the polluter pays” is generally recognised and accepted.

3.3 Fairness

3.3.1 To encourage wise investments

Investments in surface water resources are predominantly made by public agencies, though investment by beneficiaries or the private sector is common in some countries (Nepal, US). Groundwater development is predominantly a private sector activity. The objective of fairness would seem to imply full cost recovery in financial terms, and maybe recovery of more than full financial cost if sustainable utilisation is sought. However, public agencies are often influenced by other factors, e.g. political issues, specific policies or vested interests. Where political pressure from potential beneficiaries is an important determinant of the investment decision, a stated and credible policy of investment cost recovery may be an effective incentive for rational, public decision making (Svendsen, 2001a).

3.3.2 To create a benefit tax

This objective deals with the fact that farmers who benefit from irrigation are privileged, compared to rainfed farmers. Charging can either be used to cover the costs of the service (to achieve the first objective) or to raise revenues that may be used to benefit others (Perry, 2001a). There are a few cases where charges are used to fund other sectors, e.g. in Maharashtra, part of the revenue is used to finance primary education and an employment guarantee scheme (cited in Saleth, 1997). It is not clear, though, whether this diversion of revenues to other sectors implies recovery of more than full costs. In most countries collected water fees are insufficient to cover costs of providing water services, let alone subsidise other sectors. Nonetheless, fees often go to the treasury and do not remain on the scheme or even in a relevant government ministry.

3.3.3 To improve equity

The term equity can be interpreted as either being concerned with improving the allocation of the *resource*, i.e. how the resource is distributed to users, or improving allocation of the *benefits* of the resource, i.e. how the benefits are distributed to users. In Johansson (2000), equity of water allocation is “the ‘fairness’ of allocation across economically disparate groups in a society or across time and may not be compatible with efficiency objectives” (p.7). Charging could, therefore, either be used as a benefit tax, to distribute the benefits received by irrigators to others in society, or targeted at different groups within the system, e.g. to improve benefits for farmers at the tail-end of a system.

IWMI (internet) cites equity as being one objective of water pricing, in terms of reducing the gap in income distribution. However, they do not clarify whether this is to reduce differences within groups of irrigating farmers, or different groups in society. They also state that the equity objective of water pricing is still questionable. According to Tsur and Dinar (1995), water pricing has not been successful in redistributing income.

It appears that equity, rather than being an objective for water pricing, is an issue which policy makers and others need to take into consideration when examining the implications of their chosen objective(s). The way in which the equity of allocation objective is interpreted depends on the background of the decision makers or their advisers.

Ultimately, "with any change in environment, whether it is physical in the case of increasing water scarcity or whether it is political in the case of changing water institutions, there are groups who will be better off and those who will be worse off. When examining the potential of an irrigation pricing mechanism to better manage existing water supplies, it is essential to evaluate these groups in order to successfully implement the pricing policy" (Johansson, 2000, p.45).

4. PRICING METHODS

4.1 Non-volumetric methods

There are several non-volumetric methods commonly used in irrigation: output pricing, input pricing and area pricing. Output pricing methods charge a water fee for each unit of output produced by the user. Under input pricing a farmer pays for irrigation water indirectly through higher prices for inputs purchased from the government or water agency. Both input and output pricing are easy to implement since inputs and outputs are readily observable and water use measurement is not necessary (Johansson, 2000). However, neither measure is favoured by economists because of distortion effects inherent to taxation (Rhodes and Sampath, 1988).

Under area-based pricing, farmers pay a fixed price per unit of irrigated area. This is the most common method of pricing. A survey of 12 million hectares of irrigated land, reported in Johansson (2000), indicated that in more than 60% of the cases water is charged for on a per hectare basis. It is easy to administer but has the practical difficulty that the area of land is assumed to be an adequate proxy for the proportion of water received – which may not be so because of logistical, physical and political reasons (Rhodes and Sampath, 1988). Large systems suffering from head-end tail-end problems, or systems where both perennial and annual crops are grown, may face these kinds of difficulties. This is similar to the un-metered charges for domestic water based on the property supplied.

4.2 Volumetric methods

Volumetric methods charge for water per unit volume supplied at the measuring point. This requires:

- Information on the volume used by each individual farmer or a defined group of users below the measuring point.
- A central water authority or Water Users' Organisation to set the price, monitor use and collect fees (Johansson, 2000).

Where field sizes are small, farmers numerous and water is distributed in open channels, the costs of installing water measuring devices and monitoring of individual users are prohibitively expensive. In these cases, water can be delivered to an intermediate point, e.g. a farmer organisation, leaving farmers with the responsibility of distributing and charging individuals for water (del Castillo, 1997; Meinzen-Dick, 2001; Perry, 2001a). This is seen as a solution by governments or donor agencies, but in reality it involves "devolving the most difficult part of the operation, the actual interface between "supply" and "demand", to others [the users]" (Perry, 2001a, p.5). In larger schemes, free-riding will be a problem (Svendsen, 2001). If government agencies are unable to measure or charge individual farmers volumetrically, the assumption that farmer organisations will be better equipped to do so requires investigation. There is perhaps scope to mix volumetric and area based systems, for example, volumetric bulk supply to a User Group and area based charging for the members of that group. (The technical and cost problems are reduced, though not eliminated, where water is distributed to users in pipes rather than open channels.)

Because of equity considerations, tiered pricing (multi-rate volumetric method) is commonly used in domestic water supply, the idea being that large water users subsidise small users by paying substantially more for water above a social minimum amount. Tiered volumetric pricing in agriculture is found in regions with sophisticated monitoring technology, for example California and Israel (Johansson, 2000).

Some authors emphasise the need to charge per unit of water consumed (by evaporation or pollution) as opposed to diverted, but due to difficulties in estimating evapotranspiration this is hardly ever done (Huffaker *et al*., 1998). Perry (2001a) emphasises the fact that in an irrigation system it is the consumption of water (through evapotranspiration, pollution or loss) which is the key factor in water scarcity, rather than the quantity of water diverted. In some cases, water that is "lost" from a system will be stored (e.g. in an aquifer) and used later in the season or elsewhere. "In all heavily developed basins, with more than one diversion point on the river, a proportion of the "losses" from upstream projects forms inflows to downstream projects" (*ibid.*, p.6). It is the "quantities of water released from storage that do not reach the crop [that] are the legitimate concern of the operators and beneficiaries" (p.7). One example where water is lost from the system is where it becomes polluted in the recycling process and cannot be used downstream. Rosegrant (1997) adds that water can also be lost if its recovery becomes too expensive, for example by deep percolation (economic sink). However, from the perspective of capital investment and financial management of the system, the volume of water withdrawn is significant as costs relate to the volume of water diverted. These are important concepts to understand in any consideration of water productivity or water allocation at, say, the basin level. However, for practical purposes it is important to note that volumetric charging for water will continue to measure the volume diverted or abstracted from a source, rather than the volume consumed by the crop or lost to a sink, for the foreseeable future. This is for the pragmatic reasons associated with problems of measurement but also because the capital and operating costs of a system are determined by the volumes of water abstracted and conveyed, not the volume consumed. Note that two different elements of water pricing literature arise here. Water scarcity and water pricing to reduce demand should logically focus on the volumes of water *consumed* whilst concerns of cost recovery focus on the volume diverted and managed, irrespective of whether it returns to the basin for use by other, downstream users.

4.3 Proxy methods for volumetric charging

Volumetric pricing is difficult to implement and in some schemes a mixture of methods is practised. When water flow is reasonably constant, implicit volumetric pricing is possible by charging for time of delivery. This method is easy to monitor and can be found in many small-scale, farmer-managed irrigation systems around the globe, although payment is often in kind rather than in cash and the main objective is monitoring water rights rather than efficient allocation (Small and Carruthers, 1991; Bandaragoda, 1998).

Malhotra (1982), Jurriens *et al*. (1996) and Perry and Narayanamurthy (1998) describe the Warabandi system adopted in India and Pakistan in which water charge varies by crop and season. Kumar and Singh (2001) provide examples of similar charging methods from Gujarat. Water-intensive crops, such as sugarcane, can be discouraged by setting the water charge substantially higher than for other crops.

Abstraction licences may provide a proxy method for volumetric charging or may require actual volumetric measurements. They are more common in the developed world or where individual farm holdings are larger. The individual farmer meets all capital, operating and maintenance costs of pumps or other infrastructure and in addition pays an annual licence fee for abstraction. This may be a flat-rate annual tariff, based on the abstraction (pump) capacity or a two part tariff. In the UK, a two part licence fee is used – a fixed element, making up 25-50% of the annual charge, is determined by the maximum volume that is permitted; the remaining component is determined by the volume actually abstracted (OECD, 1999). This system clearly requires the metering of water use.

4.4 Market based methods

Water users have been able to use their political power to prevent major increases in irrigation water (Becker and Lavee, 2002). Rosegrant and Binswanger (1994) suggest that water markets provide a flexible and efficient way to allocate water while at the same time providing incentives that are beneficial for water users. When water savings can be traded, they provide extra income to farmers, while pricing leads to a reduction in income.

Rosegrant and Binswanger (*ibid.*) make important distinctions between administered prices set so as to reduce demand, and tradable water rights. Often the value of subsidised irrigation services is capitalised into land prices. Raising water charges to reflect the value of the irrigation service is therefore unsustainable for farmers who have paid the premium price for land plus subsidised water, and highly unpopular among other farmers who have profited from cheap water. Defining a tradable water right, on the other hand, with charges related to the cost of the irrigation service, allows farmers to either continue farming and profiting from the cheap water, or to sell the water right at a true "market" price to the highest bidder.

The latter system has the long-term benefit of allowing water to move to the highest value use, while providing a stable charging environment for those not participating in water trading.

Initial impacts of introducing tradable water rights include:

- An increase in water demand where previously under-utilised entitlements are sold to the highest bidder.
- Creation of very wealthy farmers who opt to sell water rather than continue to farm.

(D Blackmore, Commissioner, Murray Darling Basin, personal communication, 2002)

Markets range from formal to informal. Informal water markets are found for example in India (Saleth, 1997), Pakistan (Bandaragoda, 1998; Meinzen-Dick 1997), Chile (Hearne & Easter, 1997) and Mexico (Thobani, 1997). Transactions are typically small-scale and local, selling surplus water to neighbouring farmers or towns (Johansson, 2000). Finney (personal communication, 2002) reports an extremely well-developed informal market for water in Bangladesh where water from shallow tube wells, of which there may be 700,000 in the country, is sold to groups of between 14 to 17 farmers. Through this informal market over 10 million farmers gain access to irrigation water.

Formal markets involve tradable water rights, permanent or seasonal transfers or transactions between sectors and jurisdictions. They are described for the Western US (Colby, 1998), California (Howitt, 1998), Texas (Griffin, 1998) and Spain (Garrido, 1998). Probably the most advanced system of tradable water rights now in operation is in the Murray-Darling Basin in Australia, where diversion entitlements are traded at the seasonal and permanent levels with a defined security of availability (see Section 7. 8).

The debate concerning water markets focuses on their feasibility (high transaction costs, externalities, lack of legal and institutional framework) and on equity issues. There is concern that poor farmers or households will not be able to pay high prices for water, and will be disadvantaged by markets. Meinzen-Dick (1997), referring to small farmers who cannot afford their own pumping equipment, argues that informal markets increase these farmers' access to water. Ultimately, markets are rarely undistorted even in sophisticated economies and market-led systems alone cannot overcome potential conflict between objectives of productive efficiency and poverty reduction. This is a specialist field of study that is relevant to irrigation charging but applies to very few countries and will not be considered in detail in this study.

4.5 Linking pricing objectives and methods

There should be a clear linkage between objectives and pricing methods. Some pricing methods are more suitable to achieve certain goals than others, (see Table 1). If the main objective is to recover costs, the most obvious choice is an easy-to-implement, non-volumetric method, such as area pricing or output taxation. Area pricing has little or no effect on water applications by individuals and its effect on water use efficiency is negligible. Irrigation service fee (ISF), mostly charged on a per area basis, is primarily used for cost recovery and does not induce efficient water use. On the contrary, it may lead to higher water use since users feel that they are entitled to use as much as they want as they pay for it.

According to Rhodes and Sampath (1988), volumetric water pricing is "superior" as a means to induce efficient water application by individual farmers. But volumetric water pricing may *not* be the most suitable method to generate revenue to cover O&M costs. The implementation costs of volumetric pricing are high and may outweigh revenues (Perry, 1995). For example, in the Samaca scheme in Colombia the Water User Association abandoned volumetric fees after Irrigation Management Transfer, because of the high costs in relation to revenue (Mora Pena, 1997). Further, where water availability or demand is variable due to climatic conditions, income derived from water sales is also variable while a major part of O&M consists of fixed costs (personnel, buildings, equipment). Maximising water user associations' revenues through volumetric pricing and inducing water saving behaviour (and hence promoting fewer water sales) are inherently contradictory objectives. For example, Azevedo and Asad (2000) examine bulk water pricing in Brazil. They estimate that in São Paulo, once water charges increase, users will probably reduce the amount of water they use, and revenues will fall. This brings the sustainability of the system into question, as there will be less input for O&M costs, etc.

Volumetric pricing may play a role in efficient water allocation within and between sectors, provided the price is set at the 'right' level. Water markets and tradable water rights, with abstraction licences, where feasible, are theoretically the most effective in achieving allocation efficiency in a strict economic sense, but these methods may not generate sufficient revenue to the water agency to cover O&M costs. Formal markets and/or pricing potentially lead to inequitable access to water resources and disadvantage poor farmers who lack resources to buy water (Gleick, 2002). On the other hand, as Meinzen-Dick illustrates, informal groundwater markets may increase poor farmers' access to water, particularly those who cannot afford pumping equipment (Meinzen-Dick, 1997).

It is crucial to achieve a balance between desirable objectives, implementation feasibility and possible unintended impacts of pricing modalities. Combining too many diverging objectives under the same pricing policy may lead to a lose-lose, instead of win-win, situation. A mix of methods may be required to achieve the required objectives. For example, after Irrigation Management Turnover, the Rio Lerma system in Mexico introduced a two part tariff: a flat rate in proportion to landholding to cover fixed costs, and a small volumetric rate to cover variable costs (Kloezen *et al.,* 1997).

Table 1 Summary of the relationships between irrigation charging objectives and pricing methods

Pricing method	**Charging objective**		
	Service delivery and cost recovery	Water allocation and quality	Fairness
Non-volumetric methods	Yes	No	No
Volumetric methods	Maybe	Yes	Yes
Market based methods	No	Yes	Maybe

5. INSTITUTIONAL AND ORGANISATIONAL ISSUES AFFECTING WATER CHARGING

Even when the objectives for water pricing are clear, there are a large number of institutional and organisational issues that can affect the implementation of a charging policy. Those issues which are likely to have some bearing on most pricing mechanisms are addressed in this chapter. Issues that are more specific to a given pricing mechanism are considered in subsequent chapters.

The OECD (1999) highlights the fact that agricultural water pricing policies do not usually occur in a vacuum and that they are often driven by factors outside the irrigation and agricultural sectors. The report also stresses that sending out signals about water scarcity can often be done by other means, provided appropriate institutional arrangements are in place and respected by all stakeholders. From a slightly different perspective, Molle (2001a) emphasises that institutional and technical reform of the water sector is imperative and must pre-date water pricing. The manner and sequence in which reforms are implemented are important, though both abrupt and phased-in introductions have their limitations (Renzetti, 2000).

5.1 Who should pay?

In many cases, it is not clear-cut who should be held responsible for the costs of irrigation development. It is widely believed that the farmers should bear the costs of O&M. However, Bakker (1999) argues that this is unreasonable, as consumers have benefited most from irrigation development through lower cereal grain prices. Likewise, Sampath (1983 and 1992) argues that, especially in developing countries, there are millions of indirect beneficiaries, such as consumers, who benefit as much as or even more than the direct beneficiaries of irrigation (i.e. farmers). Consequently, it is unjust to expect the farmers to bear the full burden. He argues that both consumers and producers should legitimately share the cost of irrigation development. Perry (2001a) uses a similar logic in arguing that the indirect beneficiaries of irrigation, i.e. the consumers, should be willing to subsidise irrigation development through taxes. Against this it could be argued that those who benefit from the products made by an industry that uses electricity should contribute to the power supply bill of that industry other than through the costs of the products they buy. This seems a difficult position to defend.

Perry (1995; 2001a) and Bakker (1999) consider the issue of multiple users of water. Perry (1995) highlights the fact that in Egypt water has a number of uses, some that compete with each other and some that are complementary, making water pricing more complex. Besides farmers, beneficiaries may include villages that receive domestic water supplies, flood control, and hydropower. The costs of supplying the water, as well as drainage, should therefore be divided between them. According to Bakker, "the importance and value of multiple uses of irrigation water are often underestimated" (p.26). Bakker questions who should pay the water fees, i.e. which group (or groups) actually constitutes the "users" and whether this includes the irrigators, livestock owners, fishermen, domestic users or brick makers. However, the issue becomes even more complicated when one considers that farmers themselves are multiple users of water.

