In resources are allocated on demand

Browse: All subjects Business & Economics Economics Learn about: Online Resource Centres VLE/CMS Content Test Banks From our catalogue pages: Find a textbook Find your local rep Economics studies the allocation of scarce resources in society as a means of satisfying human wants or desires. In doing so, it takes into account the availability of resources, methods for the production of goods and services, their exchange, and the distribution of income within society. Economics is anthropocentric, and as such provides useful tools that can support decision-making. However, decisions concerning water allocations are guided not only by concerns of economic efficiency but also considerations of equity, environmental protection and social and political factors, to name but a few. This chapter focuses on the issues considered and tools used in the analysis of economic efficiency as the primary objective of water resource allocation. Economic appraisal and allocation of waterGiven its fundamental preoccupation with scarcity, economics defines the conditions required to secure the most efficient allocation of scarce resources in a variety of contexts. Water resources provide important commodity and environmental benefits to society. Any particular use of water will be associated with opportunity costs, which are the benefits foregone from possible alternative uses of the resource. Decision-makers are faced with balancing, for example, water demands from agricultural irrigation for food production with the desire to preserve wetlands for fish and wildlife habitat. Economics contributes towards improved allocations by informing decision-makers of the full social costs of water use and the full social benefits of the goods and services that water provides. The main approaches that form the methodological basis for strategic economic appraisal are cost-benefit analysis and cost-effectiveness analysis. Cost-benefit analysisCost-benefit analysis is carried out in order to compare the economic efficiency implication of alternative actions. The benefits from an action are contrasted with the associated costs (including the opportunity costs) within a common analytical framework. The benefits and costs are usually measured physically in widely differing units; comparison is enabled through use of the common numeraire of money. The benefits and costs of each option are determined relative to the common scenario that would prevail if no action were taken. The net benefit of each option is given by the difference between the costs and benefits. The most economically efficient option is that with the highest present value of net benefit, i.e. net present value (NPV); economic efficiency requires selection of the option with maximum NPV. Options are economically viable only where the NPV that they generate is positive. Cost-benefit analysis provides a rational and systematic framework for assessing alternative management and policy options. It entails identification and economic valuation of all positive and negative effects of alternative options. This involves the translation of all benefits and costs into monetary terms, including where possible, non-marketed environmental, social and other impacts. It is based on the underlying assumption that individual preferences should determine the allocation of resources among competing uses in society. Selection of cost-benefit analysis as a decision-support tool is at the discretion of analysts and policy- and decision-makers. It is the responsibility of analysts to ensure that the underlying assumptions of a cost-benefit analysis are appropriate to a specific situation and that the results are valid and reliable. Cost-benefit analysis reflects a specific paradigm that is considered more or less appropriate in different domains of decision-making. The appropriateness depends on culturally determined beliefs, norms and values, regarding, for example, the legitimacy of the social-political organization of decision-making, public consultation and the process of value elicitation. Cost-effectiveness analysisCost-effectiveness analysis (also known as least cost analysis) is used to identify the most cost-effective option for achieving a pre-set objective or criterion. The relevant objective is set, options for achieving it are identified, and the most cost-effective option is identified as that with the lowest present value of costs. It is assumed implicitly that the benefits of meeting the goal outweigh the cost and that the action is therefore economically viable. Cost-effectiveness analysis is suitable for use in situations where valid and reliable estimation of the benefits of alternative options is not feasible. This is particularly relevant to actions that involve environmental change. Instead of attempting to identify and value the benefits, the most cost-effective means of achieving a desired objective is identified. For example, cost-effectiveness analysis is suited to situations where clear and defensible conservation targets or other environmental goals exist that can be measured in terms of biophysical units such as minimum water quality standards. It can also be used to identify the most effective option for a fixed amount of funding that has been allocated to achieve a policy objective. The drawback of cost-effectiveness analysis is that it does not identify the benefits of actions or the willingness of society to pay for improvements in environmental quality, which are important considerations in many decision contexts. For these reasons, cost-benefit analysis is, where practicable, the preferred tool for decision support. Economically efficient allocation: the theoryThe focus on economic efficiency as the primary objective in the development and allocation of water resources is because of its importance as a social objective; efficiency values having viable meaning in resolving conflicts and assessing the opportunity costs of pursuing alternative uses (Young, 1996). Although economically efficient allocation of irrigation water is rarely attained in practice, analysis of economic efficiency provides a useful point of reference for understanding causes of inefficient allocation and mechanisms for improving the overall economic performance of irrigated production. At the outset, economic efficiency needs to be distinguished from the various technical definitions of efficiencies associated with irrigation (Perry and Kite, 2003; Seckler, Molder and Sakthivadive, 2003). However the two types of efficiency are related in the sense that both seek to maximize the productivity of water in terms of output per cubic metre of water. Economically efficient allocation of water is desirable to the extent that it maximizes the welfare that society obtains from available water resources. Welfare in this context refers to the economic well-being of society and is determined by the aggregate well-being of its individual citizens. Economically efficient allocation maximizes the value of water across