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Measuring Irrigation Subsidies Some Conceptual and Methodological Issues

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SUMMARY

Irrigation water provisioning is a complex undertaking. Most large-scale irrigation projects are multi-purpose in nature. These projects have been built over a long period of time and still providing service even after they have lived their economic life. The provisioning and use of irrigation water are associated with a number of externalities—both economic and environmental—whose costs have to be borne by the governments or the society. Irrigation water use is also associated with significant opportunity costs. Given these intricacies associated with irrigation water, estimating the cost of irrigation water is not easy. Several issues need to be resolved. How should the capital costs of irrigation be apportioned in multi-purpose projects? Should the capital cost of existing infrastructure be treated as a sunk cost? If not, how much of the capital cost invested in irrigation projects during the last several decades should be accounted for? How should the opportunity cost of irrigation water be measured? Should the cost of externalities be counted when estimating the cost of irrigation? Are the necessary data available to estimate these costs? Does a clear conceptual framework exist to estimate various costs?

As on the cost side, there are similar questions on the revenue-realization side also. Are farmers the only beneficiaries of irrigation water infrastructure? Should farmers pay for all the costs of irrigation? Are there any other revenues for the government from the impoundment and sale of irrigation water? Are enough data available to estimate revenues?

Answering the above questions is not easy. Given the complexities surrounding the estimation of the costs of irrigation water and the revenue realized therefrom, one wonders if these complexities in the estimation of costs and revenues have been addressed in the available estimates of irrigation subsidies. A consensus on a working and widely acceptable definition of subsidies, and their methods of measurement, is important, if subsidies are to be measured in a way that makes their estimates more meaningful, transparent, comparable and useful across nations. The present paper attempts to provide a conceptual and methodological framework so that more comparable estimates of subsidy could be derived.

Keywords: Irrigation, Cost, Revenue, Multipurpose projects, Joint cost, Subsidy.

1. INTRODUCTION

Irrigation accounts for 70 to 90 per cent of total water use in developing countries and for more than one third of water use in many OECD countries. Irrigated agriculture occupies about 17 per cent of the planet's cultivated land but provides about 40 per cent of the world's food supply. Much of the increase in global agricultural production over the last several decades can be attributed to the expansion of irrigation. In addition to helping increase agricultural productivity and agricultural production, irrigation has also been credited with helping increase the incomes of farmers, in tackling problems of rural poverty and in keeping prices of food lower than they would otherwise be.

The world over, most irrigation systems have been built and operated by the governments or their agencies. Typically, irrigation water users are charged only a fraction of the cost of supplying water to them. In many cases, these charges fail to even cover operation and maintenance (O&M) costs, and they almost never cover

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any of the substantial capital costs incurred in developing water collection and distribution systems (Repetto 1986, Tsur and Dinar 1995). In developing countries, the recovery of irrigation O&M costs range from 20 to 30 per cent in countries like India and Pakistan and up to 75 per cent in Madagascar, and depreciation of the fixed capital is virtually uncovered (Dinar and Subramanian 1997). According to another study (Sur *et al.* 2002), farmers across the world seldom pay more than 20 per cent of the full cost of water. The study also claims that "full [cost] recovery, to the best of our knowledge, including the recovery of the full investment cost, has not been practiced anywhere" (Sur *et al*. 2002). The governments have often justified subsidies for irrigation water to several factors - achieving greater food production and security, poverty alleviation, employment generation, social equity concerns, etc. Whatever be the logic, the form, or the amount of subsidies given, subsidies in general have discouraged more efficient use of available water.

Some of the available estimates of irrigation subsidies suggest that subsidies on irrigation water in both developing and developed countries alike have been pervasive. Based on a World Bank study in 1994, Van Beers and de Moor (2001) estimate irrigation subsidies in developing countries at $20 billion to $25 billion per year, with a majority of these given in Asia. Myers and Kent (2001) estimate irrigation subsidies in developing countries at around $29 billion. Both Myers and Kent (2001) and Van Beers and de Moor (2001) estimate total water subsidies in OECD countries at $15 billion per year, the majority of which are for the irrigation sector. Brown *et al.* (2000) gave an estimate of $33 billion per year for global irrigation subsidies. The above estimates of subsidy are likely conservative and could vary substantially depending upon how the subsidies are defined and measured.

2. MEASURING IRRIGATION SUBSIDIES

Theoretically speaking irrigation subsidies can be defined and measured from three different perspectives (Gulati and Narayanan 2003).

(a) *From the perspective of the irrigation water-supplying agency* : From the perspective of the government or supplier, an irrigation subsidy is defined as the net cost to the government in making irrigation water available. From this angle, one can conceptualize an irrigation subsidy as the difference between the cost of making irrigation water available and the revenue received as payments from the beneficiaries of irrigation water. Thus, this concept is akin to that of "losses" incurred by the irrigation authority or supplier in delivering irrigation water.