In Asia, 90% of dams are for irrigation or are multi-purpose; in Africa, 70% are for irrigation or are multi-purpose (World Commission on Dams, cited in Perry, 2001c). Following the period of major water resource development in the 1950s, the price, in constant terms, of major food grains has fallen by 50% or more (Perry, 2001c) due to the combined effects of the "green revolution", fertiliser availability and more secure water supplies. Agricultural subsidies in many major exporting countries confuse this picture (more than half the revenues to the rice industry in the US are from subsidies (USDA, 2001)). However, it is clear that a share of the cost of constructing irrigation facilities should reasonably be attributed to non-farmers who benefit from low-priced, secure food supplies. We do not address the complex issue of cost allocation in the broad sense of who benefits from irrigation.

In Macedonia, private landholdings are small and dispersed and farmers are often part-time and/or absentee. It is therefore difficult to give farmers responsibility for the O&M of the system (Hatzius, 2000). In Indonesia, a problem raised by users in one area was that farmers outside the irrigation system were using water from the main canals, but were not paying an Irrigation Service Fee (Gerards *et al*., 1991). In the Jordan Valley, sharecroppers pay part or all of the water charge, while the landowners generally pay the infrastructure costs (Huppert and Urban, 1999).

5.2 Revenues – who benefits?

A recurring question is whether revenues should be used in the system where they were collected, flow back to the government for 'general' cost recovery in irrigation or be considered as tax income to government. There is little published information addressing this issue in any detail. A logical deduction might be that in order to motivate farmers to pay for irrigation services, it is important to ensure that fees are used in the irrigation sector, and more specifically for implementing irrigation services on the scheme where funds are raised. However, as Johnson (1990) states, this approach contradicts not only most of the literature on water pricing in public irrigation systems in the developing countries, but also donor agencies, who tend to focus on increasing the level of cost recovery from system users, without due regard for the final destination of the revenues raised.

5.3 Timing of payment

Johnson (2001) states that the simplest method to collect payment is before each irrigation delivery. This system saves staff from having to chase farmers for payment after each season. In Mexico, all fees are collected by the end of the season and in China, in Shanxi Province, townships, as intermediary suppliers to farmers, pay in advance for water delivery. However, in the Philippines and the Niger Valley (Abernethy *et al*., 2000), fees are still outstanding at the end of the season. In the Niger Valley, the time limit for payment can be extended to six months after the end of the season. This means that even though actual fee collection rates are high, co-operatives are always operating at a loss – in some cases, this loss will amount to the fees of two seasons. Clearly, this puts the co-operatives under increasing pressure.

Where volumetric charging is adopted, that component of the fee which is determined by the volume delivered must be billed after the event. In the Jordan Valley, bills are issued on a monthly basis and reflect the volume delivered in the previous month.

5.4 The role of pricing structure

The price or tariff structure used must reflect the wider objectives of water charging – normally cost recovery or demand management. In the water supply and sanitation sector, Boland and Whittington (1998) offer a critical assessment of Increasing Block Tariffs (IBTs) that "have become the tariff structure of choice". They report their widespread use in water supply projects in the developing world. With increasing consumption the price charged per unit volume rises. This mechanism is seen as a means of cross-subsidising the cost of a basic supply to poorer consumers by charging more than the supply cost to wealthier consumers, who consume much greater volumes. However, Boland and Whittington question their value on a number of counts and urge the greater use of simpler, two part tariff structures – a fixed, service charge and a variable charge determined by the volume consumed.

IBTs and simpler two part tariffs both require volumetric measurement of supply and for this reason their use in the irrigation sector is not widespread. It may also be questioned whether the objective of cross-subsidy is so widely accepted as being desirable in the irrigation sector. Shatanawi and Salem (no date) and Becker and Levine (2002) report their use in Jordan and Israel respectively, where the supply to individual farmers is metered. However, in both these countries an upper limit, which determines the maximum volume that may be used for irrigation, is imposed by central government ministry. Within that allocation some water saving may be achieved through the incentive of increasing tariffs. Shevah (no date), describing the situation in Israel, states that the IBT system has led to irrigation water savings of 10 –15%. In the literature on Jordan, discussion of pricing reflects concerns over cost recovery in the state-managed Jordan Valley Authority rather than the use of price to control demand.

Most irrigation agencies rely on simpler, fixed cost price structures, most frequently using a charging system based on the area irrigated. Even in an advanced and water scarce economy such as Spain, Berbel and Gomez-Limon (2000) report that a fixed cost per hectare for irrigation water is still the most widespread charging mechanism, although Maestu (2000) reports trials of water metering and two part tariff structures on three Spanish schemes. It is notable that on these schemes the variable element actually reflects the energy cost associated with pumping and pressurising water delivery systems rather than a direct charge for water according to the volume diverted. Maestu (personal communication, 2002) also stresses that in water scarce basins, water allocation, rather than price, is used to control demand and ensure adequate supply to industrial, municipal and environmental sectors. The same situation pertains to France. Tardieu and Prefol (2002) describe the current system of using water quotas for farmers before arguing that wider use should be made of step pricing to ensure compliance with the quota, rather than reliance on metering and financial penalties for over-consumption.

5.5 Form of payment and system size

There are fundamental differences between irrigation systems of different sizes and this is reflected in the form of payment used (Johnson, 2001). In small irrigation systems of 100 to 300 ha, e.g. in Indonesia, Thailand and the Philippines, payment is often made in kind and maintenance is carried out by the farmers. Many small-scale systems cannot hire professional staff to improve the management of the system as fees are paid in kind, and no funds are generated. Larger systems of 3,000 to 20,000 ha demand greater management but with greater numbers of farmers, sufficient funds can be generated to pay for professional staff and provide adequate maintenance.

In some small systems, farmers are gradually making more contributions in cash, e.g. in the Niger Valley, most fees are paid in an equivalent amount of crop, but at one system, the alternative of cash payment is being used increasingly (Abernethy *et al*., 2000). In systems in Eastern Europe and the Former Soviet Union, payment in kind continues, as well as in Vietnam (Nguyen, 1999). Such payment systems are either the equivalent of a fixed charge (if the crop contribution is fixed) or benefit-related (if the crop contribution is a proportion of production). These payment systems do not lend themselves to being readily adapted to comply with a volumetric water charging system.

5.6 Calculating O&M costs

A method followed in several places is a systematic description of key maintenance processes, including a breakdown of the resources required – labour, material, equipment (GITEC/PANYA, 1998). For these components, unit costs are determined that are adjusted with increases in labour, material or equipment costs. On the basis of a status survey, which involves an inventory of the damage to the system, the maintenance requirements for the year are assessed. The status survey is preferably done in a decentralised manner - in a joint walk-through with water users (Euroconsult/ PPA, 1994) or by field engineers of the water agency. A similar method, designed to assist annual maintenance planning and costing through the use of condition assessment procedures that link condition to structural function and stability, is described by Cornish (1998).

There are, however, some limitations in this process. First is the acknowledgement that many irrigation systems are 'living infrastructure', with change, particularly in the command area, a frequent occurrence. The implication is not only that new structures and canals are added, but also that some parts are selectively neglected – because they are no longer needed or too difficult to keep in operation. A second point closely related to this is what the norms are for adequate maintenance. It is also important to assess what the maintenance processes are aiming to achieve. To restore assets to their original state may not be possible, nor in many cases useful. In practice, trade-offs will have to be made. A third point concerns the unit costs. While applying this methodology in Thailand (GITEC/PANYA 1998), it was found that different regions have very different cost structures. It was also found that there is considerable sensitivity in approving and adjusting unit costs. If farmers are to pay higher water prices to meet actual O&M costs (and possibly capital costs), quantitative and transparent planning procedures will be required so that users can see and understand the reason for charges being as they are.

Skutsch (1998) presents a review of the factors that contribute to ineffectual maintenance regimes in irrigation systems and makes the case for higher expenditure on maintenance to avoid premature expenditure on costly rehabilitation which has high opportunity costs for the national treasury.

5.7 Ability to pay, willingness to pay, fee collection

It is argued that the willingness to pay "depends largely on the ability to pay" (Perry *et al*., 1997, p.4). There is understandable concern that even with the same basic need for or value of water, the rich will get more and the poor less. Many fear that the increased use of economic instruments may create inequalities with water flowing not "by gravity but by purchasing power" (cited in Molle, 2001a, p.11). However, where water is scarce the available water has to be allocated for different uses either through economic or political means. Water allocation made on a purely political basis, with no economic component, could also disadvantage the poor as they have the least political power (Winpenny, personal communication, 2002). Winpenny argues that both political and economic measures are thus needed to achieve equity and economic efficiency.

It can be argued that farmers below a certain level of poverty should not have to pay fees. However, as Svendsen (2001a) demonstrates, this raises problems of equity – and of determining who should be exempt from paying. Svendsen believes that a combination of food subsidies and full cost charging for irrigation is preferable. However, del Castillo (1997) refers to a World Bank Project in Peru where the irrigation infrastructure is to be handed over to users. Users will repay loans to banks and will be responsible for rehabilitation, operation and maintenance costs. If small farmers are unable to repay rehabilitation costs, they will in effect be subsidised by wealthier farmers, who will pay more. Del Castillo does not elaborate how farmers will be tested for their ability to pay and clearly, the system will fail where the majority of farmers are unable to pay – or where wealthier farmers are unwilling to pay.

A concise account of the relationship between fee collection and willingness to pay is given in del Castillo (1997): "The record of non-payment and non-collection of fees for water is long and well-documented. It reflects two problems: weak incentives to collect and limited willingness to pay because services are poor. In many cases the record of poor collection can be attributed to lack of political determination to enforce collection and limited motivation of agencies to collect, since they are not required to cover their costs" (p.150). The lack of incentives for agencies to collect fees is also highlighted by Svendsen (2001a).

The ability to pay is not the only factor determining willingness to pay – user confidence in the service delivered and its financial management also plays an important role. In many settings a vicious circle exists of poor service delivery, low cost recovery, minor corruption and inadequate maintenance, leading to further decline of services and decreasing willingness to pay. Del Castillo (1997) confirms that "…failure to recover costs and to reinvest in the systems leads to a vicious cycle whereby service declines with collections…and consumers, in turn, become less willing to pay for poor-quality services provided" (p.150). To move to a virtuous circle, service delivery must be improved and sustained. If this were achieved, the poor would be more willing to pay.

The concept that users are unwilling to pay because the service is poor is supported by Ahmad (2000) in the Near East, where users are reluctant to pay an increase in fees if it is not related to an improvement in the service provided. Likewise, Molle (2001a) states that users in general will be more likely to pay if payment can be linked to an improvement in management and maintenance. In more general terms, Postel (1992) links ability and willingness to pay to the reliability of irrigation water to farmers. Also, a study by Waughray *et al*. (cited in Waughray and Rodríguez, 1998) of small-scale irrigation schemes in Zimbabwe shows that the price small communities would be willing to pay for maintaining a reliable water supply could potentially cover marginal and replacement costs. This hypothetical price is six times greater than the water charges set for large sugar estates in the same region.

Ray (in press) acknowledges the fact that higher fees will clearly only affect farmers' incomes if fees are actually collected. Likewise, Molle (2001a) states that if the main objective is cost recovery, the fees collected must be greater than the administrative cost of collection.

Gerards *et al*. (1991) introduce the idea that within the system there must be "mutual accountability" between the institutions, irrigators and service providers for the system to operate effectively. Molle (2001a) adds, "if irrigation agencies are gradually made financially autonomous, with a high degree of income coming from water fees, they will also be committed to reform and improvement" (p.30). He highlights that where this has not occurred, high costs in fee collection and high rates of non-payment are often to blame.

5.8 Enforcement

There are several reasons why irrigation charges are not paid. These do not necessarily relate to a reluctance to pay on the part of water users. Unpaid bills may have their cause in poor methods of collection, wrong bills, non-delivery of bills or other mistakes in the revenue administration. In most cases, however, non-payment is due to the absence of effective sanctions – which may or may not indicate an unwillingness to pay. There are three categories of sanctions, i.e. penalties, legal action and suspension of water deliveries. In a recent global ICID survey, 45 out of 51 irrigation providers had used one of these three categories of sanction (Lee, 2000).

Suspension of water deliveries is far more powerful than the other two sanctions. Bos (1990), for instance, described that fee collection by water users' associations in Argentina only became effective after the associations were allowed to stop the delivery of water to defaulters. However, not all systems are amenable to this sanction and this is politically sensitive and may be unacceptable in some cultures.

5.9 Regulatory bodies

The involvement of the private sector in utilities such as water, telecommunications and power supply has prompted increased emphasis on regulatory mechanisms. Regulatory mechanisms are seen as a key part of managing private or public supply of a monopoly good but there are very few examples of regulatory bodies in irrigation supply and there is little published information on the role or effectiveness of regulators within the irrigation sector. One exception was the introduction of irrigation service fees in Indonesia (Euroconsult/ PPA, 1994). At the district level, this introduction was implemented by a Consultative Body, chaired by the district head or mayor, and seconded by the head of the district planning board and the head of the irrigation agency (public works at that time). Representatives of water user federations were part of these Consultative Bodies as well. The Consultative Bodies, supported by a secretariat, decided on the work programme but also determined irrigation service levels and irrigation service tariffs.

5.10 Resources

Some countries have insufficient economic and technological resources to deal with serious water management problems (Klohn and Appelgren, 1998). Where political and institutional reform, related to water pricing, has been carried out, it has required significant investment of time and money, as Kemper and Olson (2000) demonstrate in Mexico and Brazil. Resources also include training, as Svendsen (2001a) and Abernethy *et al*. (2000) highlight. The need for data is also an important issue, and can relate to both theoretical and practical data in research (Dinar, 2000) or practical information from the field (Gerards *et al*., 1991).

To manage their own finances, WUAs require training in financial management, budgeting and bookkeeping (Svendsen, 2001a). Svendsen states that everyone dealing directly or indirectly with finances should be trained, including staff and members of any overseeing bodies. In addition, he states that computer-based accounting programmes can improve the quality of record keeping. However, although the need is clear it is not always apparent who would provide and pay for this training and support.

In the Niger Valley, co-operatives, who are responsible for an entire irrigation system, require training in management skills, particularly communication and record keeping to deal with collecting fees, keeping track of bills, arrears and individual accounts for every member (Abernethy *et al*., 2000). The complexity of the fee system has exacerbated this need for training in a country where levels of education and literacy are low. In some cases, the system has been applied inadequately by the co-operatives. In others, the system has simply not been applied at all.

The introduction of Irrigation Service Fees in Indonesia was dependent on a complex database (Gerards *et al*., 1991). This was to be supported with data from the field about all water users and their landholdings – "each hectare brought under ISF requires the collection and verification of over 40 data entries in the first year" (p.15). This was a daunting task, considering that the pilot phase, covering 60,000 ha, was to be expanded to 700,000 ha by 1996. The authors emphasise that the database would cover *all* farmers and that "anything less than 100% sets the stage for failure" (p.15). However, by 1997, only 420,000 ha had been turned over to WUAs (cited in Vermillion *et al*., 2000), with the programme apparently delayed by the government's decision that systems should be improved before being turned over to farmers.

Hatzius (2000) examines the potential of a new water fee system in the Republic of Macedonia, where a number of factors are delaying the elaboration of a Water Master Plan and data collection (relating to WUAs). These include institutional deficiencies and a lack of resources, staff, professional and managerial expertise, political will and participation among sectors. Either a decentralised or centralised approach in water management would require support from donor institutions, including technical assistance, training, computer hardware and software.

5.11 Governance

Political realities and vested interests have to be taken into account when establishing charging systems. For example, in the Jordan Valley, wealthy landowners, who obtain water when it is not their official turn, can use their political influence to avoid prosecution. It is therefore not in these farmers' interests to favour reforms that would interfere with current practices. Similarly, a less influential farmer is unlikely to complain officially about not receiving sufficient water, as this could jeopardise the amount of water he receives in the future. In addition, farmers willing to pay extra money to officials carrying out maintenance are more likely to get any maintenance problems solved quickly (Huppert and Urban, 1999). Some landowners have access to powerful decision makers within Government and use this to ensure that all services are provided quickly. This disrupts staff motivation and questions their authority. "Whatever approaches are pursued, it is apparent that there will be no substantial improvements in the functioning…of irrigation water provision in the Jordan Valley until more effective governance mechanisms are established" (*ibid*. p.68).