all sectors of the economy. This is achieved through the allocation of water to uses that are of high value to society and away from uses with low value. Efficient allocation occurs in a competitive, freely functioning market when supply is in equilibrium with demand. Under these conditions, the marginal cost of the supply of water (the cost of supplying an additional unit) is equal to the marginal benefit of the use of water (i.e. the benefit of goods and services provided by an additional unit of water). The marginal benefit and marginal cost are the same across all uses and equate with the market price. However, where there are distortionary constraints, such as subsidies or taxes, the maximization procedure will result in a second-best efficient allocation (Tsur and Dinar, 1997). A feature of economically efficient allocation is that no reallocation can make anyone better off without making at least on person worse off, a condition that is described as "Pareto optimal". The relative efficiency of alternative allocations can be analysed with respect to this, i.e. in terms of whether they provide a "Pareto improvement". A change in allocation is considered desirable if at least one person gains in welfare and no one loses. However, this criterion proves too stringent in practice as few changes can be made in the real world that do not reduce the well-being of others. For this reason, an adaptation is usually employed; this is described as a 'potential Pareto improvement' or the Kaldor-Hicks criterion. A change in allocation is considered desirable if those individuals who gain from the change can hypothetically compensate those who lose and still be better off than they were previously. It is anticipated that compensation does not take place, owing to difficulties of identifying and compensating all necessary individuals. The criterion of potential Pareto improvement forms the basis of cost-benefit analysis, which is used to analyse the relative economic efficiency of alternative courses of action (e.g. water allocations, and new irrigation schemes). Although economic efficiency is an important factor, there are additional economic issues that decision-makers need to consider. Two of these issues are the distribution of costs and benefits across society and their distribution across generations. In terms of the former, neither the equity implications of an allocation nor the equity of the prevailing distribution of wealth are considered in analysis of economic efficiency (van Kooten and Bulte, 2000). Focusing first on the equity implications of an allocation, costs and benefits are usually specified using values that are representative of the whole of society (based, for example, on a random sample). However, the costs and benefits may not be borne equally by society; they may be concentrated in specific geographical areas. These differences may also correlate with differences in income borne by sections of society: environmental costs (e.g. costs imposed by polluted water supplies) are often borne disproportionately by low-income sections of society (NMI and NOAA, 2001). Such disparities can be incorporated into analysis through studies of costs and benefits for separate sections of society (NMI and NOAA, 2001), though this adds to the information requirements and the demands of the analysis. The prevailing distribution of wealth is usually assumed to be a given in analysis of economic efficiency. Equal weight is given implicitly to costs and benefits experienced by all members of society. However, circumstances arise where it is socially desirable to alter the distribution of wealth in the pursuit of greater equity. This can be incorporated into the analysis through the use of distributional weights. Weights are assigned to costs and benefits according to the section of society that they accrue to and the desired redistribution of wealth. For example, high weights can be applied to benefits that accrue to poor sections of society and low weights to benefits for the rich. Application of this procedure is challenging because of the difficulties of identifying the distribution of costs and benefits within society and of specifying appropriate weights, which is subjective. In the past, it has usually been considered more appropriate for decision-makers to consider prevailing inequalities separately from analysis of economic efficiency. In terms of equity in the distribution of costs and benefits over time, it is argued that economic analysis commonly favours consumption in the present at the expense of future generations. Analysis of economic efficiency addresses the distribution of costs and benefits over time through the use of discounting: all costs and benefits are converted into present values using a rate of time preference (discount rate) (discussed further in Chapter 4). The discount rate used is intended to represent society's preference for consumption in the present over the future. The rate is commonly prescribed by government agencies and is typically positive and less than private discount rates. On the one hand, it can be argued that government has a responsibility for the interests of both current and future generations and that it sets the social discount rate accordingly. One the other hand, it is argued that the rates used are too high, placing low weight on consumption in the future and discriminating against future generations (NMI and NOAA, 2001). A further argument concerns the use of a zero discount rate, which would place equal weight on the interests of all generations. However, its application would result in rejection of all use of non-renewable resources (e.g. oil) or any irreversible developments (e.g. construction of dams). It could also result in rejection of investments that might be of great value to future generations, through creation of wealth or new technologies (NMI and NOAA, 2001). Concerns about future generations can be addressed better if they are considered separately from analysis of economic efficiency, through, for example, application of safe minimum standards (Chapter 4). Reasons for inefficient allocationAlthough water resources perform many functions and have important socio-economic values, water is in many respects a classic non-marketed resource. Even in its use as a tradeable commodity, market prices are not generally available. The reasons why water has no price are often related to the historical, socio-cultural and institutional context in which water is used and managed (e.g. the return of water use rights for groundwater or surface water on farmers' land). In addition, although water can be captured and shared, water flows can also be recycled. This often makes it difficult to break water down into marketable proportions. An important cause of this economically inefficient water use (where costs outweigh benefits) is the failure of institutions involvement with the allocation and management of water. 