(b) *From the recipients' point of view – benefit to the recipient* : From the beneficiary's point of view, irrigation subsidies should relate to the actual value of water to the beneficiaries rather than the amount of public expenditure incurred in making water available. From the beneficiary's point of view, therefore, an irrigation subsidy would measure the difference between one's willingness to pay (WTP) for the water and what one actually pays. In terms of micro-economic theory this is akin to the concept of consumer surplus. Repetto (1986) and Roumasset (1987) term this surplus as "economic rent."

(c) *From the perspective of the society at large* : This would amount to defining an irrigation subsidy as the difference between the true domestic resource cost (DRC) of providing irrigation water to farmers and what farmers pay to the society for irrigation in terms of their direct price for water, betterment levies, land tax and also lower prices for their output than what they would have got under a free-trade environment.

World over most of the available estimates of irrigation subsidy are derived following an approach similar to or a minor variant of the first approach discussed above Thus available estimates of irrigation "subsidies"(S) have been derived as the difference between "cost" (C) of supplying irrigation water and the "revenue"(R) realized from the sale of irrigation water to the "beneficiaries".

$$S = C - R$$

While there is no conceptual problem in estimating subsidies following this approach, the three key constituents—cost, beneficiaries and revenue—on which this approach is based need to be clearly defined, identified and understood. In the context of quantifying irrigation subsidies, analysts have interpreted these three terms differently. Depending upon how one defines and evaluates these three underlying concerns, the estimated value of subsidies can vary over a wide range. The present paper attempts to highlight some of the issues involved in clearly defining these three key constituents of subsidy estimation and present a framework for analysis so that more meaningful, comparable, consistent and transparent estimates of subsidy could be generated. In the following sections we attempt to elaborate on these three key concerns in deriving more informed estimates of irrigation subsidies.

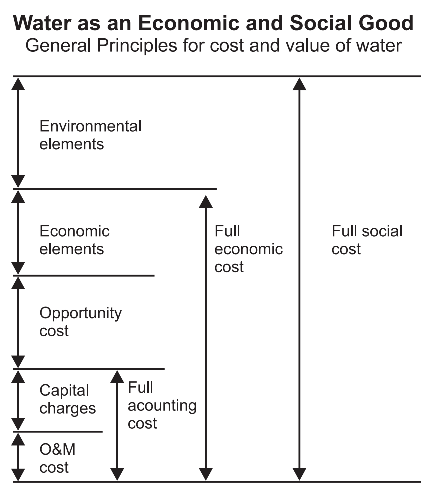
3. COST OF IRRIGATION WATER

The interpretation of the concept of the cost of irrigation water has varied greatly in the literature, depending upon the purpose at hand and the prevailing water availability scenario. Quite often, the cost of making irrigation water available has been equated with the supply cost—that is, the financial costs associated with the provisioning of water. The financial costs in turn have been equated with either the sum of the capital and O&M costs (however these may have been defined) or, more often, with O&M costs alone, with capital cost treated as a sunk cost. Attempting to equate the cost of irrigation water with the financial cost of making this water available is however be set with problems. Such an approach implicitly assumes that water is a free gift of nature, it is available in abundance, there are no competing uses for irrigation water, and its use for irrigation assumes no social, economic or environmental externalities.

In situations where the water is a constraining factor with competing uses, irrigation water supply is associated with a wide range of intermediate costs in addition to those purely associated with private or social spheres (OECD 2002). Thus making water available for a specific use, at the cost of other competing uses, say industry, requires accounting for the opportunity cost of water. Further, water diverted and used for irrigation often causes environmental externalities and degrades natural resources. From such a perspective, the costs of these externalities need to be considered while determining the cost of irrigation water. Thus the social cost of water supply is not just the cost of the goods and services that are required in order to make the water available for use, but also the costs that society has to bear in terms of reduced opportunities of using water resources in alternative ways and the costs that are necessary for maintaining and improving the quality and quantity of the water capital up to a level that is considered sufficient for long-term sustainability (Massaruto 2002).

3.1 Types of Costs

To more systematically understand the various costs associated with provisioning of irrigation water, following Rogers *et al.* (1998) we distinguish three cost concepts—the full supply cost, the full economic cost and the full (social) cost. The compositions of the various components that add up to make the different costs are presented schematically in Fig. 1. We first explain these cost concepts and then elaborate on the methodological issues involved in estimating these costs.



3.1.1 Full supply (accounting) cost

The full supply cost includes the costs associated with the supply of water to a consumer without consideration of either the externalities imposed upon others or of the alternate uses of the water. Full accounting costs thus are composed of two separate items: O&M costs; and capital charges.