Problems of corruption or mismanagement can face any institution handling financial resources (Hatzius, 2000). Financial mismanagement led to the downfall of many co-operatives in the 1960s and 1970s and Svendsen (2001c) emphasises that WUAs face the same risk. In the Jordan Valley, the efficiency of the irrigation system, including allocation of water and maintenance, is disrupted by corruption at all levels – the decision makers, institutions and farmers (Huppert and Urban, 1999). This experience is not of course unique to Jordan and most countries with large public irrigation systems (in both developing and industrial countries) face similar problems.

The practice of paying bribes to secure irrigation supplies or to have a water bill reduced are well documented, for instance in Wade (1982) and Repeto (1986). The flow of bribes has created a shadow institution and in many systems this carries more influence than the formal institutions. Some argue that paying bribes reflects an informal water market. If so, it is a highly imperfect market, because the price paid in bribes is far below the 'value of water'. In Sindh in Pakistan, the official water charge is equivalent to US $6/ha. The unofficial amounts paid to water masters and revenue collectors are of a similar order of magnitude. Contrast this with the difference in leasing a hectare of land located in the upstream or downstream section of a minor channel, assuming the difference only reflects higher or lower reliability of supplies. The difference may be as much as US $70/ha – reflecting the real value of water and indicating the willingness to pay. This leads to what social science calls a low level equilibrium: water officials are satisfied as the system generates additional income, supplementing meagre official salaries; farmers are satisfied because they pay very little for the irrigation services. But the sum total is a poorly performing system with a high degree of unreliability, making it difficult to grow sensitive crops and encouraging 'water hoarding' strategies, which result in very low water productivity.

5.12 Political and social issues

Water pricing is a politically and socially sensitive issue, in particular where economies are dependent on irrigation, as highlighted by Burger (1998) in Central Asia and Abu-Zaid (2001) in Egypt. Vested interest groups within government may use their power to slow the progress of institutional reforms. This has occurred in countries in the Near East (Ahmad, 2000), as well as in Kazakhstan (Burger, 1998), where the final reform on water pricing was modified as a result of pressure from government agencies and also changes in the relative powers of these agencies. Lack of co-operation between different departments in government, combined with other issues, can also create delays in implementing policies, e.g. the Water Master Plan in Macedonia (Hatzius, 2000).

Farmers themselves, as a group, often have political weight and resist increases in the price of irrigation services (Perry, 2001a). If farm subsidies were completely withdrawn in Thailand, there would be "political and economic chaos" as farmers constitute the largest part of the population (Molle, 2001a, p.31). On the other hand, however, a lack of farmer participation and representation in government bodies can also create its own problems, e.g. in Macedonia, where institutional reform faces both cultural and structural obstacles (Hatzius, 2000). Hatzius 'hopes' that once the economic situation has improved under privatisation, institutional change will follow. However, at the present time he acknowledges that "client and service orientation of water related services, transparency of water pricing and accountability of WMO [Water Management Organisations] to user organisations seem to be theoretical concepts far removed from the reality of Macedonia, where informal institutions…prevail" (p.9). Macedonia is by no means unique in this regard.

Abernethy *et al*. (2000) emphasise how, in the Niger Valley, the government needs to acknowledge the complexity of the farming systems where reform is being implemented and allow for this in their policies. For most farmers in the Niger Valley, irrigation forms just one of many economic activities, so "their irrigation activities cannot be separated from their rainfed and other activities, because these constrain what they can and cannot do" (*ibid*., p.31). Reform that has not taken this situation into account is inadequate and is having an adverse effect on some farmers. Considerably more work is needed on institutional and social issues, in particular on ways to bring the informal institutions into legal compliance.

5.13 Effects of neighbouring countries' agricultural policies

It is vital to remember that policies outside a country can have a stronger influence than those within, and may trigger unexpected results. For example, Nepal is gradually reducing subsidies in agriculture through various means, including the Nepal Irrigation Sector Project (NISP), supported by the Asian Development Bank and World Bank. Subsidies have been reduced on fertilisers, shallow tube wells, and electricity for pumping. However, in neighbouring India, agriculture is highly subsidised, which, as there is an open border, has a direct effect on markets in Nepal. Production costs are now higher in Nepal and, as farmers cannot gain a good price for crops – due to cheap imports from India – there is no incentive for them to go to larger markets. Production for commercial sale is thus, in part, prevented by these cheap prices. This situation clearly has implications for water pricing – it becomes impractical to increase water fees as this would increase the level of out-migration from rural areas (Parajuli and Sharma, 2001).

5.14 Water and land rights

Perry (2001a) emphasises that "An orderly system of distributing water must be in place through some existing and respected regulatory framework for allocating water among farmers…If this is not the case – or if regulations are not observed…then there is no immediate scope for improving water distribution through pricing, and attention should first be given to clarifying and enforcing water rights and the rules of water distribution". As Perry *et al*. (1997) illustrate, in the developing world, property rights in water are insecure and ineffective – tail-end farmers often have insufficient water, whilst farmers at the head take too much. For example, in Pakistan, Egypt and Sudan, it is often the tail-end farmers who bear the costs of a poorly maintained system (Ahmad, 2000).

There are many countries where clear water rights do not exist, for example Indonesia (Vermillion *et al*., 2000), the Jordan Valley (Huppert and Urban, 1999), Turkey (Svendsen *et al*., 1997), the Yemen (Ward *et al*., 2000), Niger (Abernethy *et al*., 2000) and Pakistan (Wambia, 2000) and water rights are weak in Mexico (Svendsen *et al*., 1997).

In order to establish and protect water rights, significant costs and effort are required. Until users have rights over water they cannot make any decisions regarding that water (cited in Johansson, 2000). In the Niger Valley, land rights are also an issue. Irrigators do not officially own their land, and neither do the co-operatives. However, some co-operatives can evict and replace irrigators for repeated non-payment (Abernethy *et al*., 2000). A focus on water pricing, particularly as a tool for demand management, may be premature and ineffective without first establishing a well-understood and legally-supported system of water rights for users. Establishing formal water rights needs to be handled with great care as the rich and powerful can 'capture' traditional or customary rights from the poor. Formalising water rights is thus a greater undertaking than the implementation of water pricing and governments may therefore seek to implement pricing whilst avoiding the larger issue of codified water rights.

5.15 Size of WUAs

Water Users' Associations should be "large enough…to accomplish the designated tasks by collective action" (cited in Abernethy *et al*., 2000, p.13). In World Bank sponsored projects, a system of 40 ha is given as an optimal base unit – originally for purposes of infrastructure design and management. Although this does not specify exact numbers, a system with 900 households was "administratively impossible" (*ibid*.). As Abernethy *et al*. (2000) highlight, in different locations, a system of 40 ha will involve varying numbers. In addition, levels of education, accessibility and organisational experience should also be relevant factors affecting the size of the groups (*ibid*.).

In the Niger Valley, co-operatives would be easier to manage if they were smaller (Abernethy *et al*., 2000). However, size is determined by the typical capacity of the pump stations, with some organisations having over a thousand members in order to cover the large bills for electricity, etc.

In Mexico, a water user association of 1000 - 2,000 ha is considered small and potentially financially unsustainable. Such associations may either pool their resources, or merge to form one larger association so that O&M and management can be carried out more efficiently. In other countries, WUAs are forming Farmer Organisations at different levels of the system in order to improve management (Johnson, 2001).

There is obviously great variation between countries regarding what is perceived to be a financially and managerially sustainable and desirable size for a user association.

Box 5. Exempting small irrigation users - examples from Eastern Europe

Bulgaria

- Exemption of payment in notified areas for usage of less than 10 cubic metre/day or less than 0.2 l/s.
- Exemption of payment in non-notified areas for farms of less than 0.2 ha, outside proper land, for the first 3000 cubic metres per ha per month.

Slovak Republic

- Payment exemption for usage of less than 1250 cubic metres per month.

Source: Report to European Commission – DG Environment 2001

5.16 The role of extension and 'improved' technologies

Where water pricing is promoted as a tool to bring about reduced water demand, it may be promoted in isolation without adequate consideration of other complementary means of achieving demand reduction at the farm level.

In the Yemen, Ward (2000) believes that combining an increase in water prices with the introduction of irrigation efficiency measures is a viable option. He argues that if water pricing encourages farmers to use water more efficiently, they will then be more likely to adopt water-saving technologies. Investment and research into water conservation techniques would complement a water pricing strategy, with support from government and donors. Ward comments that "more efficient irrigation could help relieve pressure on groundwater resources and restore, or even increase, farm incomes" (p.393). This is the theory, however, in Jordan, investment in water efficient technology has not led to any measurable improvement in water use efficiency (see section 7.4).

Mohtadullah (1997) examines water pricing in Pakistan, where improving farmers' water use efficiency is a priority, as water resources are under increasing pressure. He stresses the need for extension services to help farmers achieve this.

In Taiwan, irrigation water authorities have not used pricing to deal with water shortages and have relied on alternative measures – irrigation practices and technologies. However, conserving and reallocating water is now becoming a critical issue and institutional changes are essential (Hsiao and Luo, 1997).

5.17 Impacts on livelihoods

Molle (2001a) warns that economists could come under the same criticism as engineers for being too discipline-oriented and unrealistic, and that all aspects of the system need to be considered. The complexity of objectives in irrigation pricing and the interaction between them suggest that clear and unambiguous impacts on livelihoods cannot be specified. Increased charges will reduce the incomes of farmers – including the poor – and will lead to increased food costs for all. Better water allocation will benefit all – including the poor.

5.18 Summary of general issues

The generic issues cover a wide spectrum of social, political, economic, cultural, and geographical factors, highlighting the diversity of irrigation systems in general. The examples from different countries show how the issues are affected by different contexts. Many authors emphasise that there is a need to take this diversity into account when implementing water pricing (Abernethy *et al*., 2000; Johnson, 2001; Molle, 2001a). As Ahmad (2000) states, "There is not a general strategy or model to adopt for a specific water pricing policy of a country. Every country has to develop its own strategy" (p.241). Others reiterate the dangers of using a "one-model-fits-all approach" (Johnson, 2001; Molle, 2001a), which bureaucracies find easier to implement (cited in Abernethy *et al*., 2000). A change of attitude is therefore needed within the agencies implementing the reforms. As Palerm Viqueira (2001) states, "Generalisations are useful, but over-generalisations make the recommendations useless".

6. CHALLENGES TO ESTABLISHING CHARGING SYSTEMS

6.1 Financial sustainability

6.1.1 Constraints

There are a number of constraints to achieving financial sustainability in some irrigation systems. First, the price of basic agricultural commodities has fallen dramatically over the last 50 years (Perry, 2001c), so that investments that were viable at the time of their inception may not be now; irrigated agriculture thus being a victim of its own success. Second, irrigation schemes are not built solely to benefit farmers, but also to provide affordable and secure food supplies to the country concerned. While direct benefits of increased productivity may reasonably be charged to farmers, the substantial, indirect benefits of low-cost, secure food supplies may legitimately be assigned to society more generally. This may be a legitimate government policy with a high value placed on improving the level of food security through developing production systems that are only financially viable with subsidies. Third, some systems may be needed to stabilise and benefit poor rural farmers who would otherwise be exposed to regular drought and food insecurity, and who would move to already strained urban areas. Here social benefits, rather than national food security, are the key. Changes, either in world market prices or national government policies, make these schemes financially unsustainable without government subsidy.

6.1.2 Financially unsustainable systems

Governments argue that abandoning unsustainable systems and relying on rainfed agriculture would have disastrous social and environmental consequences. However, in the present circumstances, governments are finding it increasingly difficult to maintain the high level of subsidy and users are often unable to pay O&M costs (Johnson, 2001). Svendsen (2001b) argues that where an irrigation system is deemed to be financially unsustainable, alternative water sources or alternative employment should be found for those who are dependent on it – a statement that is easier to make than to implement. There is also the issue of how to determine whether a system is no longer viable (Cisty, 2001; Svendsen, 2001c). Cisty examines this problem, which is now facing the Slovak Republic. When it formed part of Czechoslovakia, irrigation systems were built to ensure food self-sufficiency, rather than for economic benefit. As Cisty points out, it is difficult for farmers to establish which irrigation systems are no longer sustainable, as all agriculture is in decline (see also Box 6, for the case of Bulgaria). Svendsen (2001b) indicates that a "triage system" is needed, where irrigation systems that have potential, in financial and economic terms, can be separated from those which do not. Where systems fall between the two categories, governments may intervene and subsidise them.

In certain cases, the expansion of large-scale irrigation infrastructure may not be compatible with full cost recovery (OECD, 1999). It is unlikely that eventual users of large-scale systems under construction in Portugal and Turkey will be capable of repaying all the capital costs. One of the large-scale projects, the Alqueva project in Portugal, is to be financed mainly by the European Union. It is interesting to note that this contrasts with the Water Framework Directive (2000) (European Union, internet), one of its objectives being full cost recovery applied to all users.

Box 6. Financially unsustainable systems

Examples of irrigation systems that are no longer viable are the pump stations in Bulgaria. In 1991 they still served an area of 579,000 ha, whereas gravity systems provided water to 325,000 ha. The dramatic changes of the nineties made the pumping stations unprofitable and the area served by them fell to 275,000 ha. In contrast, gravity irrigation increased slightly in the same period to 344,000 ha.

(Report to European Commission – DG Environment, 2001)

Tardieu and Prefol (2002) discuss the French response to the Water Framework Directive's insistence on full cost recovery. They argue that charging that includes the past financial costs of major infrastructural investment would be socially unacceptable. They argue instead for an intermediate or "sustainable" cost, which covers all operation and maintenance costs but excludes the cost of past investment.

An extreme interpretation of full cost recovery would render many large schemes "financially unsustainable" but a pragmatic understanding of "unsustainable" embraces only those schemes that cannot cover routine O&M costs without subsidy.

6.1.3 Cost recovery

Whilst recently there has been increased pressure for O&M costs, at least, to be recovered directly from the beneficiaries, this has not always been the case. In an older World Bank report of 1986, experience in 48 irrigation projects in East Asia and the Pacific, South Asia and the Middle East, and South America showed that 75% of the projects required recovery of operation and maintenance costs. Success in meeting this objective was achieved in only 22 projects (46%); in the remainder, cost recovery ranged from zero to some level below operation and maintenance needs. The report concluded that the evidence cast doubt on the principle that costs of irrigation must be directly recovered from project beneficiaries, because the link between funding of operation and maintenance and payments by farmers was often absent. Where governments subsidised necessary operational costs or indeed recovered significant indirect revenues from farmers through distortions in output prices, funding for operation and maintenance could be sustainable and adequate (World Bank, 1986).

6.1.4 Resources, under-assessment and recovery rates

Basic investment is required to operate and maintain systems in a sustainable way (Johnson, 2001). Johnson highlights the fact that transferring poorly maintained irrigation systems to users is often cited as being a way of not only improving O&M, but also reducing costs to the State and the users. However, as he demonstrates, where systems are already chronically underfunded, this will only lead to further deferral of maintenance and general decline. Governments then have to borrow (historically from development banks but increasingly less so) to rehabilitate their irrigation systems, creating a vicious circle. Under-assessment of the true cost of service provision can be a problem of a similar order of magnitude as non-payment. The degree of under-assessment, by its nature, is difficult to estimate, but one study in Pakistan estimated losses due to under-assessment to be 35% (Eurconsult, 1997).

The discussion on what price to charge should be secondary to the issue of improving recovery rates for any charges that are set. The summary information presented in Annex 1 shows that recovery rates of water charges are usually below 50%. Moreover, in several countries levels of recovery have declined. In Pakistan, recovery rates dropped from 38% in 1994/95 to 26% in the following season; in Macedonia, they fell from 85% in 1990 to less than 40% in 2000 and in Surinam, water users stopped paying water charges altogether and water boards practically disappeared (Risseeuw, 1997). In Croatia no charges are collected for irrigation because the area and income involved are too small to justify the costs of collection (Ostoji and Luksic, 2001).

6.1.5 Irrigation management transfer

Reviews of irrigation management transfer (IMT) policies demonstrate that problematic recovery of water charges does not necessarily disappear after management transfer. Vermillion *et al.* (2000) note that experiences generally on cost recovery (as part of IMT) are mixed. Many transferred schemes struggle with enforcing fee collection and free rider problems. In Colombia, the level of cost recovery declined in two out of three case study areas after IMT (Vermillion and Garcés-Restrepo, 1998). IWMI's comparative irrigation performance study showed that financial self-sufficiency in most schemes is low. Clearly, considerably more work is needed to address the issue of poor recovery rates and on designing simple mechanisms acceptable to farmers and management agencies.