'Failure' refers here to institutions where 'they induce or favour decisions that lead society away or prevent society from achieving socially optimal resource allocations' (OECD, 1994). Sources of institutional failure include markets, policies, and political and administrative factors. They derive from a fundamental failure of information or lack of understanding of the multitude of values that may be associated with water resources (Turner and Jones, 1991). Market failure Although markets can achieve economically efficient allocation, they are commonly unable to do so. Described as market failure, this occurs through an 'inability of the market to lead the economic process towards the social optimum' (OECD, 1994). Market failure can occur through the non-existence of markets (for externalities and public goods), their failure to communicate necessary information (the social discount rate, society's attitude towards risk and uncertainty), restricted operation of markets (under a monopoly), and inadequate institutions or regulations (absence or non-enforcement of property rights). Activities can impose losses or gains in welfare on individuals other than those engaged in the activities. If these losses or gains go uncompensated or unpaid for, they are described as externalities (negative and positive, respectively). Externalities are not incorporated into market prices, so are not accounted for in market-based allocation. This results in socially suboptimal resource allocation and market failure. Return flows of water are an example where both positive and negative externalities can be generated. Negative externalities arise where pollution from water use imposes additional treatment costs on downstream users. In the context of irrigation, drainage water from fields often carries high levels of agrochemical pollutants, which can lead to losses of aquatic habitats downstream. Optimal allocation of water requires that supply costs be increased to reflect the costs of mitigating the negative externalities. Positive externalities are also generated by return flows, which form a vital element of many hydrologic systems. Irrigation often performs a secondary function in that it recharges aquifer systems. Such external effects can mean that while farm-level water use efficiency may be apparently low, at the catchment level, water use efficiency of irrigation may be much greater. Thus, improvements in efficiency at the farm level may be at a cost of overall efficiency of the hydrological system. By definition, a public good can be enjoyed without diminishing the supply (i.e. is subject to non-rival consumption) and others cannot be excluded from its use (and consequently it is not traded). As a result of the non-rivalry characteristics, demand for public goods is collective: it is the sum of the separate demands of individuals for the good. Although some uses of water tend towards being rival in consumption, e.g. agricultural, residential or industrial uses, others such as recreational and aesthetic uses are non-rival. Thus, water supply has often been exposed to 'open access' pressures, with a lack of enforceable property rights allowing unrestricted depletion of the resource. Furthermore, even where water resources are privately owned, many of the benefits they provide may be off-site, and may not accrue to the owner (e.g. downstream flood protection). The lack of a market for these benefits limits the incentive to maintain the resource, as the private benefits derived by the owner do not reflect the full benefits to society. Most commonly, the non-traded nature of public goods hides them from market-based decision-making, which results in market failure. The preference of individuals for consumption in the present rather than the future is understood to usually exceed that of society. Where allocations are determined based on the discount rate of an individual decision-maker, this is likely to give less weight to long-term costs and benefits. Typically, this translates into the selection of courses of action that are of short-term net benefit and rejection of those that are of net benefit only in the longer term. A particular concern is the favourable consideration that is given to courses of action that yield net benefits in the short term, but incur substantial costs on society in the long term. The supply of irrigation water is often controlled by only one agency, a situation described as a monopoly. Under these conditions, the supply of water is not subject to market competition. The supplier determines the price and quantity of water supplies. This can result in inefficient allocations and is a source of market failure. For example, a monopolistic supplier may elect to allocate water between farmers in a manner that does not make the maximum contribution to social welfare. Similarly, the supplier may set the water supply at a level that exceeds the optimum for society (resulting in overabstraction) in order to maximize profits. Property rights are the characteristics that define the rights and duties associated with use of a particular source of water (van Kooten and Bulte, 2000). The nature of these property rights can determine the efficiency with which a source of water is used. Particular types of property rights regime result in market failure. Property rights regimes can be considered in terms of four types: private, common, state and open-access. With private property rights, a private individual owns the resource and has the right to use, benefit from, and sell the resource, subject to a duty to refrain from socially unacceptable activities (such as imposition of negative externalities). These rights are subject to state regulation and protection, which is required for private property to exist and to exclude unentitled individuals from its use. However, the rights can be eroded in circumstances where resources supply public and private goods jointly. In order to maximize profits, the owner of a private resource manages the resource like an asset: its use is allocated over time such that the total present value is maximized. The owner delays use of the resource (if it is economically rational to do so) because of the expectation of being the only beneficiary of the resource in the future. With common property rights, a group of individuals owns and manages the resource. The individuals in this group have specified rights and duties regarding the resource, and enforced rules exclude other individuals from its use. Common property ownership of resources tends to play a larger role in developing countries than in the industrialized countries (van Kooten and Bulte, 2000). Communities that have the characteristics required for successful common management of resources are more prevalent in developing countries: communities that are small, relatively immobile, close knit, and that have a common ethos and shared beliefs. Moreover, common property resources can have an important role in these communities as they can aid the distribution of wealth and provide a means for reducing the marginalization of poor, e.g. provision for the