O&M Costs: These costs are associated with the daily running of the supply system. Typical costs include purchased raw water, electricity for pumping, labour, repair materials, and input cost for managing and operating storage, distribution and treatment plants. In practice, there is typically little dispute as to what are considered O&M costs and how they are to be measured.

Capital Charges: There are some disagreements about the calculation of capital charges. While older methods use a backward-looking accounting stance and look for the costs associated with repaying the historical stream of investments, modern methods stress a forward-looking accounting stance and look for the costs associated with replacement of the capital stock with increasing marginal costs supplies. These coupled with the O&M costs approximate the long-term marginal costs.

3.1.2 Full economic cost

The full economic cost of water is the sum of the full supply cost as described above, the opportunity cost associated with the alternate use of the same water resource, and the economic (pecuniary) externalities imposed upon others due to the consumption of water by a specific actor.

Opportunity Cost: This cost addresses the fact that by consuming water, the user is depriving another user of the water. If that other user has a higher value for the water, then there are some opportunity costs experienced by society due to this misallocation of resources. The opportunity cost of water is zero only when there is no alternative use—that is, no shortage of water. Ignoring the opportunity cost undervalues water, leads to under-investing in water conservation and causes serious misallocations of resources among users.

Economic (Pecuniary) Externalities: As a fugitive resource, water results in pervasive externalities. The most common economic externalities are those associated with the impact of an upstream diversion of water or with the release of pollution on downstream users. There are also externalities due to over-extraction from, or contamination of, common-pool resources such as lakes and underground sources. There may also be production externalities due, for example, to the agricultural production in irrigated areas damaging the markets for upland non-irrigated agriculture, or forcing them to change their inputs. The externalities may be positive or negative, and it is important to characterize the situation in a given context and estimate the positive or negative externalities and adjust the full cost by these impacts.

Positive externalities occur, for example, when surface irrigation is both meeting the evapotranspiration needs of crops, and recharging a groundwater aquifer. Irrigation is then effectively providing a "recharge service." However, the net benefit of this service will depend on the overall balance between total recharge (from rainfall and surface irrigation) and the rate of withdrawal of groundwater.

Negative externalities, as discussed in Briscoe (1996), may impose costs on downstream users if the irrigation return flows are saline, or where return flows from towns impose costs on downstream water users. These negative externalities should be borne by the water users who impose these externalities on others.

3.1.3 Full (social) cost

The full cost of the consumption of water is the full economic cost, given above, plus the environmental externalities. The environmental externalities are those associated with public health and ecosystem maintenance. Hence, if pollution causes increased production or consumption costs to downstream users, it is an economic externality, but if it causes public health or ecosystem impacts, then we define it as an environmental externality. Environmental externalities are usually inherently more difficult to assess economically than the economic externalities, but we argue that it is possible, in most cases, to estimate some remediation costs that will give a lower-bound estimate of the economic value of damages.

While theoretical classification of different costs is relatively straightforward, in practice quite often, a clear distinction between the financial costs, environmental costs and resource costs becomes difficult, as there are risks of overlap and even mix-up with the consequence of double counting.

3.2 Methodological Issues

Having defined the various cost concepts we now briefly highlight the methodological issues associated with estimating some of these costs

3.2.1 Estimating annualised capital charges

Valuation of capital

The attributable annual cost of capital invested in irrigation infrastructure comprises two components: the annual interest cost; and the annual depreciation. Since these costs are to be calculated on the amount of capital invested, an important question that needs to be resolved is: what is the capital base on which these annualised costs should be calculated?

Construction of water-resource projects is an on-going process. Most of the projects constructed decades ago are still in service. This implies that the capital invested in these projects is still yielding benefits, by making water available, and that all the water that is currently being provided by these water-resource structures cannot be attributed to the current capital expenditure alone. Thus, one must carefully take into account the capital invested at different points of time in the past several decades to arrive at a capital base, which should form the basis for estimating the annual cost of capital—interest and depreciation.

Before addressing the questions related to accounting systems and the choice of valuation methods for the evaluation of capital cost, there is another important issue, relating to multiplicity of use of a number of irrigation structures, which needs to be resolved in the context of determining the capital cost.

Allocation of joint capital costs

An important characteristic of many public utilities is that they provide multiple goods and services simultaneously. Most large water-resource projects have this characteristic, providing at the same time some or all of the following services: irrigation water, municipal water supply, flood protection, hydro-electric power, recreation, navigation, fisheries and so forth. While some of these demands are competitive (such as agricultural and industrial consumption), others are complementary. In Asia, for example, 90 per cent of dams for irrigation are multi-purpose (Easter and Liu 2003). In addition to helping realize the greatest total benefit from the natural resource, the multiple nature of the project also helps makes the project more cost effective, since the sum of marginal costs of each component may be less than the total cost of the project. Thus a multiple-purpose project may be practicable where a single-purpose project may be impracticable.