Svendsen (2001a) states that it “seems irresponsible of governments to attempt to transfer clearly non-viable schemes to users without some form of ongoing subsidy”. He adds that farmers “need access to an independent assessment of the financial viability of schemes before they can make an informed choice of whether to accept or not”. However, this may not be an option if financial assessments are not available or where transfer is compulsory. Svendsen argues that costs resulting from bureaucratic inefficiency and corruption must be removed before full costs are passed on to users. Although Svendsen maintains that irrigation agencies should be moved out of the public sector and given incentives for efficient performance, he does not specify whether this would be by means of farmers’ organisations taking more responsibility for collecting and setting fees or through private organisations carrying out these activities. If it is the former, Bruns (2001) supports the fact that it may be useful to look at cost recovery from a farmer perspective, rather than the more traditional government perspective. “A crucial change can occur if IMT truly results in self-governance where farmers and their elected representatives feel they are choosing to levy fees on themselves, rather than just collecting charges set by an outside agency” (*ibid*.). However, if it is the latter, where a private organisation is dealing with farmers’ organisations and aims to make a profit, as opposed to all fees being reinvested into the system, it raises serious political questions about system sustainability and ownership of publicly funded assets.

6.2 Irrigation charging and water saving

6.2.1 Irrigation efficiency and water losses

It is a common perception that irrigation efficiency (the ratio of water diverted to water consumed by the crop) is low. However, *at basin level*, efficiency may be much higher because losses at one point are recaptured elsewhere and the scope for water savings over a basin or sub-basin may be much smaller than anticipated[3] (Molden *et al*., 2001; Molle, 2001a). Therefore, should water pricing induce water use efficiency upstream, it would not necessarily increase water availability. Water availability and allocation therefore need to be examined from a basin perspective. If ‘losses’ from a system really do go to a sink or the quality is too low for reuse then improving scheme level efficiency is critical. In this case, pricing as an incentive to conserve water may be justified. In other cases, to ensure that savings are real, it would be preferable to price water according to the amount consumed rather than the volume diverted (Perry, 2001a), but as stated previously, this is normally impractical due to the difficulties of measurement.

6.2.2 “Getting the prices right”

According to several authors (Burger, 1998; Ahmad, 2000; Johansson, 2000; Ray, in press), the policy of setting a low price for water does not create the proper incentives to use water efficiently or to reuse wastewater (Ahmad, 2000). It also “sends wrong signals to the producer and consumers about the true scarcity value of resources which often leads to over-production and over-consumption of commodities which are resource depleting and environmental polluting” (*ibid*., p.232). Johansson (2000) states that pricing water consumption ‘correctly’ is one means of achieving allocation efficiency.

To provide incentives for careful water use, it is necessary to establish a charging system that causes water users to think carefully about the decision to apply water to their crops and to weigh marginal water use against its marginal cost. The charge must be related to the amount of water used and the cost to the irrigator must be "appreciable". This may lead to charges that are considerably higher than the cost of service provision, as Perry (1995) demonstrates in the case of Egypt. It is commonplace for irrigation costs to make up only 2-3% of the total costs of production. In such cases even a doubling of water cost has little impact on the farm budget. However, where small-scale farmers operate very close to the margin, much lower fees may achieve the desired economies (Svendsen, 2001b).

Ray (in press) discusses the implicit assumptions made of “getting the prices right” to deter wasteful use of water and achieve irrigation efficiency (see Box 7). She concludes that for India these assumptions are

3 This nomenclature introduces yet another “efficiency” concept: at the basin level, in Molden’s terms, “efficiency” means the proportion of total available water that is consumed.

violated and that enforceable and transparent allocation rules may be more effective to curtail water demand. Molle (2001a) reaches similar conclusions for Thailand.

"Getting the prices right" to guide efficient allocation of scarce water resources and balance supply and demand is a much more complex issue than just inducing efficient water use. Some authors suggest that the value of water (or any other resource) is the maximum amount the user is willing to pay for the use of the resource. To achieve financial sustainability of irrigation schemes, at least recurrent O&M costs should be recovered. If, on the other hand, pricing is used as a regulatory measure to ensure efficient allocation of water resources, *all economic costs* – including opportunity costs and economic externalities – need to be taken into account. However, Briscoe (1996) claims that estimated values of opportunity costs are crude and inexact, and widely depend on factors such as use, location, season, time, quality and reliability of supply. "Most certainly these ballpark estimates can never, and should never, be used to make technocratic decisions on allocations and prices. But examinations which emerge from these estimates do show some striking and remarkably consistent themes which have major implications for policy. In addition, high marginal values in non-irrigation uses rapidly decline, and indeed become negative, as water is shifted out of irrigation, so that apparently substantial gains from inter-sectoral transfers can easily be overestimated (Perry, 2001a; Savenije and van der Zaag, 2002).

Box 7. Assumptions underlying effective pricing for demand management

"Getting the prices right" in irrigation pricing is based on many assumptions:

1. Water prices are significant in the overall crop budget, and as a fraction of crop net revenues. If not, the income effect of price increases may be so small that the water demand will barely respond.
2. There is a volumetric link between what a farmer pays and what he receives. If water is charged by the hectare, as it usually is in developing countries, its marginal cost is zero and higher prices cannot induce efficiency.
3. Farm level inefficiencies are significant in relation to overall system inefficiencies. If not, the farm level may not be the place in which to look for water savings.
4. Farmers do not diversify into high-value crops and irrigate using wasteful methods *because* water is so cheap. If low-valued crops are grown for other reasons, e.g. for own consumption, or because farmers face labour constraints, price signals may not have the expected effect.
5. The changes to the physical infrastructure that are necessary to implement water trades or volumetric pricing, such as measuring devices, channels for conveyance, etc., are not prohibitively expensive. If they are, any gains from trade will be neutralised by these implementation costs.
6. Tradable water rights can be allocated and enforced without high transaction costs, and third party effects, if significant, can be countered. If not, these costs and potential losses will overcome the benefits of trade or local water savings.

N.B. Points 1, 3 and 4 relate to the effectiveness of price incentives, as opposed to implementation. Points 5 and 6 relate to the difficulties of implementing higher water prices or tradable water rights.
(Ray, in press)

6.3 Volumetric pricing and water use

6.3.1 Limitations of volumetric pricing

A major obstacle in the implementation of volumetric water pricing is the high cost of the required measurement and billing system. Where farmers are numerous and field sizes are small, the process of monitoring water use, billing and collecting fees is difficult in practice and carries high overhead costs.

Water measuring devices at farm level and institutional infrastructure are lacking in most places. Perry (1995 and 2001) shows that in Egypt and Iran, costs of pricing to farmers are likely to outweigh projected benefits. Svendsen (2001b) accepts that apart from a few successful cases in China and some higher-income countries, the high cost of measurement and billing presents problems – both real and potential – for volumetric pricing. A study among OECD countries shows that volumetric pricing in agriculture is not widespread because of practical obstacles (OECD, 1999). As long as the transaction costs remain a high percentage of the revenue collected or of the value of the production, volumetric measurement is difficult to justify.

6.3.2 Empirical evidence on volumetric pricing and water use

While there exists a large body of descriptive and normative literature on water pricing, analytical studies that numerically assess the impact on farmer behaviour are relatively few. Of these studies, most deal with the Western USA and OECD countries and studies in developing countries are rare. The impact of volumetric water pricing and farmer response to increased charges depends on a variety of factors. As mentioned, where return flow reuse plays a prominent role, the impact of pricing on basin level water use may be limited. Box 8 provides an overview of factors that influence the price elasticity of demand for irrigation water – that is the amount of change in the quantity demanded for a given change in price.

Values of elasticity of demand are normally negative as demand falls when price increases. Higher absolute values of elasticity indicate that the percentage change in volume demanded is large, when compared with the percentage change in price. Price elasticity estimates from a study in OECD countries vary considerably, from -17.7 to -0.05. Other studies confirm the wide range (OECD, 1999). The price range for which the elasticity is measured, is an important – if not *the* most important – determining factor: the higher the price range, the higher the elasticity. Existing low prices of water may be the main reason why farmers are not very responsive to price changes. Moreover, factors other than price may have a greater impact on the quantity of water demanded: climate variation, agricultural policy, product prices, and reliability of water supply.

Box 8. Empirical evidence on elasticity (responsiveness) of demand of agricultural water to price

- Elasticity depends on:
  a) Initial price of water: the lower the price, the less responsive farmers are to price increases.
  b) The availability and relative cost of alternative water sources.
  c) Crop value: elasticity is higher for low value crops.
  d) Production costs: if water is only a small part of the input costs there is little incentive to change irrigation methods; thus high production costs lead to low elasticity.
  e) Application rates: if farmers are applying excessive amounts of water, there is scope for conservation without the necessity to change irrigation method.
  f) Ability to change crops (climate, soils and markets).
  a) Ability to change to more efficient irrigation technology.

- One study suggests that water demand is inelastic only up to a given price level. Beyond this price "threshold" water demand may be very price responsive. The level of price "threshold" depends on:
  a) The economic productivity of water.
  b) Price of water compared to overall production costs.
  c) The set of alternative production strategies, to substitute for water consumption.
  d) Proportion of land devoted to permanently irrigated crops.
  e) Irrigation technologies in place.
  f) The size of water allotment.

- Depending on the irrigation technologies in place, short-term elasticity may be very low compared to long-term elasticity (switching to more water efficient technologies or management practices takes time). Where efficient, high-tech, on-farm water management is in place this effect is reduced.

US Bureau of Reclamation (1997)

Existing water use practices and irrigation technology play a major role. Varela-Ortega *et al*. (1998) compared the price elasticity of water demand in three regions in Spain. They concluded that in the 'old' irrigation schemes, where water application techniques were relatively inefficient, the response to increasing water charges was much higher than in the modern systems with drip systems. The authors conclude that technical endowment has a major effect on the response to water pricing. The higher the technical proficiency, the less responsive the district is to water pricing. Dinar and Letey (1996) develop an analytical model to compare the effectiveness of water pricing to curtail water use in four regions in California. They conclude that price policies were found to be less effective in regions where water is relatively abundant and the price is relatively low. An important conclusion they drew is that water quantity reduction policies were found to be more effective than water price policies.

The adoption of improved irrigation technologies in Spain does not depend significantly on water price level, but on structural factors, agronomic conditions and financial constraints (Varela-Ortega *et al*., 1998). Green and Sunding (1997) endorse this finding with empirical evidence from California. They conclude that technology choice may be driven by water price in some locations, but mostly it critically depends on land quality and crop type. Caswell and Zilberman (1990), in their studies in California, demonstrate that the probability of adopting drip irrigation technologies increases with higher water prices, although land quality and environmental considerations seem to play a more important role in technology choice. Burt *et al*. (2001) argue that adoption of drip irrigation does not necessarily lead to 'water savings'. They emphasise the importance of distinguishing between water diverted, water transpired by plants and evaporated from bare soil. Furthermore, effective use of drip requires a highly reliable water supply to the farm. Huppert and Urban (1999) report that the adoption of drip irrigation by many farmers in the Jordan Valley has not led to significant reductions in water diversion as farmers are aware of the unreliability of supply. They tend to over-apply water through their drip systems on the occasions when water is available, eliminating any potential water saving.

The initial price of water also influences the impact of any increase in water charges. The lower the initial price, the smaller the farmer response to a price increase. This is supported by Briscoe (1996) in the western United States. A comparative study among OECD countries reveals that, despite the wide range of observed or modelled price elasticities in irrigation water demand, at low water prices they are consistently low (OECD, 1999). The study states that only above a certain threshold price does demand become elastic (responsive to price). The US Bureau of Reclamation (1997) reports similar evidence. Dinar and Letey (1996) observe that because (surface) water is a quantity-rationed input, small water price increases would not alter producer decisions and would not induce water conservation. Irrigation water demand curves in Spain exhibit a perfectly inelastic (non-responsive) stretch at low prices and become elastic beyond a certain threshold (Varela-Ortega *et al*., 1998). Since prevailing prices are low, this implies that only considerable increases in price, i.e. setting the price above the threshold, will induce the desired efficiency.

Ray (in press) stresses that even where volumetric pricing leads farmers to improve their water use efficiency, they can only improve the management of that fraction of diverted or released water that reaches their fields. On many large surface irrigation schemes this might be as little as 25%; the rest of the water released may be lost in conveyance and no pricing policy is likely to address these losses.

Because of the factors discussed above, effects of volumetric pricing on water use seem to be limited. Malla and Gopalakrishnan (1995) report that price increases in Hawaii had no significant impact on water use, since climate factors such as rainfall were the determining factors in water use decisions.

6.3.3 Effects of volumetric pricing on farm incomes

Berbel and Gomez-Limon (2000) estimate that farm incomes in Spain will have to decrease by 40% before water demand decreases significantly. Perry (1995) estimates that inducing a 15% reduction in water demand in Egypt through volumetric pricing would decrease farm incomes by 25%. Ray (in press), in her study on water pricing in India, uses an analytical model to show that in order to induce the water-conserving response under existing allocation practices, a six-fold price increase would be needed. In Iran, to be effective in curtailing demand, water prices would need to be raised by a factor of ten (Perry, 2001a). Price increases of this order of magnitude are quite unlikely in the prevailing political context and thus the political feasibility of volumetric water pricing, as a tool to curtail demand, is questionable.

Severe impacts on farm income are implicit in using water pricing as a means to limit demand, as compared to the rationing solution. Enforceable and transparent allocation rules and abstraction licences may be a more effective way to curtail demand (Perry, 2001a; Ray, in press). Bernardo and Whittlesey (1989) use a mathematical programming model to show that farmers in Washington State substitute water with labour by switching to a more water efficient use of their current irrigation technology. Consequently, under restricted supply (rationing), water use can be reduced up to 35 percent for surface irrigation and 25 percent under centre pivot schemes, without greatly affecting farmer income. Hoyt (1984) reaches similar conclusions for groundwater use in the Texas High Plains. His results imply that if water supply is restricted by 20%, farmers' profit will not be affected significantly. However, increased water extraction costs and crop prices have no significant impact on the efficiency of water use. He argues that due to the inelastic demand for irrigation water, reliance on price mechanisms to conserve water has a limited impact in the short run. Only if prices increase dramatically, do capital investments in more efficient irrigation technology become viable – at considerable profit loss to farmers.

6.4 Water markets

Issues raised in relation to water markets include the requirement for a suitable legal framework (including the definition of water rights), transaction costs, market failures and equity concerns. The proper functioning of water markets requires that water rights are formalised. This is seldom the case in developing countries. Formal water markets exist in Australia and Chile and there has been some transfer of use between sectors but mostly within sectors.

Local, informal markets have existed in many countries and can function with less legislation but they only operate on a small scale and will not change big-picture water allocation between sectors.

In Gujarat, India, groundwater markets have existed for 70-80 years. Richer landowners invested in diesel pumps and pipe distribution networks to sell water to others who could not afford pumping equipment. As water has a price, individual sellers and buyers will use it efficiently. However, this does not prevent groundwater depletion problems, and inefficient use of the resource from a societal point of view. On the contrary, lack of enforceable regulation, well-defined property rights and high profitability induce overuse. In this context, water resources are open access resources. Local water markets also exist in Spain and in the USA (Rogers and Hall, in press).

Opinions vary on the distributional impacts of water markets. Chambers *et al.* (1990) and Kahnert and Levine (1993) favour the view that extensive development of groundwater will lead to competition favouring buyers of water – predominantly the poor. On the other hand, evidence from Gujarat shows that in a situation of scarcity, the wealthier farmers who can afford more expensive, deeper wells tend to "capture" the resource. In fact, where an aquifer is likely to be exhausted before the cost of pumping rises to levels that curtail demand, the "market" is actually a competition among pump owners to extract as much water as they can, and use or sell it at a price in excess of the cost of pumping. It is not a market in alternative water supplies.

A conclusion may well be that where water is plentiful, unrestrained development will benefit the poor as prices fall, while in areas of scarcity, a legal framework is needed to protect both the viability of the resource as well as the needs of weaker parts of the community.

7. SELECTED WATER PRICING COUNTRY EXPERIENCES

The objective of water pricing in more developed countries is often to allocate a scarce resource between sectors, whereas in less-developed countries, particularly in Asia, it is to recover costs (Johnson, 1990). However, IWMI (internet) record that in many countries, principally in South Asia, water pricing has not even achieved the objective of cost recovery.

This section presents some country-specific experience of water charging policies.

7.1 Niger

The information here is drawn from Abernethy *et al*. (2000) who present findings from four irrigation systems in the Niger Valley.

In the Niger Valley, the government's objective is to transfer the operation and maintenance of irrigation schemes to co-operatives of water users (government-sponsored organisations) as the cost to government is too high. Users pay fees that are designed to include all operational costs, part of the initial capital cost, some of the costs of the government's supervisory agency, and savings towards repairs and renewal (which constitute nearly 20% of the fee). Water and energy costs are divided among farmers according to the size of their landholdings. Details are made available to members after each season. The results, so far, are considered to be "acceptable" by the authors, though there are concerns about the sustainability of the system, in particular the finances of the co-operatives.