harvesting of fish and plants from communally owned wetlands by low-income households. With state property, the state owns the resource. The state may allow individuals to use the resource, but according to its rules and under its regulation. In an open-access situation, no property rights are assigned to the resource, which results in open access to the resource for all potential users. Water from both underground and surface sources is often an open access resource. Use of the resource is subject to neither exclusion nor regulation. Individuals have complete autonomy in its use. The property rights of resources are often held in combinations of the above regimes and can alter with a change in situation. The efficiency of resource use under these regimes is based on four determining conditions (Tietenberg, 1992): full specification of ownership and entitlement to the resource (universality); accrual of all benefits and costs exclusively to the entitled individual (exclusivity); exchange of property rights in voluntary transactions (transferability); penalties that prevent individuals from encroaching or taking property rights without prior agreement (enforceability).Table 3 indicates the extent to which the four property rights regimes satisfy these conditions. Economically inefficient resource use is associated particularly with open-access property rights. Open-access characteristics can also arise through poor management or a failure to regulate the use of common-property and state-property resources. The absence or non-enforcement of property rights for resources with open-access characteristics can lead to use of the resource at rates that exceed the social optimum. Described as the "tragedy of the commons", this occurs where individuals have no incentive to conserve the resource because there is no assurance that other users will do likewise. Policy and institutional failure Allocation of water can be socially suboptimal not only through the failure of markets, but also through failure of government policy and associated instiututional arrangements. Policy failure occurs where government regulatory instruments (e.g. taxes and exchange rates) or government policies create market price distortions that make it economically rational for individuals to use resources in a socially suboptimal manner (OECD, 1994). Sectoral policies for agriculture and the environment, and for other sectors such as employment and taxation, can encourage suboptimal resource use and allocation. Moreover, government interventions intended to correct for market failure can result unwittingly in greater degradation and depletion of environmental resources if the regulatory environment is not suitably 'joined up'. TABLE 3Property rights regimes and their conditions for efficient resource use Conditions Property rights regime Private property Common property State property Open access Universality Yes Yes (for the group) No No Exclusivity Yes (except for externalities and provision of public goods) Yes (for the group) No (although non-nationals are excluded No Transferability Yes Yes (for the group) No No Enforceability Yes (legal & social sanctions) Yes (legal & social sanctions) Yes (legal & social sanctions) No Efficiency Efficient, but inefficiencies arise in presence of externalities and public goods. Efficient in many cases, but inherent risk of breakdown. Usually inefficient, owing to government failure. Very low, no incentive to conserve. Source: Pearce, Whittington and Georgiou (1994). goods. Failure in sectoral policies can arise through inadequate consideration of impacts on other sectors, particularly with regard to the environment (OECD, 1994). Bias in the formulation of policy towards sectors that exercise strong economic and political power can further marginalize the concerns of other sectors. Agriculture provides various examples of policy failure, such as subsidized irrigation and land improvement. A policy of subsidized supplies of irrigation water provides farmers with water at a price that is less than the marginal cost. Farmers respond to the low price by using quantities of water that exceed the social optimum. In an extreme case, this can result in overabstraction of aquifers and waterlogging of the land. An alternative example of agricultural policy failure is the provision of subsidies to drain land and to divert surface water, both of which can contribute to the degradation or destruction of wetland sites. Political, administrative and other institutional factors can distort market signals in a manner that encourages socially suboptimal resource use. Pressure to gain re-election can lead governments to over-supply state services for example. At the extreme, this can favour excessive economic development at the expense of resource conservation. Political failure can also occur through lack of government intervention, e.g. in response to market failure. Administrative failure refers to a range of problems within the organization of government at the various levels, leading to inadequate policy implementation. Examples include: rigidities due to entrenched traditional divisions of labour within administrative organizations, and insufficient integration between agencies and departments. Other institutional failures include inadequate availability of information for policy-makers, and poor communication between rural electorates and urban-based central government. These policy and institutional failures are generic and could apply to most government interventions. The significance for irrigaton is the scope and depth of government involvement in irrigation (Burke, 2003). Water allocation policyAs indicated above, economic efficiency and equity are important considerations in the allocation of water. Greater efficiency is required in the face of increasing water scarcity, and equity is a concern because of the importance of water to the livelihoods and well-being of rural communities in particular. It is possible to derive a broad classification of policy measures that are relevant to managing resources within the boundaries of a nation. The measures include the redefinition of property rights and investment policies. TABLE 4Policy measures relevant to resource management Conditions Public sector Private sector LDCs DCs LDCs DCs Property rights: Pricing P = MC P = MSC P = MSC P = MSC P = MSC Quantity trading Possible emissions & resource quota trading Emissions &resource quota trading Command & control Environmental quality objectives Environmental quality objectives Environmental quality objectives Environmental quality objectives Investment policy CBA CBA EIA EIA LDC = least-developed country; DC = developing country; P = price; MC = marginal cost; MSC = marginal social cost; CBA = cost-benefit analysis; EIA = environmental impact assessment. One thing to be kept in mind is that many of the large public irrigation schemes that were promoted as part of the green revolution, particularly in Asia, were designed to target poor rural communities and as such