However a problem arises with regard to the basis for allocation of the total cost of the project to its constituent components. In the literature, various methods have been suggested for allocating joint costs. The traditional methods most commonly used in water-resource planning practices to allocate joint costs are (1) to allocate costs in proportion to some single numerical criterion, such as use, population or level of benefits; or (2) to allocate certain costs (*e.g.*, marginal costs) directly and divide the remainder on the basis of some scheme similar to the first method (Young *et al.* 1982). Chief among variants of the first method is the use-of-facilities (UOF) method. Among the second group of methods, the two main ones are: (1) alternative justifiable expenditures (AJE); and (2) separate costs, remaining benefits (SCRB) methods (Easter and Liu 2003; Young *et al*. 1982; Young 1985). Each of these methods has its merits and problems. Notwithstanding the choice of methods for cost allocation, it is important to underline the importance of allocation of joint cost in to different constituents as an important first step in determining the capital base for estimating annualized capital cost of irrigation. This part has generally been overlooked in most of the available estimates of subsidy.

Annualized capital cost

Having discussed the modalities for estimating the capital base to be used as the foundation for the computation of the annual cost of capital invested, the next important issue is estimating the annual cost of capital. As discussed earlier, the annualized capital comprises depreciation and interest costs. We first deal with the issue of depreciation and then with the interest cost on the capital invested.

Estimation of depreciation

Estimating rates of depreciation requires making suitable assumptions about the life of the project and the method and rate of depreciation.

What should be taken as the life of the irrigation project for the purpose of calculating depreciation? Like any other man-made structure, irrigation projects based on dams or otherwise have a finite life, though the economic life of these structures may span several decades, and often the structures will keep providing a service long after their technical or design life has been surpassed. Dam management around the world is coming to realize that, although dams generally last beyond the lifetimes of the people who have built them, they do not last forever. Dams are subject to life cycles of design, construction, operation, rehabilitation and, finally, decommissioning. On the other hand, projects constructed in more recent years can be expected to last much longer than those constructed sometime in the past. This is because of better technology, design and the quality of material used to construct them.

In addition to the factors associated with the design and the construction of a project, its life depends upon several other factors, including the level of attention paid to issues such as sedimentation; the quality, adequacy and regularity of maintenance; the quantity and the quality of water (in areas of acidic water the life of a dam may be much less); the extent of rehabilitation and restoration works undertaken, and so forth. Thus, depending upon these factors, some projects may survive much longer than their designed life, while some may even survive for a shorter time than anticipated. For example, the lifespan of the Tarbela Dam in Pakistan, which was originally projected to be 60 years when it was first completed in 1974, is now expected to be about 80 years (UNEP 2004).

Given the heterogeneity of projects in terms of their nature, location and size, year of construction, quality of construction, water and operations, adequacy and regularity of maintenance, and extent of rehabilitation works undertaken, what should be the basis for determining the life of the project? This is an important consideration that needs to be given due consideration in determining the depreciation cost.

Having dwelt on the issues relating to the life of the asset, the next important step in determining the annualized cost is the method for calculating the annual depreciation. The most accurate method for determining annual depreciation is the "utilization method" whereby the depreciation is calculated according to the usage of the asset in a given year. The more the asset is used, the larger the value of depreciation. The application of such a criterion for the evaluation of annual depreciation for irrigation projects is generally difficult due to the non-availability of information regarding annual usage. As a result, probably the alternative method -the straight-line method, which suggests the use of linear depreciation following the service life of the asset, could possibly be used.

Estimation of interest cost

There are alternative ways in which the interest cost of capital can be accounted for. One way of computing the interest cost is to charge the interest on the book value (at historical prices) of the project at interest rates actually prevailing in the past when the capital borrowing took place. Another way could be to evaluate interest at current borrowing rates without evaluating the capital at current prices. The question that needs to be resolved is what borrowing rate should be used for evaluating the cost of capital.

Funds for most irrigation projects, especially in the past, were for the most part funded either out of budgetary allocations, through grants and loans at concessional or nominal rates of interest from central governments to state governments, or through loans or bonds raised by the state governments or their agencies. However, the loans or bonds issued by the state to raise money in most cases were not specifically meant for the purpose of irrigation, but formed the general pool of state borrowing. As such it is not generally possible to relate particular loans to any specific uses. These borrowings carry different maturity periods with varying interest rates and as such it is difficult to identify a unique interest rate for borrowing for irrigation investments. In more recent times, there has been increased project, or state-specific, funding from international lending institutions such as the World Bank and the Asian Development Bank. While some of the lending from these international donor and lending institutions is provided in the form of grants, the rest may not carry the burden of any interest (such as International Development Association grants from the World Bank to developing countries) or are charged interest costs which are generally much below the cost of borrowing from commercial financial institutions. Given these complexities on the different timings during which such funds are raised, the basket of sources which constitute these funds, the length of timing for which the funds are raised, and the differential interest rates at which the funds are borrowed during different periods, it is difficult to assign a unique interest rate which could be used to evaluate the cost of borrowings. What would be an appropriate rate at which the interest cost could be evaluated?