For ten seasons from 1992-1996, the average seasonal fee at three rice-growing systems was US$ 124 / ha / season (converting to Purchasing Power Parity this is equivalent to approximately US$ 425 / ha /season). This is high by international standards, as it includes both energy and some capital costs. Total production costs (including the opportunity cost of family labour) comprise 70-80% of crop value. The irrigation fees are equivalent to between 12-25% of gross crop value so water fees make up a large part of the total cost due to the inclusion of both energy costs and capital depreciation.

Fee collection rates are high, at between 90 to 100% but there is often considerable delay in farmers paying their bills so the co-operatives regularly face cash flow difficulties. Even at these very high fee levels and with high ultimate collection rates, it has not been possible to achieve full cost recovery and the intention that the co-operatives should accumulate a savings fund has not been realised. Rather, the element of the fee intended for savings is used for day-to-day running costs, due to the short-term absence of cash. The authors suggest that the continuing lack of cash and savings, coupled with organisational and accounting structures imposed upon the co-operatives by the government when they were formed, pose a serious threat to the long-term sustainability of all of the co-operatives studied.

Irrigators in two systems are dissatisfied with their organisations' inability to include them in decision making. Maintenance levels are low, reflecting uncertainty about responsibilities and finance. Most of the funds are being used to cover operational costs and occasional capital costs with little or no allocation for savings or maintenance.

Although improving water use efficiency was not a major policy objective, attempts to reduce water use, by encouraging farmers to improve irrigation scheduling, have not been successful. Irrigation forms only one of many economic activities for farmers, and there is often conflict between rainfed and irrigated agriculture, so farmers have little inclination to invest more time in water management.

Where water supplies have been improved, land productivity is high, while water productivity is low. In general, farmers tend to take as much water as possible to irrigate their crops and have little incentive to improve water use efficiency. Although conveyance losses are between 40 and 60%, and farmers will pay for this lost water, the extra cost is divided between the members of the co-operative, who may number a thousand. Similarly, it is uneconomical for farmers to provide labour towards improving the system, as they will only gain one thousandth part of any benefit.

7.2 Iran

Perry (2001a) assesses the potential impact of water pricing on The Zayandeh Rud Basin in the Esfahan Province, Iran. The basin faces problems typical of arid areas – irrigation is a prerequisite for agriculture and downstream users face deteriorating water supplies, both in quantity and quality.

In 2001, water prices in Iran were Rial 20 per m^3 (US$ 4 / 1000m^3). For several crops, including wheat, barley, maize and rice, this comprises approximately 5% of the total revenue, and less than 10% of net revenues, which is a relatively small value compared to the overall crop budget, so water is a small component of cost. This implies that unless charges for water are much higher, volumetric pricing will have very little impact on farmers' choice of crop or management of water.

IWMI's analysis of a much wider data set (cited in Perry, 2001a) indicates that a water price of between US$ 3 - 5 / 1000 m^3 may be required to cover O&M costs on extensive, gravity-fed surface irrigation systems. The charge in 2001 of US$ 4 / 1000 m^3 lies neatly in this range. The same wider data set indicates that prices would have to be raised to US$ 20 - 50 per 1000 m^3 to have any significant impact on demand. This would create more revenue, but could cause political problems, as the supplying agency would make substantial profits.

By increasing water prices, farmers could be dissuaded from purchasing additional canal water and encouraged to invest in more efficient irrigation technology. However, Perry demonstrates that in Iran water prices would have to increase as much as twenty-fold before farmers invested in field technologies to improve water use efficiency. Only at that price would farmers start making a profit from their investment and stop buying additional water. At this level, water charges would be equivalent to two-thirds of gross revenues for basic field crops. Investing in improved technology could result in higher yields and a move to higher-value crops. This would lead to an increase in land productivity and water consumption at the farm level (more productive crops would actually *consume* more water), and a decrease in return flows to drains and aquifers. Where downstream users depend on return flows, this could be detrimental.

Perry also shows that different policies can have varying effects on the environment over time and space, particularly where the overall salt balance is critical to the 'health' of a basin. He concludes that "irrigation "efficiency" and productive, sustainable irrigation have no precise relationship and that the optimum "efficiency" must be locally defined in relation to impacts in the area concerned and elsewhere. The implications for a pricing policy as a tool in this environment [where salt is critcal] are obscure" (p.14). Thus, governments have to think carefully about farmers' response to changes in policy, and how this would affect the environment.

7.3 India

7.3.1 National situation

According to Saleth (1997), water pricing could be used to achieve water use efficiency in India, a country where water resources are becoming increasingly limited. However, much of his text is centred on water pricing to recover the costs of the system, and even this has not been achieved.

States and provinces set water rates, but these are not standardised and do not reflect the scarcity value of water. Most states charge for canal water. Area-based water rates often vary by crop and season, by category of project, irrigation type and category of user (cited in Saleth, 1997). Canal projects also sell water to domestic and industrial users, lease fishing rights, sell timber, etc.

In most states, fee recovery does not cover O&M costs and in certain states (e.g. Bihar and Rajasthan) the collected fees do not even cover the cost of collection. Collection rates decreased from 64% in 1974-75 to

8% in 1988-89. The aggregate recovery rate, averaged across states, was just Rs 20-70/ha (US$ 1.2 – 4.2 /ha) in 1989/90. However, Government of India figures indicate that to cover O&M costs, rates would have to be at least Rs 200-250/ha (US$ 12 – 15 / ha) (cited by Saleth, 1997). Thus, across the country, only 20% of O&M costs were being recovered.

Farmers have no incentive to use water efficiently as charges are too low and are based on area irrigated. Inefficient water use has led to severe environmental problems – rising groundwater levels, waterlogging and soil salinity. Administration is ineffective. Assessment and collection of fees is often carried out by different departments, or a department not related to irrigation. Farmers need to be involved in setting rates, because at present they simply oppose any suggestion of an increase in price.

Groundwater is used more efficiently than canal water, as a result of private sector involvement in developing the resource and development costs. Charges for groundwater are generally high enough to cover operating costs but not capital costs or resource costs.

The Vaidyanathan Committee report (cited in Saleth, 1997) highlights the need to recover not only O&M costs, but also a small proportion of the capital cost (1%), with a group-based distribution system for canal water. The report recommends implementing a two part tariff comprising a flat annual fee and a volumetric charge. Authorities agree that water rates must be revised regularly to generate the revenue needed to cover the full O&M costs and a portion of the capital costs. However, these proposed water rates would comprise only 6% of the gross value of output, which would not promote more water efficient practices.

7.3.2 Mula canal

In the Mula canal, India, Ray (in press) examines whether water charges are the most effective way of reducing demand and improving farm level efficiency.

Water is heavily subsidised on the Mula canal. Water fees are low, but they are adjusted according to the season and crop grown, so there is some relation between the volume of water and fee level. Groundwater supplementing the canal is also cheap, as electricity is subsidised. Fee collection rates are low, ranging from 15% to 64% between 1977 and 1990. Fees comprise a small part of crop revenues, in most cases approximately 1% of average net profits per acre, which gives farmers no incentive to reduce the volume of water they use. A farmer might be encouraged to grow more water-efficient crops if water fees were higher; however, prices would have to be raised substantially to form a significant part of the crop's net revenue.

Using a mathematical model, Ray compares the effect that the alternative policies of higher water prices or water rationing would have on crop choice (and therefore water demand) on a median-sized farm. The model shows that to produce a more efficient cropping pattern, a six-fold increase in price would be needed to have the same effect as rationing. Clearly, such increases in price would be politically controversial.

The model was used to establish farmers' response to changes in the price of sugarcane. (Sugarcane has a low water productivity, but a high land productivity and requires less labour than more water-efficient crops such as vegetables, oilseeds or spices.) When it becomes increasingly unprofitable for farmers to grow cane, even at low water prices, farmers will change to more water-efficient crops such as sunflowers and groundnuts (cited in Ray, in press). In reality, however, there would be strong opposition if the government tried to remove the support price on sugarcane.

Ray emphasises that water prices can only affect the water over which the farmers have some control, and those inefficiencies which are caused by low water prices. In the Mula canal, this means that farmers can be encouraged to be efficient with only 25% of the irrigation water diverted from the reservoir – as this is the proportion of water that reaches farmers' fields.

Finally, it is interesting to note that since the establishment of a WUA in 1994-95 in Minor 7 in the Mula Project, major changes have taken place in the cropping pattern. In the command area of the WUA, the area under sugarcane has increased from 15% to more than 50%, the area under wheat has decreased from 30% to 15% and the area under oilseeds has declined from 35% to less than 3%. The gross irrigated area has increased by 30% from 257 hectares in 1989-90 to 460 hectares in 1994-95 (Naik and Kalro, 1998). Whilst policy makers and researchers might urge water conservation and the adoption of less water demanding crops, in reality the opposite appears to be occurring, with water being allocated to more profitable, though water-inefficient, crops.

7.3.3 Regional systems of irrigation

Perry (2001b) examines the potential of water pricing in India, focusing on the five regional systems of irrigation – warabandi, shejpali, localisation, field-to-field and tank projects, see Table 2. In all five systems, changes would have to be made to legal, regulatory, and operational aspects before water pricing could be introduced effectively, see Table 3.

Perry analyses water pricing as a means of achieving a balance between supply and demand. Currently in India, water fees range from Rs 100/ha to Rs 400/ha (US$ 2-8/ha), which equates to US$ 0.4-1.6 / 1000m^3 in equivalent volumetric pricing. Sugarcane fees can be as much as US$ 30 / ha, which equates to US$ 1.5 / 1000m^3 in volumetric pricing. Considering the typical value of water (US$ 100-200 / 1000m^3), even if there were significant increases in current prices, water would still be priced at a fraction of its typical value, and this would have little effect on demand. Perry therefore concludes that it would be more effective to allocate water among users and that this could lead to productive and conservative use of water. Such allocation, of course, requires a political system that can act on unbiased, technical advice and take difficult decisions, and a legislative process that is not easily manipulated by powerful interest groups.

Table 2 Characteristics of the five regional systems of irrigation in India

System	Location	Details – crops/cropping patterns, etc
Warabandi	North-west India	Farmers can grow crops of their choice. Mainly wheat, cotton, rice, pulses; some fruit and vegetables.
Shejpali	Western India	Farmers must obtain official sanction for proposed cropping pattern, then can draw water according to "crop needs". Cash crops – sugarcane, cotton, tobacco – and foodgrains.
Localisation	Southern India	Cropping pattern legally defined for whole command. Rice and sugarcane, cotton and tobacco. Tail-end farmers usually receive less water – have to grow drought-tolerant coarse grains and pulses.
Field to field	Eastern India and delta areas of southern India	Kharif irrigation is obligatory (and charged for) over the entire irrigable area, while rabi irrigation is organised annually, according to water availability.
Tank systems	Southern India	Subset of the field-to-field. Spill from upper tank is primary inflow to lower tank.

(adapted from Perry, 2001b)

Table 3 Status of legal, regulatory and operational issues in Indian irrigation

System	Legal	Regulatory	Operational
Warabandi	Water right assures equitable share of total water, not quantity. Crop selection is free.	Rules are generally followed; distribution equitable and uniform.	Physical system not suitable for differentiated supply at farm level.
Shejpali	Water right assures “adequate” water for crop, not specific volume.	Water distribution skewed.	Systems difficult to operate, but in principle suited to differentiated supply.
Localisation	Water right is for “enough” water for specified crop only.	Generally rules are difficult to enforce.	Not possible to provide differentiated supply.
Field to field	No water rights at farm level.	Water distribution between farms not controlled.	Impossible to provide differentiated service.
Tank systems	Water rights hierarchical among tanks and farmers within tanks.	Rules are locally enforced.	Difficult to provide differentiated service.

(Perry, 2001b)

7.4 Jordan

Renewable water resources in Jordan are just 209m^3 per capita/year and any country with less than 1000m^3 per capita/year is considered to be severely limited in socio-economic and environmental terms. Driven by this scarcity, the main objective of the Jordan Valley Authority (JVA), the body responsible for the overall operation of the Jordan Valley irrigation system, is to balance supply and demand between the irrigation sector and the municipal demand of Amman. Within this situation of extreme water scarcity and with increasing demands for water to be transferred from agriculture to meet the growing needs of Amman, the volumetric water pricing system that is in place is not used primarily as a tool to manage demand. Rather, fixed, volumetric allocations are made to farmers at the beginning of the season. Volumetric charging is expected to give the farmers some sense of the value and scarcity of water but the key objective of charging is to recover O&M costs. The water supply to Amman is ensured not by any pricing policy but by clear allocation assisted by pre-season simulation modelling of demand and supply.

Water fees cover approximately 50% of the O&M costs for irrigation. Total costs to government of the irrigation system in the Jordan Valley, in terms of O&M plus capital costs, amounted to 10.4 million JD (Jordanian Dinar) in 1997 (US$ 14.6 million) (cited in Huppert and Urban, 1999). Until 1990, water fees were 0.003 JD/ m^3 (US$ 4.2 / 1000 m^3) and by 1999 were at 0.015 JD/m^3 (US$ 21.1 / 1000 m^3). This figure would have to be trebled in order to achieve full cost recovery (*ibid.*). However, there is strong political pressure to keep the fees low.

It is hoped that increasing the level of water fees will result in increased water use efficiency. However, Huppert and Urban warn that although “the level of water charge has been subject to constant debate in recent years…the institutional aspect of financing has been touched upon less frequently” (p.58). One major aspect affecting the effectiveness of water pricing is that the maintenance budget is independent of the fees collected.

Although the water fee is related to volume consumed, the Jordan Valley Authority has stopped repairing water meters. No-one has any real interest in the repair of water meters – neither the farmers, as this would limit the amount of water they were allowed, nor the staff at the JVA, as fees are not related to the service provided and they are short of resources. When field staff are asked about how bills are prepared in the absence of meter readings, they indicate that the volume is deduced from an assumed discharge rate (water is released through an orifice plate on the end of the pipe) and the time for which the valve is open.

Despite wide-scale adoption of drip technology, application efficiencies for irrigation water have not improved significantly and distribution efficiency remains low. Farmers perceive the JVA's water supply to be unreliable. Thus, when water is available they tend to over-irrigate to store water in the soil, a situation which leads to greater losses (cited in Huppert and Urban, 1999).

7.5 Macedonia

Hatzius (2000) examines the potential for establishing a water fee system in the republic of Macedonia, but does not elaborate on why irrigation pricing is so important or what the objectives for water pricing are. He mainly focuses on the difficulties facing the reformers.

The fundamental problem in the water sector in Macedonia is the financial instability of the Water Management Organisations, who each have different accounting systems. Water fees were seen as being a way to recoup losses from the system, rather than being determined by real costs. This has led to a situation of deteriorating services for irrigation and a decline in fee recovery – in 1990, recovery rates were 88%, by 1995 this figure had fallen to 35% – with the State unable to invest in the irrigation systems. Finally, it started becoming uneconomical for farmers to grow for the market. The situation reflects the general deterioration of the economy in Macedonia.

The author believes that any reform in water pricing should consider the following aspects:

- Willingness and ability to pay.
- Social aspects of water – adapting the system for those who cannot afford to pay.
- Supply and demand of water and water-related goods and services.
- Different institutions to deal with the provision and financing of water-related goods and services.
- Marginal cost pricing.
- Users' involvement in the financing of O&M and other investments in the system.
- Establishing different organisations to manage different levels of the system.

7.6 California, USA

Teerink and Nakashima (1993) give a résumé of water supply pricing in California. It is striking that water pricing is only perceived as a mechanism to recover costs – there are no practical examples of it being used as a demand management tool.

Historically, irrigation districts, and thus individual farmers, drawing water from infrastructure built by the USBR (United States Bureau of Reclamation) were expected to pay water fees to cover the annual O&M costs. Capital costs were to be recovered through long-term repayment with no interest charges. In some instances, even these terms were relaxed and irrigation districts were charged according to their "ability to pay". This subsidy was justified on the basis that the original federal investment was made to achieve regional development and full cost recovery was not always a pre-condition to investment.

The 1982 Reclamation Reform Act imposed the need for much greater cost recovery by the USBR from irrigation districts. Since then, water prices have risen sharply when long-term contracts between the Bureau and districts have come up for renewal.

Water prices vary considerably between districts depending on annual O&M costs, the extent of past underpayment of capital costs, the interest on that and requirements for new capital expenditure. The irrigation district then adds its own costs such that farmers may pay as much as US$ 55 /acre foot (US$ 44 / 1000m^3).

A US General Accounting Office report (cited by Teerink and Nakashima, 1993) stated that in 1984 irrigation and municipal/industrial customers had repaid only 5.5% of the capital investment of US$1.38 billion. Furthermore, not even the annual O&M costs were being covered by the existing water rates.