were never oriented to maximize economic output, rather to guarantee production of food staples (Pluquellec, 2002). The proper pricing of inputs (such as raw water) and outputs (such as agricultural irrigation products) can be viewed as a form of property right designation, while command and control measures are also means of defining property rights or modifying existing ones. Table 4 shows the various generic types of policy measures. Once a regime of property rights has been established, the proper pricing of a resource requires that it be priced at least at marginal private costs, and preferably at marginal social cost (especially in the longer term and where output prices are below private production costs). As pricing of water affects the allocation decisions of those with competing wants, then by correctly pricing water, efficient allocation of water is achieved. However, the standard economic efficiency (marginal) cost pricing result is sometimes problematic as regards the specification of production technology. In the water supply sector, inputs to production are often not perfectly divisible. Investments often require large lumps of capital (e.g. for dams and reservoirs). In such cases, marginal cost pricing to achieve economic efficiency requires some form of intervention (Sherman, 1989). Table 4 lists quantity-based measures as a separate policy option although they have similar effects to the price-based measures. Finally, investment policy, which is most usually characterized in terms of cost-benefit analyses, is applicable to all public sector operations (although environmental impact assessments are employed most widely in assessing private sector environmental impacts). Water allocation systemsWater allocation systems differ in the extent to which they address efficiency and equity iobjectives. The various systems can be compared according to several criteria (Dinar, Rosegrant and Meinzen-Dick, 1997; Howe, Schurmeier and Shaw, 1986; Winpenny, 1994). These criteria include: Flexibility in allocation of supplies: allocation requires flexibility such that supplies can be shifted between uses and sectors, as demand changes, so as to achieve efficiency. Security of tenure for users: established users require security of tenure if they are to be expected to take the necessary measures to use the resource efficiently. Although this may conflict with flexibility, problems should not arise if sufficient water reserves are available to meet unexpected demands. Payment of real opportunity costs of water by users: users should pay the real opportunity costs of their use, so that other demand or external effects are internalized (see Chapter 3). Predictability of the allocation outcome: in order to achieve the best allocation and minimize uncertainty minimized, the outcome of the allocation process needs to be predictable. Equity in the allocation process: users should perceive the allocation process to be equitable. Political and public acceptability: the allocation should serve the various political and public values and objectives, thereby making it acceptable to the groups in society. Efficacy in achieving desired policy goals: the form of allocation should change an existing undesirable situation towards one where the desired policy goals are achieved. Administrative feasibility and sustainability: the allocation mechanism must be practicable, adaptable and allow an increasing effect of policy.Water allocation systems range from government-controlled to market-led systems, and combinations of the two. The prevailing institutional frameworks (including laws, regulations, organizations) and the water resources infrastructure (Dinar, Rosegrant and Meinzen-Dick, 1997) influence the precise nature of allocation systems. However, they commonly fall into one of only a small number of categories: public allocation, market-based allocation and user-based allocation. Public (administrative) allocation of water is determined by the state. It is used for intersectoral allocation of water, as the state usually is the only institution that has jurisdiction over all sectors of the economy (Dinar, Rosegrant and Meinzen-Dick, 1997) and because allocation of water is considered too important to leave to the mercy the market. The state can control allocation within sectors through, for example, granting permits for water abstraction. In agriculture, the state commonly administers allocation of water to large-scale irrigation schemes and to sections within the schemes. Distributions can be based on historical allocations or political influence (Dinar, Rosegrant and Meinzen-Dick, 1997). The state is less commonly involved in allocation at the farm and field levels. Under such allocations, the price of water is usually subsidized, low and charged on a fl at-rate (e.g. per hectare) or fixed-charge basis (not according to the amount of water consumed). Public allocation of water enables pursuit of objectives other than economic efficiency, such as equity and environmental protection. Some aspects of water allocation lend it particularly to state control (and pose challenges to market-based allocation). The economies of scale and the high levels of investment required for infrastructure readily create monopolistic supply and consequently a need for regulation. The joint provision of goods and services by water resources (e.g. provision of water for irrigation, hydroelectric power generating capacity and recreational services) and the provision of public goods (e.g. flood control) also suit state-controlled allocation. Many water resources are open access, so require state regulation of use. The interdependence of surface water and groundwater resources can require regulation of abstractions to prevent depletion of surface water and groundwater supplies. Finally, the essential role of water in meeting basic needs can require state control of allocation under conditions of drought (World Bank, 1993). However, there are problems associated with public allocation of water. These arise through poor management of infrastructure and inadequate development (which result in wastage of water), inadequate implementation of regulations (which can, for example, result in excessive pollution), and subsidized prices (which result in economically inefficient and excessive water use). Public allocation usually precludes user participation, a key objective in the international consensus for water resources policy (as stated in the Dublin Principles). Moreover, the institutions engaged in public allocation are typically sector-oriented, which fosters neither the integrated nor the flexible management required for effective intersectoral allocation. Thus, where public allocation is necessary, efforts are required to limit the potential deficiencies. User-based allocation of water is undertaken through collective management of water sources, supplying water for either collective or individual use. Examples include farmer-managed irrigation systems and village-managed local water supplies (for example, allocating water to domestic use, irrigation and livestock). User-based allocation requires established rights to water use and an appropriate institutional framework that has the capacity and strength to determine and regulate use. Its effectiveness is determined by the characteristics of the community (size, mobility of the population) and its institutions, and by the extent to which social norms (such as social awareness of efficiency and resource conservation) influence water use. User-based allocations have the advantages that they are informed by knowledge and understanding of the needs of the local population, and can be flexible and responsive. Effectively operated systems can allocate water efficiently and address equity concerns. User-based allocations are sustainable, politically acceptable and are supported by the consensus in international policy (Chapter 1). However, effective allocation is dependent on the existence of a strong and transparent institutional framework, which is not always present (Dinar, Rosegrant and Meinzen-Dick, 1997) Market-based allocation is determined by transactions in water use, at prices determined by the forces of supply and demand. It encourages greater efficiency in the use of water, and flexible and responsive allocation. Such allocation is reliant on effective operation of the market. Markets for water are often hampered from achieving this by subsidies, few suppliers and inadequate information. Moreover, they are distorted by externalities: uncompensated costs and benefits of water use that are imposed on others. These costs and benefits are not internalized into the price of water, which results in pervasive socially undesirable outcomes (such as the reduction or pollution of surface water flows for downstream users). Where it is judged desirable to establish a market for water, trade in the rights to water use is generally more acceptable than volumetric pricing as farmers view the latter to entail appropriation of their prior rights in water use. Such establishment of a market requires clearly defined rights for water use (usually determined by the state), specification of the initial allocation of rights, the necessary institutional framework and the infrastructure required to enable trade in water. In this sense the basis used for the pricing is an important determinant of the acceptability. Pricing and cost recovery in the irrigation sectorIrrigation water is commonly priced volumetrically or using a fl at rate or fixed charge. A special case of volumetric pricing is marginal cost pricing which requires metering of water use (which makes it suited to pumped water supplies such as tubewells) and the necessary administrative capacity. A review of World Bank policy and practices recommends that for efficient use, irrigation water is priced volumetrically, based on opportunity costs (Julius and Alicbusan, 1989). Where this is not feasible (e.g. for gravity-fed systems and canal irrigation), water can be charged for at a fl at rate or a fixed charge. The charges are based not on the amount of water used but on other variables such as the land area, value of landholding, crop output, or non-irrigation inputs (e.g. land improvements). The most common form of charging is based on land area, as this is easy to administer and suited to continuous flow irrigation (Johansson, 2000). However, the actual preview of charging for irrigation water is not necessarily consistent with economic expectations and straightforward notions of price and costs (FAO, 2004). Nevertheless, farmers place high marginal values on irrigation water, often a number of times higher than the charges actually imposed (Repetto, 1986) and increases in charges may not affect demand where these marginal values are so high. On the other hand, underpricing can be expected to encourage wastage of water, poor maintenance of irrigation systems and inefficient applications of water, resulting in reduced agricultural output. With regard to private irrigation schemes, while irrigators have to meet the full financial costs of private irrigation schemes (although subsidies reduce the costs in some cases), it can be agreed that they rarely face the opportunity costs of water use (Briscoe, 1996). However, public irrigation schemes throughout the world have been subsidized to such an extent that charges rarely cover even operation and maintenance costs. Recovery of at least these costs is needed to enable the maintenance of irrigation systems, which is crucial to improved irrigation performance. Nevertheless, cost recovery can achieve such improvements only if the associated revenues are applied to improvements in the system. In public schemes, farmers sometimes do face a restricted measure of opportunity costs, which can arise implicitly as a consequence of water rationing. However, this is likely to underestimate the true opportunity costs significantly. Simulation analysis (Maass and Anderson, 1978) has indicated large differences in the economic losses arising from water shortages between market systems (which incorporate opportunity costs) and public allocation systems. Market systems were also found to be greatly superior in terms of the equity of distribution of the losses resulting from water shortages (contrary to the expected doctrine regarding procedures that perform well in terms of allocative efficiency). There are further lessons that are important to the successful reform of water resource allocation policy (Briscoe, 1997). Although conventional economic wisdom suggests that users should pay the full economic costs of water supply, pursuit of such an aim is impractical and unhelpful in most developing-country contexts. Users commonly resent paying prices for water that exceed financial costs of supply, and object to paying for water supplies that were previously free. In order to be acceptable, tariffs need to be set on a basis that is understandable, transparent, legitimate, and that stimulates accountability. The challenge in irrigated agriculture is to ensure that farmers take into account the opportunity costs of water use (which are often an order of magnitude greater than current charges) and that institutional arrangements are in place to ensure that water moves to higher value uses. The incorporation of opportunity costs into water tariffs is not a straightforward task for a number of reasons: the information requirements are considerable; such charges would be objected to on the grounds that they entail appropriation of current users' 'property rights'; and farmers would have to pay substantially more than the cost of service provision, which may be politically unacceptable. Emerging international experience suggests that the appropriate approach to ensure that users consider the scarcity value of water is to clarify property rights and facilitate the leasing and trading of these rights. "Getting prices right" is important (Kloezen, 2002). Nevertheless, the lessons from experiences with pricing irrigation water