3.2.2 Operations and maintenance costs

Operations costs refer to the costs associated with the operation of a system and include such items as staff costs, management costs and electricity for water pumping. Maintenance costs refer to the expenses incurred on actual maintenance of the irrigation system to keep it in working order. Maintenance and renewal costs thus are the costs of maintaining assets in order to provide a good service until the end of their useful life. Given that many water-related assets have extended operational lives and some of them may be buried in the ground or under water, it might be difficult to estimate the appropriate level of maintenance costs needed to operate the assets without their deterioration. The major cause of non-sustainability is the usual but incorrect assumption of saving on maintenance costs at the expense of long-term sustainability.

O&M costs are based on the running costs entered in the project accounts for any given year. While some countries keep separate accounts for operations and maintenance, often the two are put together as O&M costs in public-accounting systems. Procedures for estimating annualized O&M costs are, however, different from those employed in the case of estimating capital costs. Unlike in the case of capital-cost estimation where one has to account for the capital invested in the past to estimate the annualized capital cost of the irrigation infrastructure, the estimation of O&M costs is relatively straightforward and they are measured by the costs incurred during the year of reference only.

There are, however, serious questions that can arise that relate to the adequacy and availability of funds for O&M costs and the efficiency of their use. For example, public-sector irrigation agencies are typically overstaffed and most of the funds allocated for O&M activities go towards paying the salaries of staff, leaving very little money for the actual maintenance of the system. Further, as corruption is a factor in these institutions, the actual remaining money spent on maintenance may be less still, thereby affecting the quality of the maintenance provided which ultimately gets reflected in the quality of service provided to the users and the willingness of the users to pay for the service. While it may be desirable to use some measure of "efficient" cost for operations and maintenance, it may be difficult to define a uniform measure, because of the differences in underlying conditions such as the nature, size, location and age of the project; the quality of construction; and the nature of the institution operating and maintaining the project (Vaidyanathan 1992).

While the estimation of O&M costs would appear to be straightforward, in practice this may not always be the case. Sound data recording and bookkeeping for O&M are of crucial importance in irrigation (Tiercelin 1998). Lack of availability of proper disaggregated records often hampers estimation of these costs. Further complicating their evaluation, if the responsibilities are being shared by more than one agency, such as public-sector agencies and Water Users Associations (WUAs), the record-keeping of the latter may not be adequate and appropriate for subsidy estimation. Further, evaluating maintenance costs may be complicated if certain prevailing practices implying no financial transaction (for example, cleaning or clearing of canals by farmers themselves) have to be considered. The maintenance issue becomes crucial since WUAs will have to cover these costs, via a monetary or labour-based contribution by farmers, especially in view of the past tendency to curtail such contributions. The simple fact that different entities may ultimately cover capital costs on the one hand (the public sector), and O&M costs on the other hand (mostly farmers through a WUA, and possibly other users) generates some complications. Nevertheless, if data on the O&M cost of the systems is available, the computation of O&M costs is relatively straightforward in comparison to the estimation of annualized capital cost.

3.2.3 Opportunity cost of irrigation water

The marginal returns of water, or the value of water, vary across time and space, and across and even within different water-using sectors. Irrigation water, for example, has a very high value at certain times of the year, such as at certain critical crop growth stages, as compared with other periods. The value of irrigation water also depends upon the type of crops grown in an area; for example, it would be higher in a region growing fruits and vegetables than in an area growing fodder or low-value cereal crops. In a region with an acute scarcity of irrigation water, even at the individual farm level the value of irrigation water will vary depending upon whether the available fixed quantity of water is used to grow water-intensive crops on one hectare of land, for example, or grow less water-intensive crops on three hectares of land. Similarly, the value of water would be high in the hydropower, industrial, commercial and residential sectors (and certain environmental sectors) compared with many uses in the agricultural sector. If water is allocated a low value and is utilized for agriculture at the expense of high-value uses, the lost opportunity resulting from the misallocation of water represents an economic cost to society. Thus, if water is currently used in the agricultural sector, the opportunity cost—*i.e.*, the value of the best alternative use—may be 10 times higher or even more (Briscoe 1996).