New contracts were therefore to be negotiated, "aimed at recovering, within 50 years, that portion of the existing plant in service allocated to irrigation and municipal/industrial water."

The evidence is that water pricing in the irrigation sector has been used solely to recover some portion of O&M and capital costs. Full cost recovery of capital investment has only recently become an objective of federal (USBR) schemes. In some schemes, long-term fixed contracts have meant that water fees have not even covered annual O&M costs.

7.7 Israel

The information presented here is drawn from Becker and Lavee (2002).

Israel faces severe water scarcity but to date there is no evidence of water charging being used to reduce demand by the agricultural sector. The Water Law of 1959 nationalised almost all water sources in Israel and established the Water Commission Agency to oversee the development and management of water sources and the allocation of water allotments to different users.

Table 4 shows the annual use of water by agricultural, industrial and residential sectors.

Table 4 Annual water allocation between sectors, Israel

Sector	Approximate annual use (Million cubic metres Mcm)
Agricultural	1250 (61%)
Industrial	120 (6%)
Residential	670 (33%)
Total	2040 (100%)

(Source: Becker and Lavee, 2002)

Becker and Lavee (2002) argue that priority has historically been given to the agricultural sector which has had a strong political lobby. From the early 1990s onwards, the Ministry of Finance has sought to increase water charges paid by farmers but the farming lobby has refused to accept increased prices, pressing instead for the development of additional water sources, including desalinisation.

Presently, farmers are given a water allocation for which they are charged on an increasing block tariff, according to the percentage of the allocation used. For the first 50% they are charged US$ 0.18 / m^3 (US$ 180 /1000 m^3), for the next 30% they are charged US$ 0.22 / m^3 (US$ 220 / 1000 m^3 and for the last 20%, US$ 0.29 /m^3 (US$ 290 / 1000 m^3).

Israel's water supply is derived from three principal sources, the coastal aquifer, the inland, mountain aquifer and the sea of Galilee. In addition to these three main sources, there are a further five, locally important aquifers. All of these sources have been overexploited, with annual withdrawals exceeding recharge. The pragmatic response to this has been for the Water Commission Agency to cut back allocations to the agricultural sector. Ironically, despite this simple and practical response, Becker and Lavee argue the theoretical case in support of using water pricing to reduce agricultural demand rather than further reliance on this apparently simple and transparent mechanism.

7.8 Australia – The Murray Darling Basin

The Murray Darling Basin, in south-eastern Australia, involves three States and comprises an area virtually equal in size to South Africa. Water supplies are scarce and extremely erratic; soil salinity is severe. In a process that began more than 20 years ago, water rights (essentially based on historic patterns of use) have been formalised so that each riparian has an entitlement (or entitlements) specified in terms of both volume and security. Highly secure rights are met (or exceeded) in almost every year; less secure entitlements may only be met in one out of every four years – so the water allocation rules are consistent with the erratic nature of water availability. Salinity entitlements – the rights of an area to *export* salt – are also specified, and each area must stay within its entitlement, or face significant financial penalties. Water deliveries are measured at the farm gate, primarily in order to confirm that entitlements have been taken.

Once water rights had been firmly established and documented, the possibility existed to allow trading in water rights. The system is increasingly complex, given the possibility to buy and sell:

- Seasonal entitlements to water.
- Permanent entitlements to water.
- High security entitlements.
- Low security entitlements.

The complexity of "definitions" of water entitlements points clearly to the body of knowledge and legislation required to specify water rights.

An additional complication, being addressed currently, is the possibility to trade water at significant distances, i.e. outside a local jurisdiction – which inevitably involves third party impacts on river flows, recharge, etc. This process, which introduces inter-state trading, is now being implemented, and involves a number of key components:

- Water "equivalence" ratios, which define, at the basin scale, what a unit of water in one place equates to in terms of water at another location. Thus, a purchaser of 100 units in location A may have to buy 120 units from Location B, or 95 units from Location C in order to have the supply he needs. (These ratios lead to variations in price between locations for a given quantity of water).
- There are procedures within each State's water licensing authority to authorise sales and purchases (both states have to concur).
- Annual adjustments to State allocations by the Murray Darling Basin Commission, reflecting transfers.

The entire process of transferring a water right involves 12 steps (see Murray Darling Basin Commission, internet). To date, water trading is limited. Permanent transfers are taking place at an average rate of about 1% of total availability per year; temporary transfers are occurring at a rate of around 10% of total availability per year. Transfers are almost exclusively within agriculture, rather than between sectors. Interesting impacts of trading so far are:

- Pressure on water use actually increases because previously "dormant" entitlements, perhaps of low value in a particular location, are no longer left flowing downstream to alternative users but are rather sold to someone who will use the entitlement.
- Many farmers (large and small) have "cashed in" their water and retired.

General lessons are:

- Water trading can work to move water from lower to higher value uses, **provided:**
  - Water rights are in place, measured and enforced.
  - Infrastructure exists to divert water entitlements from one location to another.
  - Legal and administrative arrangements exist to monitor and oversee market operations.

8. PRINCIPAL FINDINGS

This review has presented the range of theoretical and observed impacts of irrigation water charging as they are presented in the literature. Much of the literature focuses on the theory of water charging – the objectives of pricing policies and what pricing ought to include. A smaller part presents information on water charging applied in the field, often providing snapshot data on actual water prices, levels of fee recovery and the extent to which O&M and capital costs are being recouped. There is much less information available on the practical aspects of designing and implementing an irrigation water charging policy. This would include methods for calculating future costs and thus determining charges, managing different agencies' responsibilities for levying and collecting fees, calculating the costs of fee collection and establishing the frequency and timing of billing and the means of enforcement and sanction. These issues receive much less attention in the literature, being addressed in just one or two specific case studies.

This chapter presents a summary analysis of the issues identified in the literature.

8.1 Drivers for change

Four key factors have led to the recent attention given to water charging in irrigated agriculture:

- The Dublin declaration that water should be treated as an economic good, and subsequent policy statements at the Second World Water Forum and the Bonn International Conference on Freshwater.
- General trends towards private sector involvement in previously public services – with consequent attention to revenues and financial viability.
- Signs of water shortage in many countries, and the need for demand management in situations where supply augmentation is no longer feasible.
- Current high levels of subsidy to irrigation, in parallel with underfunding of maintenance and deterioration of infrastructure.

Taken together, these factors have driven the debate on water charging policies, first in the water supply and sanitation sector and more recently in the irrigation sector. However, whilst there are apparently compelling reasons why water pricing should be used as an economic and management tool in the irrigation sector, there are numerous theoretical and practical constraints that arise when the issues are examined in more detail.

8.2 Design of a charging system

In designing any charging system it is imperative to know clearly what the **objective** is. There are three broad classes of objective for water charging:

- Recovery of service delivery costs.
- Water allocation, demand management and quality.
- Fairness – e.g. benefit taxation, equity.

The objectives of cost recovery and demand management are those which are most widely pursued in practice through water pricing mechanisms. Macro-economic problems of resource allocation between sectors are a growing concern but these are seldom addressed through pricing. Rather, volumetric entitlements and, in some cases, the possibility of trading those entitlements, are used to achieve such inter-sectoral allocation. Pollution charging and benefit taxation are recorded in the theoretical literature but they are seldom the principal drivers of national water pricing policies.

Where the objective of pricing is to reflect the **cost of the service**, the question arises of what should be included in that cost. The range includes:

- Capital infrastructure – and whether current or historic prices should be incorporated.
- Routine maintenance.
- Rehabilitation due to failures of previous maintenance.

- System improvements.
- Planned replacement of major facilities.
- Unplanned major expenditures caused by extreme events.

Beyond these financial costs, a range of less tangible costs are suggested for inclusion:

- Impacts on affected downstream users (irrigators, households, fishermen, ferries).
- Environmental impacts.
- Social impacts.
- Impacts of food security and prices.
- "Scarcity" cost – the economic value of water in its highest value alternative use.

Where the objective is to recover a specific level of the service cost, 'simple', non-volumetric pricing mechanisms can be used, charging per hectare of land owned or irrigated. Non-volumetric methods are much simpler to administer than volumetric methods as there is no requirement for extensive measurement infrastructure and continuous field recording. However, cost recovery should not be considered easy because it relies on simply assessed parameters. The literature shows that other political, economic and institutional factors, independent of the basis for charging, can lead to very low levels of fee collection and cost recovery.

Where the objective is to limit demand, the literature identifies (but often does not clearly distinguish between) two distinct approaches – volumetric water pricing and tradable water rights. In practice, it is often the case that volumetric charging is applied in parallel with tradable water rights. In such cases the volumetric charge is designed to capture the cost recovery objective, while the water rights system is used to limit demand to the available supply. It is an important observation of the literature review that nowhere is volumetric charging used directly as the means to bring supply and demand into balance where there is a water shortage. Thus, in Jordan, Israel and Morocco, all countries facing extreme water scarcity, water pricing is used to recover service delivery costs. Volumetric water **allocations** rather than water price, are used to ensure that municipal and industrial sector needs are met. In all of these countries, water is priced on a volumetric or approximate volumetric basis to indicate its value to users and discourage profligate use, but there is no attempt to use water pricing to achieve the balance between supply and the demand of competing sectors. This distinction, between signalling water's value, and therefore discouraging wasteful use by farmers, and the goal of allocating water between sectors, based on free-market prices, is very important. The first appears logical, but it must not be assumed that simply because farmers place a value on water they will reduce their consumption to the extent that resource planners may wish. It is telling that not even the most water-short nations of the Middle East, many with advanced conveyance and distribution infrastructure, e.g. Israel, have yet sought to achieve either intra- or inter- sectoral allocation of scarce water resources through pricing. In such cases, tradable water rights (allocations) appear a more practical option.

Water markets and tradable water rights are theoretically more effective than water pricing as a means of achieving allocation efficiency. However, formal water markets may potentially lead to inequitable access to water resources and disadvantage poor farmers who lack resources to buy water. Unless safeguards are provided, there is a risk that water will flow increasingly according to purchasing power. This concern applies to any use of price as a mechanism to reallocate water but where poor farmers are given a tradable water right it may provide them with an income comparable to that obtained through farming. Formal markets for large transactions between sectors require a well-defined legal and regulatory framework. The rule of law must be respected and all stakeholders must accept the impartiality of those defining allocations. Australia, the USA and Spain are commonly cited examples of countries where water allocation and tradable water rights are being used to manage the allocation of an increasingly scarce supply.

8.3 The effects of charging on water saving

The literature indicates two important areas where the effects of a water pricing system on water saving must be carefully assessed: price response and the nature of water "savings".

First, the price response to volumetric water charging is widely agreed to be minimal. Current prices are well below the range where water saving is a significant financial consideration for the farmer, so prices must be raised dramatically and generally well beyond estimates of the cost of the service, if volumetric charges are to have a significant impact on demand. Some authors suggest that volumetric prices would need to be 10 to 20 times the price needed for recovery of the full supply cost.

Second, the agricultural sector is seen as profligate in its use of water when, on large irrigation schemes with open channel conveyance, as much as 70% of water diverted from a source fails to arrive at the crop. However, three important points must be made concerning these 'losses':

1. 'Lost' water often returns to an aquifer or river and can therefore be used by downstream users. It is only lost if it deteriorates in quality or drains to a sink from which it cannot be economically recovered. Thus, switching to 'high-tech' irrigation methods such as drip or sprinkler may not result in any overall savings of water if the previous losses were recaptured by others.
2. The farmers' in-field management of water accounts for less than half of the losses. More than half the total losses occur in the conveyance and distribution canals. As individual farmers have no control of this infrastructure, pricing incentives cannot affect these losses.
3. Withdrawal of water, which then returns to a river or an aquifer, will increase the cost of service delivery but may not affect overall levels of water scarcity.

8.4 Implementing charging policies

Even the more straightforward objective of full supply cost recovery has been difficult to achieve in practice. In Annex 1 a few of the wealthier member countries of the OECD, including Japan, France, Australia, Spain and the Netherlands, stand out as achieving full recovery of annual O&M costs and some recovery of capital costs in certain schemes. However, in the overwhelming number of cases, water charging is not, as yet, covering even annual O&M costs. Amongst the nations of the OECD, subsidy of irrigated agriculture by governments is still widespread. Even new developments now under construction in Turkey and Portugal do not envisage full recovery of capital costs through charges to farmers. The literature refers to various institutional and political factors that hamper full supply cost recovery in different countries, including:

- The lack of political will to impose higher costs on farmers.
- Unwillingness to reduce costs by slimming down overstaffed government agencies.
- Lack of motivation on the part of agencies charged with fee collection, as fees return to the treasury and recovery is not linked to funding.
- A vicious cycle of low O&M expenditure leading to poor performance and increasing reluctance on the part of farmers to pay when they see no benefit.
- Insufficient resources – time, money, training – given to planning and implementing cost-effective charging mechanisms.
- Practical and political difficulties associated with enforcement of pricing policy.

The widespread policy of irrigation management transfer does not necessarily ensure recovery of full supply costs. The literature indicates that whilst turnover often leads to an increase in levels of cost recovery, revenues are still generally insufficient to cover full supply costs, as tariffs are set too low and higher prices may be politically unacceptable.

Where volumetric charging is applied to limit consumption, delivery must be measured and controlled to the individual user. The nature of most irrigation systems in developing countries, often serving thousands of individual, small farmers, has required that the service is provided at an aggregated level, to a group of users. Massive investments in re-engineering would be required to even theoretically provide for "volumetric" delivery and pricing to individuals, and given the poor level of service now observed, the challenge to administration and management would be unrealistic.

Despite these serious obstacles, important changes are occurring. The issues of increased cost recovery, reduction of hidden subsidy and the use of pricing as an economic tool for demand management are now on the agenda of many governments. It is now more widely recognised that irrigation infrastructure and service provision, like any other service, must be paid for, either through charges levied on users or through transparent government subsidy that is quantified and publicly justified. The OECD report on agricultural water pricing (OECD, 1999) recognises that the goal may not always be to eliminate subsidy but to achieve reform, but change is certainly called for.

The more open debate is a major step forward and it is important that the objectives of a water pricing programme are clearly articulated in any discussion. Cost recovery and water demand management are two distinct objectives which require different types of intervention. Nonetheless, it is still surprisingly common to find substantial documents where these different objectives are apparently interchanged at random. This confusion, or blurring, of objective must be avoided so that policy makers, and those who advise them, have a clear understanding of what they are seeking to achieve and the tools that are relevant to that objective.

Whatever the objective in view, the introduction of a water charging policy should not be viewed as a 'silver bullet' that can deliver all. Rather, water charging should be part of a larger package of measures designed to move from the vicious circle of deteriorating service, user reluctance to pay leading to further decline, to a virtuous circle where farmers are willing to pay for a good service with the revenue collected invested in sustained and improved service delivery. In the case of demand management the literature again indicates that pricing is only one element. Legally recognised water rights and allocations and the use of tradable water rights are other common elements in such a programme.

Mexico is frequently held up as an example of a country that has achieved a substantial reduction in the levels of subsidy going to the irrigated agricultural sector with many irrigation systems now achieving financial self-sufficiency. However, this was achieved only after wide-scale reform of the agricultural sector, which included:

- Privatisation of state-owned agricultural input supply services.
- Major reform of land tenure law.
- Writing of a new water law which defined rights and allocation mechanisms.
- Transfer of responsibilities for system O&M to newly formed WUAs together with transfer of plant and equipment.
- Restructuring of the line agencies overseeing irrigation with major reductions in staff numbers.

(Kloezen, 2002)

While these far reaching measures were appropriate to the situation in Mexico, other countries will require different actions. What is clear is that water pricing is likely to be only one element in a larger package of measures that must be designed according to the particular situation and desired outcome in any given nation.

8.5 Information gaps

Much of the literature focuses on economic water pricing and its role in cost recovery or more efficient water use. There is little information on the 'social good' aspects of water charging. As a result there is a divide between the theory of water pricing and reality, where subsidies in providing irrigation services are common and have even increased. Such subsidy is commonly regarded as unsustainable but there is a need to re-examine this and ask which subsidies are positive and which are negative for an intended policy objective.

There is much written material on water pricing but far less on effective collection mechanisms. In many countries the issue is not one of how to determine the level of water prices, but how to enforce any pricing policy. Without due consideration of the revenue collection and enforcement systems, policy makers may design pricing policies that are theoretically sound but unmanageable in practice. This area requires wider study and honest reporting.

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http://lnweb18.worldbank.org/essd/essd.nsf/a95275735facede4852569970057eeb2/f1f6c8cf72c879368525 6a770057a57d/$FILE/Yemen%20Water%20Pricing.pdf)

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Annexes

Annex 1

Water charging in irrigation – data from the literature

Annex 1 Water pricing for irrigation – data from the literature

Notes on water pricing data

1. Many factors in water charging practices change rapidly over time – prices charged, recovery rates and even price structures. Data presented in the Table reflect the information provided by the cited source but there can be no certainty that the information is still current.