suggest that water allocation methods are sensitive to physical, social, institutional and political settings, thus making it necessary to design allocation mechanisms accordingly (Johansson et al., 2002). Pricing, opportunity costs and economic benefitsAs water becomes increasingly scarce, the legitimacy of treating it as a 'free' resource arises. Arguably, the absence of pricing, as well as the lack of cost effective recovery, has been a major determinant of inefficient and excessive agricultural use of water. In response to these problems, many countries and water management agencies are turning to water pricing mechanisms to allocate water (Dinar, 2000). However, economists disagree on the appropriate means and methods for pricing water and on the notion of an optimal water pricing policy. The methods used to price water and the performance of these is dependent on the physical, social, institutional and political context. Nevertheless, as the pricing of water affects the allocation decisions of those with competing wants, then correct pricing can led to efficient allocation. In this context, pricing refers to the introduction of amended financial charges in situations where water was previously free or underpriced, or to the consideration of the economic value of water in decision-making through use of an appraisal and accounting procedure, such as cost-benefit analysis. Because water resources are often non-marketed, it is extremely important to ensure that, where possible, the 'true' economic value of these resources is accounted for when making investments, or decisions concerning water and environmental policy. 'Accounting' or 'shadow prices', determined through the economic valuation of water resources, are employed in such decision-making in place of market prices. Unless water resources are priced correctly, and those prices internalized in decisions, distortions arise. These bias investment and policy decisions against concerns about water resource depletion and degradation, resulting in misallocation of resources and suboptimal social welfare. The opportunity costs of water resource use and the economic value of the benefits can be compared in terms of whether the use is economically sustainable or socially optimal. The characteristics of the agriculture sector and its relationship to the water system require careful consideration when designing instruments to internalize the opportunity costs in water use and/or to change water use behaviour. These include: the nature and complexity of water use and/or pollution (including environmental effects); geographical/location characteristics; characteristics of the target group (e.g. farmers); market characteristics.However, given the criteria discussed earlier for comparing allocation mechanisms, no general guidelines exist as to how to price water. The right design depends upon the specific characteristics of the agriculture sector and the aim one has in mind of pricing water in the first place. Opportunity costs of resource depletion and degradationMarginal opportunity cost (MOC) is an important and useful tool for conceptualizing and measuring the physical effects of resource depletion and degradation in economic terms. MOC seeks to measure the full societal cost of an action or policy option that employs a natural resource such as water. Economically efficient resource management requires that the price that users pay for resource use should equate with the MOC. Where the price is less than the MOC, then the resource is overconsumed or overutilized. A price that is higher than the MOC results in the resource being underconsumed or underutilized. Sustainable management is achievable through sustainability pricing, which also includes a premium to cover the costs that accrue from any resource depletion. The concept of opportunity cost is used to refer to the value of a resource in its best alternative use, i.e. other than the purpose being considered. This is the cost to society of use of the resource. It is considered in terms of a change at the margin, i.e. the MOC, because management decisions usually entail relatively small changes in resource use. MOC comprises three components. The first component is the direct economic costs of water abstraction, such as the costs of labour, equipment and materials used for abstraction. Such costs require adjustment for any subsidies, taxation and market imperfections in order to reflect true opportunity costs (shadow pricing). These costs vary with the difficulty of extraction. The second part of MOC is external costs that arise from water use (Chapter 3). This is the net value of any losses and gains in welfare that water use imposes on individuals other than those engaged in the activity. External costs arise because changes in one component of the natural resource base affect other components and the efficiency with which other activities can be conducted. Costs that occur in the future require discounting in order to make them commensurate with present day costs. Although information on marginal external costs is difficult to obtain and often imprecise or incomplete, useful approximations are possible. It is the external costs that arise from unsustainable resource use that are of particular interest. The final component of MOC is relevant for non-renewable resources. Where such resources (which are fixed in supply, e.g. overabstracted aquifers) experience a positive rate of exploitation, then use of a unit of the resource results in its non-availability for future use. A scarcity premium can be placed on the resource, its magnitude depending on: the size of the resource stock relative to the rate of exploitation; the strength of future demand relative to present demand; the availability and cost of future substitutes; and the discount rate. This scarcity premium is known as the user cost (Conrad and Clark, 1987) and relates to the value of the opportunity foregone by exploiting and using the resource in the present period rather than at sometime in the future. It also incorporates increases in the costs of future resource use and exploitation that occur as a consequence of current use and exploitation (e.g. the increases in costs of future pumping of groundwater that occur owing to the greater difficulty of extraction). Marginal user costs also apply to non-sustainable use of renewable resources. The user cost of non-renewable water resources is often ignored, especially where water resources are treated as an open-access resource and users behave in an individually competitive manner. This can happen in situations where property rights are ill defined or not enforced (Chapter 3). Use of the water is then governed by the law of capture, on a 'first come, first served' basis. Each user tries to extract as much as possible from the resource in the fear that other users will exploit the resource first, and also in the belief that the amount they themselves use is only a small proportion of the overall stock. The consequences of ignoring the user