Irrigation is the predominant user of water in a majority of the world's river basins, accounting for sometimes as much as 80 to 90 per cent of total use. If all water used for low-value irrigation were to be transferred to high-value sectors of the economy, these sectors would not be able to utilize more than a fraction of the water due to their more limited water demand. As a result, the opportunity cost of water would apply only to a small proportion of the total volume of water used in agriculture (Hussein 2004; Briscoe 1997).Thus, after the water demands for other sectors or users have been met, the opportunity cost of irrigation water would be zero (or close to it). Under these conditions how the opportunity cost of water used in agriculture could be estimated?

3.2.4 Environmental externalities and costs

Identifying environmental externalities of irrigation, evaluating their impacts and accounting for these impacts in the costing of irrigation water is a complex undertaking. Environmental effects associated with irrigation water can be simplified and considered in two modules. Some of the irrigation-induced environmental effects are linked with the provision of irrigation water by those responsible for the irrigation infrastructure. Examples include faulty design, poor quality of construction, inadequate maintenance, improper water management and lack of drainage. Others may arise as a result of the use of irrigation water and the associated cultivation practices followed by the farmers: the nature of crop cultivated, soil conditions, intensity of irrigation and method of irrigation used. Some other externalities may be caused by factors that are beyond the control of either the providers or the users of irrigation water. A few of the impacts are unpredictable and not very well documented such as effect of irrigation on carbondioxide and methane fluxes. Further, while some environmental impacts are site or project-specific, others are more general in nature and spread over a wide geographic area. Some effects are felt in the short run, while others appear only in the medium to long term.

To add to the complexity, the environmental effects of irrigation can be positive or negative. On the positive side, reservoirs created for irrigation provide fresh water for birds and other fauna, fisheries, recreation and tourism. Irrigation canals allow the recycling of urban wastewaters from households and industry. In some locations, irrigation also helps in the management of risks, such as flooding, or those associated with crop losses as a result of periodic drought. On the other hand, the diversion of water for agriculture has often contributed to environmental problems and the degradation of natural resources. Dams, by reducing natural variability in stream flow, alter the seasonal cycles of aquatic and riparian plants and animals. There are a number of other adverse impacts associated generally with the use of irrigation water. These include surface and groundwater pollution from nutrients and pesticides used in crop cultivation, intensive forms of irrigated agriculture displacing formerly high-value semi-natural ecosystems and affecting biodiversity, increased erosion of cultivated soils on slopes and large-scale water transfers associated with irrigation projects. Given all these complexities how the costs of environmental externalities can be measured?

3.2.5 Gross cost (C) to Government for supply of irrigation water

Based on the discussion in the previous sections, the gross cost to the government of supplying irrigation water can be described as the sum of:

- Annual capital cost (interest and depreciation charges) of irrigation infrastructure (Section 3.2.1);
- O&M costs (Section 3.2.2);
- Opportunity cost of irrigation water (Section 3.2.3);
- Cost of economic and environmental externalities (insofar as they can be quantified and attributable to government expenditure) (Section 3.2.4).

Having discussed the methodological issues associated with estimation of various costs of making irrigation water available, we now turn to the second question of identifying the beneficiaries of irrigation water and the revenue accruing to government for supply of irrigation water.

4. BENEFICIARIES OF IRRIGATION WATER AND THE REVENUES REALIZED BY THE GOVERNMENT FROM IRRIGATION WATER

In the literature on cost recovery for irrigation services, the money realized from the farmers, the primary beneficiaries of irrigation water, in the form of irrigation charges is treated as revenue realized by the government on account of making irrigation water available. However, is this the only source of revenue for the government from the sale of irrigation water? Are farmers the sole beneficiaries of irrigation water and therefore the sole entities responsible for paying for irrigation water? The experience suggests that while farmers may be the primary beneficiaries of irrigation water, they cannot be regarded as the sole beneficiaries. Who are the other beneficiaries who gain directly or indirectly from the irrigation water made available to farmers? Is the government getting some of its irrigation-related revenues, knowingly or unknowingly, directly or indirectly, from some of these beneficiaries? Apart from the revenues realized from these segments of society impacted directly and indirectly by the availability of irrigation water, what are the other sources of revenue for the government from investments made in the irrigation sector?

We discuss this issue in two parts. The first part relates to identification of direct and indirect beneficiaries who gain from the availability of irrigation water. The paper then discusses the various sources of revenue for the government related to supply of irrigation water.

4.1 Identifying the beneficiaries of irrigation water

Construction and maintenance of irrigation infrastructure involves huge costs and therefore an important concern in making these public investments has always been how the costs of these investments can be recovered and who should pay for these costs (Sampath 1983; Tradieu 2004). In principle, any cost incurred in providing a service should be recovered from all those who benefit from the provision of these services (Barakatn.d.). So, the first important question is: who are the beneficiaries of irrigation water?