2. Where the source has provided price information in a local currency this has been converted into US$ using an average exchange rate for the year the source was published or the year cited in the text.

3. General trends:
   Because of the factors noted above it may be misleading to apply too rigorous an analysis to the figures and other information presented in the Table. Nonetheless, the following general observations can be made:

Country/Region: It is clear from the Table that there can be important differences in water price and charging mechanisms within a single country. Such differences may reflect different pricing objectives, different water sources, different degrees of water scarcity or irrigation schemes with different technologies, farm types or socio-economic objectives. It is therefore often not possible to make a simple statement describing irrigation water charging at a national level as considerable variations may exist within country.

***Charging Basis*:** Many different formulations for charging are reported. These include:

Irrigated area	- May vary with crop or season
Water volume delivered	- Constant rate per m^3
	- Increasing block tariff
Two part tariffs:	- fixed per area + volume

Price per 1000m^3: The range in volumetric price is very great. Very high prices are reported for the following countries:

Country	US$ / '000m^3	US cents / m^3	Notes
Israel	180 – 290	18 – 29	Prices rise through this range according to what fraction of a water allocation is consumed.
Netherlands	1330	133	Price for water drawn from municipal supply network.
Spain	160	16	This high price paid only where water is pumped from groundwater
Tanzania	420	42	Tariff applied for municipal supply used for irrigation

Leaving these few very high prices aside, there is still no neat and narrow band in which volumetric prices fall. Canada and Romania report prices below US$ 1 / '000m^3 (0.1 cent / m^3) but this represents the lowest extreme. A price of about US$ 20 / '000m^3 (2 cents / m^3) is probably indicative of the 'average' volumetric price charged for irrigation water.

Price per hectare: Where irrigated area is used as the charging basis, there is again a very great range in the prices reported. Here comparison is made more difficult as it is not always clear in the literature whether figures quoted are seasonal or annual. The highest prices are reported for:

Country	US$ / ha	Notes
Bangladesh	150	Value in a proposed strategy – may not be applied in practice.
China	50 - 150	Johnson (1999)
Greece	92 - 210	National average, cited by OECD (1999)
Japan	246	National average, cited by OECD (1999)
Niger	124 / season	
Tunisia	124 - 538	

US$ 40 – 50 /ha/year is closer to an 'average' price in more developed countries but in India many states charge no more that US$ 10 /ha/yr and in Pakistan, Mohtadullah (1997) says that the Revenue Department receives approximately 33 US cents/ha/yr.

Collection efficiency: Many of the sources do not give information on this aspect of water charging but where information is provided it again indicates huge variation both within and between countries. Thus, on the surface irrigation schemes of Bangladesh, collection rates are no more than 10% of the billed revenue, but on deep tube wells there is "almost full collection of revenues due". Of the countries where information on collection efficiency is reported, Mexico achieves the highest level with a national figure of 92% reported by Svendsen *et al.* (1997).

Proportion of costs recovered: There is more information available on this than on collection efficiency. The wealthier member countries of the OECD stand out as the few entries in the table where there is reported to be full recovery of annual O&M costs and some recovery of capital costs. These include Japan, France, Australia, Spain and the Netherlands. However, in the overwhelming number of cases water charging does not cover annual O&M costs.

Water pricing for irrigation – data from the literature

Country/Region (Year)	Charging basis	Price per 1000m³ (US$)	Price per ha (US$)	Collection efficiency (%)	Notes on collection (Type/timing of payment. Fee retaining body etc)	Actual recovery	Reference
Algeria							
National average (1995)[1] (1995 US$)	Two part tariff (Fixed charge + volume)	20 – 30 (vol. Charge)	4 – 8 (fixed charge)			Not clear. "Govt. pays many of costs, particularly for capital equip."	Salem (1997)
Argentina							
National average (1997)	Area		"70/year"	70%	Govt. and Irrigation Associations (IAs)[2]	12% O&M	Svendsen *et al*. (1997)
Australia							
N.S. Wales, Queensland (1995)	Volume	1.2 – 7.39	-			100% O&M (+CD[3] in some cases)	Musgrave (1997); cited in OECD (1999)
Southern Murray-Darling (1991-92)[4]	Volume	10.16	-			60% O&M[5]	Musgrave (1997); cited in OECD (1999)
Victoria (1995)	Volume	4.36	-			Nearly all O&M	Musgrave (1997); cited in OECD (1999)
Bangladesh							
Six major surface water schemes (Bangladesh Water Development Board – BWDB) (1998 US$)[6]	Fixed rate per cropping season	-	0.43 – 3.01	3 – 10% (1994-1998)[7]		"Inadequate"	Govt. of the People's Republic of Bangladesh (2000a and 2000b)
Meghna-Dhonagoda and Pabna (BWDB) (assuming 1998 US$)		-	7.65 – 21.25			Schemes involve pumping; price covers 12 – 25% of full O&M costs	Govt. of the People's Republic of Bangladesh (2000a and 2000b)
Average price farmers pay Shallow Tube Well (STW) water sellers for boro irrigation[8] (assuming 1998 US$)		-	148.77 – 191.29[9]				Govt. of the People's Republic of Bangladesh (2000a and 2000b)
Barind Multipurpose Development Authority (BMDA) Deep Tube Wells (DTW) (electric) (assuming 1998 US$)	Per hour of pumping	1.59 per pumping hour	-	"Almost full collection of revenues due"		Full O&M costs; admin. overheads not covered, nor replacement costs.	Govt. of the People's Republic of Bangladesh (2000a and 2000b)

[1] Irrigation water prices are expected to rise further to ensure the financial viability of irrigation water suppliers.
[2] IAs are public NGOs with full legal authority, including the power to tax.
[3] Cost of Delivery.
[4] Since 1992, real changes have risen by 11%.
[5] Estimated that charges would have to increase by 80% to cover all costs.
[6] Exchange rates in 1998, US$ = 47.05 Bangladeshi Taka (Interbank rate from http://www.oanda.com/convert/fxhistory).
[7] As of 1997-1998, water rates were charged in only six of the fifteen schemes (GK, Chandpur, Karnaphuli, Manu River, DND and Buri Teesta), although proposals exist to extend the system by another six and raise existing rates substantially.
[8] Boro is the main irrigated crop under normal crop sharing conditions.
[9] This value appears high – in 2002, farmers were paying TK 1250 per acre (+ fuel costs at approximately US$7 per acre) (Personal communication, J. Skutsch, 2002). This equates to approximately US$8 per ha (+ US$3 per ha fuel costs) (based on exchange rates for Jan-April 2002 , US$ = 59.48 Bangladeshi Taka (Interbank rate from http://www.oanda.com/convert/fxhistory)).

Country/Region (Year)	Charging basis	Price per 1000m³ (US$)	Price per ha (US$)	Collection efficiency (%)	Notes on collection (Type/timing of payment. Fee retaining body etc)	Actual recovery	Reference
Barind Multipurpose Development Authority (BMDA) DTWs (diesel) (1999)[10]	Well leased to farmer groups on yearly basis[11]	206 – 274 (per year) (+ farmers pay pumping costs)	-				Govt. of the People's Republic of Bangladesh (2000a and 2000b)
North Bengal DTW Project (BWDB) (1998)	Crop/season	-	63/ha			Approx. 65% of O&M costs; no replacement costs.	Govt. of the People's Republic of Bangladesh (2000a and 2000b)
Brazil							
Selected state irrigation projects[12] (1995)	Two part[13]	3.08 – 33.84	3.69 (per ha per month)				Azevedo (1997)
Bulgaria							
National average (assuming 2001 US$)	(Mainly) volume[14]	-	45.54 per ha (maize) for two irrigations[15]	85% for volumetric water charges (1994) 32% for irrigation tax (1994)	Branches of Irrigation Systems Company (ISC).[16]		Halcrow (2001)
National and Regional Irrigation Systems (average) (1996-98)[17] (ISCs (Irrigation Systems Companies) or WUAs use differing methods to calculate the irrigation water price)	Area or volume (varies according to crops) + water abstraction fee (state revenue)[18]	10 – 85	5.88[19] (permanent maximum price)	40% for Regional Irrigation Systems (State) 70-100% for Irrigation Water Users' Associations	Branches of Irrigation Systems Company (ISC)	Varies from < 60% O&M to full O&M (+ part of CC)[20] Average annual costs per 1000m³ for irrigation water from the Regional Irrigation Systems vary from 120 – 170 US$ (1996-1998).[21]	Bardarska and Hadjieva (2000); European Commission-DG Environment (2000); Öko (2001)
Canada							
British Columbia (1988)	Area	-	90			<100% O&M	Cited in OECD (1999)
British Columbia (1988)	Volume	0.16 – 0.2	-			<100% O&M	Cited in OECD (1999)
National average (1996)[22] (1996 US$)	Two part	1.7 – 1.9	6.62 – 36.65			100% O&M	Dinar and Subramanian (1997); cited in OECD (1999)

[10] In 1999, US$ = 49.19 Bangladeshi Taka (Interbank rate from http://www.oanda.com/convert/fxhistory).
[11] As part of this arrangement, BMDA pays up to one third of the Deep Tube Well repairs and maintenance, up to an annual limit of one third of the rental amount.
[12] The current water charging system for public irrigation projects is inconsistent. Tariffs are allocated to the sponsoring agency and distributed to the irrigation districts.
[13] K1 reflects capital costs and is paid per ha; K2 is designed to cover O&M costs – and is estimated as a function of the volume of water used and is paid per 1000m³.
[14] Does not include annual tax for Irrigation & Drainage (collection of irrigation and drainage taxes reportedly suspended since 1999).
[15] Exchange rate in 2001 (no year specified), US$ = 1.12 Euros (Interbank rate from http://www.oanda.com/convert/fxhistory).
[16] Income of ISC changes from year to year due to changing demands for irrigation water.
[17] Less than 10m³/day inside "proper land" (landowners) is free of charge (for groundwater and surface water). For individual farms with 0.2ha arable area outside the "proper land", free (surface water) is allowed for irrigation up to 3000m³/ha/month. All other users have to pay a fee for water abstraction by surface water or groundwater by Jan 2001.
[18] By January 2001, the water abstraction fee should be 0.46 US$ per 1000m³ for surface water and 2.3 US$ per 1000m³ for groundwater (Bardarska and Hadjieva, 2000).
[19] Based on 1996-98 exchange rate, US$ = 0.85 Euros (Interbank rate from http://www.oanda.com/convert/fxhistory).
[20] No subsidy for private sector, state subsidies for Irrigation Systems Company.
[21] Difference in price/costs covered by subsidies and other activities of the Regional Irrigation Systems.
[22] According to OECD (1999), this is the most representative figure.

Country/Region (Year)	Charging basis	Price per 1000m³ (US$)	Price per ha (US$)	Collection efficiency (%)	Notes on collection (Type/timing of payment. Fee retaining body etc)	Actual recovery	Reference
China							
Guanzhong Plain, Shaanxi Province (no year given)	Complex. Volume and crop (also includes national and local management fee)	27 – 49.5	50 – 150	90+	75% to Irrigation Depts. 25% for local management.		Johnson (1999)
Colombia							
5 Irrigation Districts (1995)	Area + volume	1.3 – 17.5 (volume)	12.6 – 65.7 (area)	67 – 95%	WUA[23]	Financial self-sufficiency[24]: 53% – 115%	Vermillion and Garcés-Restrepo (1998)
National average (1996)	Area/crop (fixed + volumetric fee in pump schemes)	-	52/year	76%	"Financial burden of O&M has been shifted to users"	52% O&M No clear govt. policy on responsibility for rehabilitation	Svendsen *et al*. (1997)
Croatia	No charges[25]						Ostojic Z and Lukšic M (2001)
Egypt	No charges					Some cost recovery for infra. improvements 60 – 75% subsidy on capital investments	Perry (1995); cited in Ahmad (1998);
France							
Adour-Garon W.A. (1997)	Volume	5.27	-			100% O&M	Cited in OECD (1999)
Adour-Garon W.A. (1997)	Fixed (equiv. prices)	4.6	-			100% O&M	Cited in OECD (1999)
Rhôn-Med. Cor. W.A. (1994)	Fixed (equiv. prices)	3.1 Surface water 6.5 Groundwater	-			100% O&M	Cited in OECD (1999)
Greece							
Crete (OADYK) (1997)	Surface	21 – 82	-			100% O&M	Cited in OECD (1999)
National average (1997)	Surface	-	92 – 210			60-75% O&M	Cited in OECD (1999)
Hungary							
National[26] (assuming 2000 US$)[27] (no year specified)	Area and/or vol. (+ water abstraction fee)	3.67 – 31.19 (variable fee)	5.19 – 31.19 (fixed fee)			O&M + part or all of CC[28]. 20% of all costs. Farmers also have to invest in and maintain some infra.	Öko (2001)

[23] Districts have gained almost complete control over management.
[24] Of the five districts, only RUT established an equipment-replacement fund. No district has set up a capital-replacement fund for basic infrastructure.
[25] Due to the poor condition of the agriculture sector, the low % of irrigated land and the very low collection efficiency in the past, the State Water Directorate decided not to levy water user fees on irrigation water (Ostojic and Lukšic, 2001).
[26] In 1999, irrigation water use decreased to a third of the 1998 amount; but climate (high precipitation) was more responsible than a price increase.
[27] In 2000, US$ = 1.09 Euros (Interbank rate from http://www.oanda.com/convert/fxhistory).
[28] Capital Costs.

Country/Region (Year)	Charging basis	Price per 1000m³ (US$)	Price per ha (US$)	Collection efficiency (%)	Notes on collection (Type/timing of payment. Fee retaining body etc)	Actual recovery	Reference
Eastern Hungarian River Basin Authority[29] (1999 US$)[30] Water authority selling directly from rivers (or without "main objects")	As above	3.16	No fixed charge	Lack of mechanisms for collecting financial data			European Commission-DG Environment (2000); Fucskó and Hermann (2000)
India							
Water canal rates vary by state[31]: (US$ 1989-90)[32]	[33]			"Inadequate"		In nearly all states, actual receipts fall short of full O&M costs	Saleth (1997)
Bihar Gujarat Maharashtra Madya Pradesh Rajasthan	Area + crop	-	1.80 – 9.49 2.40 – 49.85 3.90 – 60.06 0.90 – 17.84 1.20 – 8.59				Saleth (1997)
Andra Pradesh Haryana Karnataka Orissa Punjab Tamil Nadu Utter Pradesh	Area + crop	-	5.95 – 22.22 1.02 – 5.95 2.22 – 33.39 0.36 – 11.11 0.84 – 4.86 0.36 – 3.90 0.42 – 19.64		Revenue dept. (RD) collects fees		Saleth (1997)
West Bengal	Fees vary by season	-	4.44 – 35.62		RD collects fees		Saleth (1997)
India national (2001)	Area (varies by crop)	0.4 – 1.6 (vol. equiv.) 1.5 (vol. equiv.)	2 – 8 30 (sugarcane)				Perry (2001b)
Israel							
Mekorot (Israel's Water Comapany) (assuming 2002 US$)	Multi-tiered[34]	Per 1000m³: $180 first 50% of water quota; $220 for next 30%; $290 for final 20%[35]				Average cost of water supply per 1000m³ for agri. use is $290. Marginal cost of supplying 1000m³ may be $500.	Yaron (1997); Becker and Lavee (2002)
Italy							
Nurra-Serdegna (1994)	Two part (citrus)	-	250			Not available	Cited in OECD (1999)
Nurra-Serdegna (1994)	Two part (drip)	-	62.4			Not available	Cited in OECD (1999)
Nurra-Serdegna (1994)	Two part (melon)	-	125			Not available	Cited in OECD (1999)
National average (1996 US$)	Area	-	20.98 – 78.16				Dinar and Subramanian (1997)

[29] Prices of a sample of suppliers under supervision of an Eastern Hungarian River Basin Authority were obtained – prices as such are not available in any public material. Agricultural water prices are unregulated; it is a free price system. Control over prices is exerted via a process of tender (if supply is put to tender). There is no official requirement to collect price data and any information collected is confidential.
[30] In 1999, US$ = 237.4 Hungarian Forint (Interbank rate from http://www.oanda.com/convert/fxhistory).
[31] Most states impose other levies on canal water in addition to water charges (cited in Saleth, 1997).
[32] In 1989-90, US$ = Rs 16.65 (Saleth, 1997).
[33] In West Bengal, water rates vary only by season and in Kerala, rates are based only on irrigated area. In all other states, the area-based water rates are highly differentiated, not only by crop and season but also by category of project, irrigation type (flow or lift), category of user (private parties, co-operatives, government lift schemes) and other factors (cited in Saleth, 1997).
[34] Israel is now working on recommendations whereby water charges vary according to water quality (depending on salt content). Also being discussed is pricing "reclaimed" wastewater and pricing to reflect the quantity and quality of water in aquifers, as well as the location of an aquifer (Yaron, 1997).
[35] Farmers using more water than the quota provides pay much more for the excess (Yaron, 1997).