costs are that the costs of extraction are undervalued, which results in exploitation rates that exceed the optimum. This is in contrast to the situation where a single user has rights to a resource: the user has to take user costs into account because it is the user who faces the increased costs of extracting from a depleted resource in the future. In summary: marginal opportunity cost = marginal direct cost + marginal external cost + marginal user cost.Pricing based on MOC is a useful principle as it forces attention on to the externalities associated with natural resource degradation, and guides pricing policy in providing incentives for allocative efficiency. Water is allocated to high-value uses, and high social costs provide a disincentive against excessive water use (Dinar, Rosegrant and Meinzen-Dick, 1997). Failure to set water charges for irrigation on the basis of either opportunity costs or user benefits has been a classic cause of inefficiency in the agriculture sector (Repetto, 1986). Therefore, proper valuation of the socio-economic benefits derived from water resources is an important and often necessary condition for efficient and sustainable water resource use. Economic benefitsEvaluation of the trade-offs necessary to allocate resources between competing wants requires consideration of their economic value. In particular, one of the main principles of efficient and sustainable resource allocation requires knowledge of the marginal value or benefits of the resource in its alternative uses. FIGURE 8Economic value, price and consumer surplus In conventional economic terms, valuation refers to the estimation of individuals' preferences for the conservation or improvement in quality of a resource, as well as individuals' loss of welfare owing to resource depletion or quality decline. Individuals' preferences are measured in terms of how much they are willing to pay, which is also referred to as the economic value or benefit. Willingness to pay and economic value can be discussed in terms of the demand curve for a good or service. The gradient of the demand curve indicates how much an individual is willing to pay for each extra unit of the product (i.e. the marginal benefit). The price of the product gives the amount paid in the marketplace. Some individuals are willing to pay more than this price and so receive an additional benefit over and above the amount paid. This additional benefit the consumer surplus or net willingness to pay. Figure 8 illustrates this for the ordinary Marshallian formulation of welfare measures. Freeman (1993) presents a more precise Hicksian formulation. Economic value to society of a good or service is determined as the aggregate of all individuals' willingness to pay. Therefore, the price of a good or service and its economic value are distinct and can differ greatly: water can have a very high value, but a very low price or no price at all. An aggregate measure of impact on social welfare does not consider inequalities in the distribution of gains and losses among individuals. Willingness to pay relates essentially to individuals' ability to pay, which determines the relative weights assigned to their preferences. Its use infers acceptance of the prevailing distribution of income. Cost-benefit analyses usually apply equal weighting of gains and losses across all individuals, and assume a socially acceptable prevailing distribution of income. However, distributional and equity weights, which are assigned on a social or political basis, can be used to weight preferences or outcomes that are of particular importance. Although the economic value of a resource is most commonly determined by willingness to pay for gain or improvement in a resource, it is also theoretically valid to use willingness to accept compensation for loss or degradation of the resource. Theoretically, there should be no significant difference in the value of the two measures. However, empirical evidence suggests that in practice willingness to accept compensation is often substantially greater than willingness to pay (Hammack and Brown, 1974; Olsen, Richards and Scott, 1991; van Kooten and Schmidtz, 1992). Willingness to pay has become the most frequently applied measure of economic value and has been given peer review endorsement through a variety of studies (e.g. Arrow et al., 1993). The specific circumstances and the property rights regime that is associated with the resource use in question determine the appropriate measure of economic value. The area under the supply and demand curves indicates the aggregate supply and demand respectively for a good or service. In a competitive, freely functioning market, a quantity Qm of the good or service is traded at the market price Pm, which is the price at which demand matches supply. If quantities less than Qm are traded, consumers are willing to pay more than the market price (the demand curve is higher than Pm), suggesting that market price alone is only a minimum estimate of the economic value or benefit derived. The area between the market price and the demand curve (triangle A) is the consumer surplus, or the additional utility gained by consumers above the price paid. Therefore, total social benefits or TEV are the expenditure (areas B + C, or price multiplied by quantity) plus the consumer surplus (area A). The total cost of producing quantity Qm is the area below the supply curve (area C). The area above the supply curve and below the market price the producer surplus; this occurs because producers are willing to sell for less than the market price if the quantity traded is less than Qm (the supply curve is less than Pm). The net social benefit is the consumer surplus (area A) plus the producer surplus (area B). A further issue related to valuation entails the use of costs as determinants of economic value. The correct measure of economic value is determined based on benefits, as indicated by the area under the demand curve. However, some valuation techniques, such as those based on the costs avoided, defensive expenditure, replacement/substitute costs or restoration costs, use costs as a proxy for benefits. This is based on the misplaced assumptions that costs are necessarily a reasonable approximation of social benefits and that the benefits are at least as great as the costs involved in repairing, avoiding or compensating for damage. These techniques are applied widely because of their relative ease of use and availability of the data, but it is important to be aware of the limitations in terms of the information they convey. Such cost-based measures of value are derived from the supply of goods and services and should not be confused with demand-based approaches. As discussed above, the supply of goods and services entails various elements of costs, including direct, external and user costs. Taken together these elements of cost are akin to the concept of social cost, and when equated with the marginal benefits of use, lead to an efficient, in economic terms, allocation of resources.