While the primary concern for public investment in irrigation infrastructure is to help farmers adopt technological innovations and increase agricultural production, or to help minimize the impact of erratic weather patterns on agricultural production, this in no way can be regarded as the sole purpose for governments to invest in irrigation. In the literature on cost recovery, the revenues realised from the sale of water to farmers in the form of tariffs is referred to as revenue. The rationale behind recovering the cost of irrigation water (in whatever way the cost is defined) from the farmers, is that these investments have been made for the benefit of the farmers and the cost of providing irrigation water should therefore be borne by them and recovered from them.

It has however to be appreciated that while farmers may be the primary beneficiaries of the investments in irrigation, they are rarely the sole beneficiaries. From even the most casual comparison of the economic activity in a region before and after the availability of irrigation, it would be obvious that the benefits of growth as a result of the availability of irrigation water are reaped not only by multiple segments of the rural population—both farm and non-farm—but often by residents of urban areas as well (Marts 1956). Some derive these benefits directly, while others derive them indirectly through the benefits of increased agricultural production transmitted to other parts of the society. In addition to the economic benefits accruing to various segments of the rural and urban population, investments in irrigation provide a number of social benefits, such as enhanced food security, lower food prices and increased income-generating opportunities.

The fact that some benefits of irrigation are unintended and that some of these benefits accrue indirectly to non agricultural sectors—does not make them any less real, valuable or important. The argument that it is not easy to identify other beneficiaries or to quantify indirect benefits, or the amounts these indirectly impacted beneficiaries are already paying to the government, does not mean that revenue realized from the direct beneficiaries alone can be treated as the sole revenue from sale of irrigation water. The difference between the cost of irrigation water and the money recovered from farmers in the form of water tariffs should not automatically be interpreted as a subsidy to the farmers. It is therefore desirable that at least some of these indirect benefits and beneficiaries be identified and properly accounted for, along with direct beneficiaries and the revenue realized from them on account of increased production attributable to the availability of irrigation water. The number of indirect beneficiaries and the amount of indirect benefits in certain situations could be at least as large, if not more, as the number of direct beneficiaries and the amount of direct benefits (Garido 2005). In the Canadian provinces of Alberta and Saskatchewan, for example, it has been estimated that 15 to 20 per cent of the total benefits of irrigation go directly to the farmer, with the remainder to society (Hill 1985). In the case of Bhakra dam in India, it has been demonstrated that for every hundred rupees of direct benefits contributed by the dam, the indirect benefits are almost 80 rupees (Bhatia and Malik 2008). These benefits are from economic activity and employment beyond the farm benefits derived from irrigation-related activity. When methods are found to access the wealth created by indirect benefits, projects would become more viable (Tollefson and Hill 1994). That this part of the cost should be borne by other project beneficiaries and other indirect users has been emphasized by the Organisation for Economic Co-operation and Development (OECD 2002) and the International Commission for Irrigation and Drainage (ICID) (Tardieu 2004). While appreciating the need to recover costs from all beneficiaries, it is argued that since "it is not easy to identify the 'end beneficiaries' other than irrigating farmers, the community as a whole, *i.e.*, the taxpayers could be charged for it" (Tardieu 2004).

The direct benefits and direct beneficiaries have received much systematic study in the literature, and can be estimated within a reasonable margin of error. The procedures for identifying indirect beneficiaries and estimating indirect benefits and how the total benefits of a project have been shared by different segments of the society have been deficient. As such, it constitutes one of the most difficult problems in the economics of resource development. This is one of the many key issues which remain to be explored and require further methodological development (Bhatia *et al.* 2008).

4.2 Other Sources of Revenue

4.2.1 Fish production

Irrigation systems offer a diversity of water bodies for fish production. Among these water bodies, usually only dams and reservoirs are used for fish production. Canal systems have been given low attention in terms of realizing their potential for fish production. Active canals are rarely managed for capture fisheries and there is no cage or pen culture evident. However, abandoned irrigation canals are to some degree utilized for fish production. Flood control compartments are often stocked naturally with wild juvenile fish, including major carps and other food fish, during floods. Large areas of wet lands resulting from irrigation practices also have considerable potential for fisheries development but are rarely utilized. There is also the tendency to build fish farms on marginally productive agricultural land or areas. As the dependence on the canal water in fish farming systems is very high, one can consider these ponds to be an integral part of the irrigation system. The possibilities and scope for the utilization of irrigation systems for fish production, however, vary from project to project, depending upon the prevailing conditions with respect to availability, demand and management of water (FAO 2001). There are a number of examples from several countries—India, Pakistan, Turkey, Uzbekistan, etc.—where irrigation systems are being used for fish production.