Country/Region (Year)	Charging basis	Price per 1000m³ (US$)	Price per ha (US$)	Collection efficiency (%)	Notes on collection (Type/timing of payment. Fee retaining body etc)	Actual recovery	Reference
Japan							
National average (1997)[36]	Surface (rice)	-	246			100% O&M + part of CC	Cited in OECD (1999)
Jordan							
National (1999)[37]	Volume[38]	21.13				Approx. 50% of O&M costs[39]	Huppert and Urban (1999)
National (1997)	Varying tariff	8.5 – 49					Cited in Ahmad (1998)
Kazakstan							
National average (1997) (1997 US$)[40]		0.4[41]		28% (1995-96 from rural water district committees)	Farmers pay a monthly bill	Rates specified in Final Resolution below levels needed to recover basic operating costs. No link between water charges and costs.	Burger (1998)
Lebanon	No charges						Cited in Ahmad (1998)
Mexico							
National average (1997)	Surface	-	60			68-80% O&M	Cited in OECD (1999)
Cortazar (1997)	Surface	-	33			73% O&M	Cited in OECD (1999)
Irrigation District:					In most modules, users pay before they receive water[42]	100% O&M costs of Water Users and CNA (National Water Commission) staff. Districts normally have no reserve fund	Johnson (1997)
Bajo Río Bravo (1993-1994) (1993 US$)	Area	-	42.09	Approx. 100%	See above WUAs/CNA retain fees		Johnson (1997)
Various IDs	Volume[43]	2.25 – 7.79		Approx. 100%	See above WUAs/CNA		Johnson (1997)
Alto Río Lerma District (1995-1996) (1994 US$)	Area	-	7.31 – 11.96 (per season)	Most modules had a fee collection rate higher than 100%[44]			Kloezen *et al.* (1997)

[36] According to OECD (1999), this is the most representative figure.
[37] In 1999, US$ = 0.71 Jordanian Dinar (Interbank rate from http://www.oanda.com/convert/fxhistory).
[38] The Jordan Valley Authority have stopped their programme of repairing water meters.
[39] Water prices would have to be trebled to achieve full cost recovery (cited in Huppert and Urban, 1999).
[40] In 1997, US$ = 75 Tenge.
[41] This is the water charge set for agricultural users by the Govt. Resolution of Aug. 1997. In addition to the water charge, farmers also pay a service charge for the release and delivery of irrigation water by local water management authorities – between US$6.67 – 66.67 per 1000m³.
[42] Where users pay a flat rate for water per season per ha – in some cases, users are allowed to irrigate prior to payment, or they pay part of fee with an agreement to pay the rest of the fee after the end of the season.
[43] Idea of charging the districts on a volumetric basis seems logical, but it assumes that the districts will always have water.
[44] This was possible because modules could often provide more irrigation sessions over and above the amount upon which the planned collection target was based.

Country/Region (Year)	Charging basis	Price per 1000m³ (US$)	Price per ha (US$)	Collection efficiency (%)	Notes on collection (Type/timing of payment. Fee retaining body etc)	Actual recovery	Reference
National	Area/crop	-	40/ha/year (average for 1996)	92% (1997)	Irrigation Associations/ Govt. retain fee	85% O&M costs (1997)	Svendsen *et al*. (1997)
Morocco		20 surface 30 – 40 G/water	-				N L Haouari (personal comm., 2002)
Namibia							
(no year specified)	Fixed levy per ha per year + fee per area irrigated + charge rising with consumption	Unit charge of between 4 – 32.7[45]	15.6 per ha per year (board levy) + 40.4 per ha per year for first 15,000m³ of water		Fixed levy used to support the irrigation boards		Heyns (1997)
Netherlands							
National average (1998)	Surface + groundwater	1440	-			> 100% O&M	Cited in OECD (1999)
New Zealand							
Lower Waitaki (1997)	Area	-	11 – 27.5		Irrigation Companies[46]	100% O&M (running costs) + emergency capital expenditures	Scrimgeour (1997)
Niger							
Niger Valley Irrigation Schemes (Jan-June 1995 US$)	Area – price adjusted each season	-	124 per ha per season (rice)[47]	90 – 100	Mainly crop, some cash. Payment at end of season – can be delayed. Co-operative retains fee.	Not clear.[48] Co-ops unable to generate savings	Abernethy *et al*. (2000)
Pakistan							
National (1986-1991) (1995 US$)	1. Volumetric 2. Irrigation output + class of land (most common) 3. Flat rate (area)	-	0.3 – 0.36[49] (revenue per ha)			20 – 22% O&M for canals, tube wells and others	Mohtadullah (1997)
Rechna Doab (July 1995 US$)		19 (average selling or buying price) (diesel) 9 (electric)	-				Cited in Perry and al Hassan (2001)
Purchased groundwater (July 1995 US$)		17	-				Cited in Perry and al Hassan (2001)
Chishtian pump (2000 US$)		13 (diesel) 11.8 (electric)	-				Cited in Perry and al Hassan (2001)
Philippines							

45 US$4 per 1000m³ for consumption between 15,000 and 20,000m³/ha; US$10.7 per 1000m³ between 20,000 and 25,000m³/ha; US$21.8 per 1000m³ between 25,000 and 30,000m³/ha, and US$32.7 above 30,000m³/ha.
46 Irrigation Companies do not receive subsidies from the government and must collect sufficient revenues from users to at least cover operating costs.
47 Derived from a value of PPP US$425 in text, using PPP exchange rate for Jan-June 1995, 1FCFA = 0.68 US cents. 1FCFA = 0.01French Francs and US$ = 5.04 FF for same period (Interbank rate from http://www.oanda.com/convert/fxhistory).
48 Government aim – co-operatives should be responsible for O&M costs, part of initial capital cost, some of costs of government's supervisory agency and savings towards repair and renewal.
49 Revenue per ha – includes water rates, drainage and miscellaneous receipts.

Country/Region (Year)	Charging basis	Price per 1000m³ (US$)	Price per ha (US$)	Collection efficiency (%)	Notes on collection (Type/timing of payment. Fee retaining body etc)	Actual recovery	Reference
National	Area/crop/ source	-	77/year (average 1997)	58% (1995)	National Irrigation Agency	46% O&M (1995) "Govt. no longer subsidises maintenance"	Svendsen *et al.* (1997)
Poland (2000)	No charges from 2000			Lack of mechanisms for collection of financial data			European Commission-DG Environment (2000); Lorek (2000)
Portugal							
Sorraia (1991) (Public system)[50]	Volume (rice)	9.89	-			Charges rarely cover O&M costs[51]	Cited in Castro Caldas (1997)
Sorraia (1991) (Public system)	Vol. + Area + crop (maize)	12.31	-			As above	Cited in Castro Caldas (1997)
Sorraia (1991) (Public system)	Vol. + Area + crop (tomatoes)	15.63	-			As above	Cited in Castro Caldas (1997)
Romania							
National (assuming 2000 US$)[52 53]	Volume	0.37	-		National Company Apele Romane	"Costs covered by State"[54] "Romanian prices are established irrespective of costs"	Öko (2001)
National (1999)[55]	Price for raw water (for fisheries and irrigation)	0.65	-			WUAs can set tariffs for water supply (based on volume and area, O&M, drainage and an annual contribution)	Popovici (2000)
National (1997)[56]	Water abstraction fee for irrigation and fisheries	0.11 (Inland rivers) 0.02 (Danube) 0.39 (g/w)	-	Lack of mechanisms for collection of financial data	National Company Apele Romane		Popovici (2000)
Saudi Arabia							
National (1997)	No charges						Cited in Ahmad (1998)
Slovakia			-				

[50] In 1991, US$ = 144.58 Portuguese Escudo (Interbank rate from http://www.oanda.com/convert/fxhistory).
[51] Historically, in Portugal prices of irrigation water have been set to provide subsidies for the cultivation of particular crops or to support agricultural prices.
[52] Introduced in 1991, water charges in Romania are imposed on direct consumption or use, as well as on discharges according to their quantity and quality. Crops may be grown in cases where their value is less than the real cost of water used to irrigate them. Economic difficulties have decreased farm prices and consequently the demand for irrigation water (which has also benefited from the absence of recent droughts).
[53] In 2000, US$ = 1.09 Euros (Interbank rate from http://www.oanda.com/convert/fxhistory).
[54] Costs of electricity for pumping from high-pressure pumping stations to hydrants or rice fields and the costs of maintenance and repairs under land reclamation arrangements will be taken over by the newly established Irrigation Water Users Associations, and will be supported by the State for 5 years after their formation.
[55] In 1999, US$ = 15383.69 Romanian Leu (Interbank rate from http://www.oanda.com/convert/fxhistory).
[56] In 1997, US$ = 7187.75 Romanian Leu (Interbank rate from http://www.oanda.com/convert/fxhistory).

Country/Region (Year)	Charging basis	Price per 1000m³ (US$)	Price per ha (US$)	Collection efficiency (%)	Notes on collection (Type/timing of payment. Fee retaining body etc)	Actual recovery	Reference
National (1999) (1999 US$)[57]	Volume (surface water)	0 – 48.94 (incl. 10% VAT) 32.98 (without VAT) (average)		Lack of mechanisms for collection of financial data	River Basin Administrator – branches of the Slovakian Water Management Enterprise retain fee	25-30% of costs. Ministry of Soil Management subsidises agri. co-ops – up to 70% of irrigated water and electricity (or fuel)	Öko (2001); Thalmeierova -Jassikova (2000)
Spain							
Andalucia. Gen-Cab, Valencia Novelda, Genil-Cabra (Córdoba) (WA – Water Association), San Martin de Rubiales (Burgos) (WA) (1995)	Two part	27 – 133	90 – 129			100% O&M (+ CC in some cases) (+ energy costs in Córdoba)	Cited in Maestu (1997); cited in OECD (1999)
Andalucia. Viar (1995) Valencia Ac. Real (1995) Castille. Retencion (1995)	Surface	-	90 – 142.92			100% O&M	Cited in OECD (1999)
Castille. Villalar (1995)	Volume (+ energy)	70	-			100% O&M	Cited in OECD (1999)
42 irrigated areas (1995)	Varies	-	8.3 – 266 (per ha per year) 84.7 (average per ha per year)				Cited in Maestu (1997)
Water Associations (WA)	Varies	8 - 160[58]	60 – 1,200 (equivalent price in per ha per year)				Cited in Maestu (1997)
Sudan							
Irrigation schemes (1995-1996):[59] [60]	Area + crop		15.8 – 28.1 (cotton) 11.8 – 21.1 (other)[61]		Farmers tend to pay charges after each season. Irrigation Water Corporation (IWC) retains fee.	Each scheme sets its charges to cover actual O&M costs.	Adam (1997)
Syria							
National (1997)	Fixed (sometimes with crop component)		50 (per year)				Cited in Ahmad (1998)
Large-scale water users (Al Hoss Mountains – AHM) (1995)[62]	Fixed + crop (wheat)	16 (cost per 1000m³ if at least 4000m³ delivered)	65.93 (cost)			O&M costs could exceed US$110 per ha	Cited in Waughray and Rodríguez (1998)
Small-scale water users (AHM) (1995)		20 and 30[63]					Cited in Waughray and Rodríguez (1998)
Taiwan							

[57] In 1999, US$ = 0.94 Euros (Interbank rate from http://www.oanda.com/convert/fxhistory).
[58] The higher charges are paid by associations obtaining water from groundwater sources that need pumping or from major water transfers. Observations show that farmers in some associations pay nothing. Others may pay up to $500 per 1000m³ in times of drought or for occasional or emergency water.
[59] In 1995-96, the government founded the Irrigation Water Corporation and reduced subsidies significantly.
[60] In 1995-96, US$ = LS 900 (Adam, 1997).
[61] Other crops are sorghum, ground nuts, wheat and sunflowers.
[62] Using exchange rate in 1995, US$ = SL 45.5 (cited in Waughray and Rodríguez, 1998).
[63] Financial costs of extracting groundwater from a shallow and deep well, respectively. Farmers also recycle domestic wastewater through simple splash irrigation techniques.

Country/Region (Year)	Charging basis	Price per 1000m³ (US$)	Price per ha (US$)	Collection efficiency (%)	Notes on collection (Type/timing of payment. Fee retaining body etc)	Actual recovery	Reference
National (1997)	No charges since 1992					Govt. subsidises irrigation	Hsiao and Luo (1997)
Tanzania							
National Urban Water Authority's tariff structure for Dar es Salaam (Irrigation) (1996)[64]	Unclear	420.13					Mujwahuzi,; 1997
Thailand	No charges						Molle (2001)
Tunisia							
Groundwater (1993)	1) Fixed per ha (annual) 2) Hourly charge						Slim *et al*. (1997)
Kebili, Gueliada and Souk el Biaz oases (1993)			124 – 538 per year			21 – 44% O&M costs + depreciation costs	Slim *et al*. (1997)
Selected governorates (1994)[65]		20 – 78				54 – 183% O&M	Slim *et al*. (1997)
Turkey							
Mediterranean (1998)	Area (cotton)	-	49.5 (surface) 96.5 (pumped)			70% O&M	Cited in OECD (1999)
SE and Central Anatolia (1998)	Area (wheat)	-	19.8 (surface) 44.0 (pumped)			70% O&M	Cited in OECD (1999)
National average (1995)	Area/crop		25/year	72%+ (1995)		Most O&M – govt. subsidises maintenance	Svendsen *et al*. (1997)
UK							
Wales and Northumbria (1997)	Volumetric	13 – 28	-			100% costs	Cited in OECD (1999)
USA							
N. Sacramento River (CA) (1997)	Volume	4.9 + 11 (vol. up to 80%) + 14 (vol. up to 80-90%) + 16 (vol. up to 90-100%)	-			100% O&M 100% O&M 100% O&M + CC	Cited in OECD (1999)
Tehama. Col. Cl (CA) (1997)	Volume	4.9 + 25 (vol. up to 80%) + 48 (vol. up to 80-90%) + 71 (vol. up to 90-100%)	-			100% O&M 100% O&M 100% O&M + CC	Cited in OECD (1999)
Pacific North West (1990)		13.4 (average)	-			17% of total costs.	Cited in OECD (1999)
Yemen							

[64] In May 1996, US$ = Tsh 606 (Mujwahuzi, 1997).
[65] The Commissariats Regionaux de Développement Agricole use three types of water charges: a lump sum per ha when metering is not available, a per cubic metre tariff for perimétres publiques irriguées with meters and a two part tariff with a fixed per ha component and a volumetric component.

Country/Region (Year)	Charging basis	Price per 1000m³ (US$)	Price per ha (US$)	Collection efficiency (%)	Notes on collection (Type/timing of payment. Fee retaining body etc)	Actual recovery	Reference
National (1998)		20 – 40 (Farmer to farmer price)	-			"Price would have to be increased to 50 – 100 US$ per 1000m³ to cover economic costs of extracting and delivering water"	Ward (2000)
Spate irrigation	Law allowing water charges to be levied has been passed					Govt. considering involving user groups in O&M – with a view to handing over schemes to users	Ward (2000)
National (1998)	Varying tariff	20 – 1450[66]					Cited in Ahmad (1998)
Zimbabwe							
Large-scale water users (Chivi District, Masvingo Province, SE Zimbabwe) (1996 US$)		22.3[67]				In an agreement with govt., sugar estates' capital contributions will ensure access to a defined share of dam water for first 40 years at O&M only.	Cited in Waughray and Rodríguez (1998)
Small-scale water users (Chivi and Zaka Districts, Masvingo Province, SE Zimbabwe) (1996)	Annual community fee US$50 – 205 per year (+ one-off lump sum of US$477) towards O&M of the schemes[68]				Payment system on seven pilot schemes (one water point per scheme)		Cited in Waughray and Rodríguez (1998)

[66] Price in water markets.
[67] Implied price of water from the Tokwe-Mukorsi Dam that producers will face.
[68] A conventional rural water supply project in Zimbabwe estimated recurrent O&M costs to donor agency to be US$90 per water point per year.

Annex 2

Contract details

Contract - Research

This is an output of the Department for International Development's (DFID) Knowledge and Research contract R 8027, Irrigation Charging, Water Saving and Sustainable Livelihoods, carried out by HR Wallingford Ltd. The HR Wallingford job No. was MDS 0541.

The views expressed are not necessarily those of DFID.

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