However there is no organized effective data collection system which could assist in determining the quantity of fish caught in these water bodies. Traditional inland fisheries are managed by an auction system and there is limited licensing of natural water bodies. Also, the fishing rights for each compartment are annually auctioned by the respective agency owning and maintaining the system. Even if reliable estimates of fish production arising from various components of an irrigation system are not available, data on the prices at which various compartments are auctioned are available, and such data can provide an estimate for revenue derived from these fisheries and must be accounted for as revenue from irrigation systems.

4.2.2 Hydro-electric power generation

Some irrigation projects, even those not forming part of a multi-purpose project, have provided opportunities for generating hydro-electric power, a non-consumptive use of water. In addition, in locations where the gradient and quantity of water available is conducive, canal drops (run-of-the river projects) can often be used for hydro-electric plants. The economics of hydro-electric power generation depend upon the prevailing water and power availability policies, and the priorities given to the use of water between the two purposes.

In energy-scarce economies, hydro-electric power can provide a valuable adjunct to an irrigation project and can provide power during peak demand that is sometimes priced higher than off-peak power. Thus the value of hydropower is likely to be higher in situations of high water availability, where the conflicts between its use for irrigation and power generation are low, and acute power scarcity is prevalent. Because the output of a hydroelectric power plant can be varied quickly in response to changing demand, it often commands a premium price. The revenue received from sale of such hydropower needs to be accounted for.

4.2.3 Tourism and recreation

Irrigation reservoirs, dams and canals offer opportunities for water-related sports and offer other recreational options. This helps in promoting tourism. The government derives large revenues from these structures which must be duly accounted for in government accounts as revenues from irrigation.

4.2.4 Revenues from the imposition of pollution taxes

Economists have generally advocated the use of pollution taxes as a means to address environmental externalities. Following the "polluter pays" principle, the externality problem in general is sought to be addressed by imposing environmental levies and taxes on the polluter. In line with this principle, the polluter should pay, or the governments should recover, in addition to the cost per unit of water, an additional charge per unit of water equal to the external damage cost imposed on others (MacDonald *et al.* n.d.)

In the case of irrigation water, even if it were possible to somehow quantify the damages, identifying the polluters of irrigation water, and clearly demarcating the nature of damages and attributing the share of damages to irrigation water *per se* and to different polluters, is not straightforward. As discussed earlier, while some of the irrigation-related externalities are caused because of inefficient use of irrigation water, some may be caused by the providers (irrigation agencies) of irrigation water as a result of faulty infrastructure design or the poor quality construction of irrigation works, or poor maintenance of the system. Further, some of these externalities can be increased by household sewage or industrial effluents mixing with irrigation water—that is, by individuals or firms not engaged in agriculture. In addition, the externalities often stretch over large areas, which make it difficult and expensive to monitor their origin, to quantify the magnitude of different damages caused by different actors, and to allocate the cost of damages among different polluters and thereby make someone accountable, in particular, for causing these externalities. This is a subject which lacks clear answers and agreements and calls for further research.

In view of these complexities it is not known if any country imposes pollution taxes and recovers them from the beneficiaries of irrigation water; however, if it were feasible to do so, this would add to the revenues of the government and need to be accounted for.

4.2.5 Non-quantifiable returns

Apart from the quantifiable revenues to the irrigation providing agency, there are a number of other benefits to the government in general, which are difficult to quantify in monetary terms. Enough evidence is available to substantiate that the availability of irrigation water is associated with rural development, a reduction in poverty, improved food-grain availability and food security, lower food-grain prices, improved hygiene and sanitary conditions, improved returns to education, etc. These non- quantifiable benefits need to be duly recognised and accounted for while measuring returns from investments in irrigation.

4.2.6 Total revenues (R) to the government from irrigation water

The total revenue to the government from investments made in the provision of irrigation water thus comprises:

- Revenue realized on account of the sale of water from the direct and indirect beneficiaries of irrigation water (Section 4.1). Revenue realized from the sale of fishing rights (Section 4.2.1);
- Revenue realized from the sale of hydropower generated from the running of river based hydropower plants (Section 4.2.2);
- Additional revenue realized on account of increased tourism and tourism-related activities (Section 4.2.3);
- Revenues from the imposition of pollution taxes insofar as they relate to provision and use of irrigation water (Section 4.2.4). Non-quantifiable benefits (Section 4.2.5)

5. SUMMING UP: MEASURING IRRIGATION SUBSIDY (S)

A more comparable and consistent measure of irrigation subsidy

$$S = C - R$$

can now be defined as the difference between gross cost to the government of supplying irrigation water (C) as obtained in Section 3.2.5 and total revenue to the government (R) from irrigation water as obtained in Section 4.2.6. Adoption of this conceptual framework can provide estimates of subsidy which are consistent and comparable across nations.

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