The GSI's Method for Quantifying Irrigation Subsidies

JANUARY 2009

EDITED BY:
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GSI Global Subsidies Initiative
www.globalsubsidies.org

iisd International Institute for Sustainable Development
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ABBREVIATIONS AND ACRONYMS

AJEs	Alternative Justifiable Expenditures
AoA	Agreement on Agriculture
EAI	Environmental Assessment Institute
EU	The European Union
FR	flat rate
GSI	Global Subsidies Initiative
ICID	International Commission on Irrigation and Drainage
IISD	International Institute for Sustainable Development
IWMI	International Water Management Institute
OECD	Organisation for Economic Co-operation and Development
O&M	operation and maintenance
PWI	Public Works Index
SCRB	separate costs, remaining benefits
UNEP	United Nations Environment Programme
WTP	willingness to pay
WUA	Water User Association
WTO	World Trade Organization

1. INTRODUCTION

1.1 IRRIGATION SUBSIDIES

Irrigation is the major user of water in many countries and one of the leading influences on agricultural productivity. Since the availability of irrigation influences the feasibility of cultivating a particular crop, the policies of governments, financiers and owners of most of the large irrigation projects worldwide can have far-reaching influence in shaping the pattern of agricultural development and trade. Also, the operation of the World Trade Organization's (WTO) Agreement on Agriculture (AoA) overlooks the influence irrigation subsidies have in this area, as government expenditure on irrigation in the Green Box, among other domestic programs, is exempted. However, in the WTO, issues relating to subsidies have come to more prominence, and efforts to define, measure and analyze them in various sectors have gained momentum. Irrigation subsidies can also form a significant portion of a country's budgetary expenditure. Badly directed subsidies could also contribute to the depletion of limited water supplies, distort decisions over which crops get produced and artificially increase the volume of agricultural output, leading to oversupply. Also, for many horticultural products, subsidized, irrigated production in wealthier countries may potentially be competing unfairly with products grown in developing countries—economies without the financial resources to match the levels of investment achieved by their competitors.

1.2 AIM OF THE IRRIGATION SUBSIDIES INITIATIVE

The irrigation sector uses a variety of large-scale multi-purpose irrigation projects built over a significant time period. They are built, operated and maintained by governments or their agencies, and combine with small groundwater-based systems typically owned, operated and maintained by individual farmers. The provision and use of irrigation water through these two approaches is associated with a number of externalities—both economic and environmental—whose costs have to be borne by governments or society. Given the complexity associated with the provision of irrigation water, estimating the costs involved is not easy and many theoretical issues need to be resolved. The initial research effort of the International Institute for Sustainable Development's (IISD) Global Subsidies Initiative (GSI) focuses on the development of a methodology that will provide researchers with a concise and defined set of parameters to follow when quantifying irrigation[1] subsidies (as opposed to the provision of other water services such as urban supply) and developing nationally comparable estimates.

Providing irrigation water is a complex undertaking and, consequently, measuring subsidies to the irrigation sector is an equally complex task. The aim of this water subsidies initiative is to develop a practical, transparent and internationally comparable approach for measuring support to water in agriculture, guided by current data constraints and available methodologies. The methodological approach proposed in this paper adopts a "step-by-step" approach, attempting to estimate certain elements of a subsidy that may be amenable to calculation, while recognizing there are many elements still not being addressed, as debate still continues surrounding their quantification. It's hoped this initiative will establish the necessary groundwork for measuring subsidies to irrigation in order to generate better internationally comparable estimates. Research in this area

[1] As defined in the OECD's *Glossary of statistical terms*, "irrigation" refers to "the artificial application of water to land to assist in the growing of crops and pastures. It is carried out by spraying water under pressure (spray irrigation) or by pumping water onto the land (flood irrigation)." Retrieved 4 November 2008 from the OECD's website: http://stats.oecd.org/glossary/detail.asp?ID=1464

should also lead to the improvement of other research efforts (notably policy modelling) and, ultimately, to improvements in both domestic policies and international trade rules.

Developing a common methodology

The IISD-GSI commissioned and published *Towards a common methodology for estimating irrigation subsidies*, a detailed overview and discussion of a number of methods available to researchers when quantifying irrigation subsidies up to a national level. The paper was not intended to favour any particular approach over another, but rather act as an aid in helping to define a methodology to be adopted by the GSI and its research partners. The paper was discussed in March 2008 at a two-day workshop hosted by the International Water Management Institute (IWMI) in Addis Ababa, Ethiopia. Participants represented, among others, the IWMI, the International Commission on Irrigation and Drainage (ICID), the International Institute for Sustainable Development (IISD), the World Bank, and Universities in India, Malawi, Turkey and the United States.[2] At the workshop, a number of challenges to measuring irrigation subsidies were discussed. Delegates outlined the difficulties experienced in obtaining sufficient data to undertake an empirical analysis of the support provided by government to the irrigation sector. Data access was another barrier to undertaking an initiative like this. The fragmentation of data was another challenge identified; data were usually held across a number of ministries, requiring significant resources to assemble the data and assess their comparability (Steenblik, 2003). In many instances, there were simply no data in existence, requiring researchers to generate their own, where possible. Given the many practical challenges facing an initiative designed to generate national level irrigation subsidy estimates, it was felt the Net Cost to the Supplier Approach, set out in this paper, was the most applicable and preferred approach to be adopted. All delegates, however, expressed their hope that the methodology would eventually be expanded, as data sets were created and new research techniques were developed.

In response to inputs and comments received from invited experts attending the Addis Ababa workshop, peer reviewers and external water provisioning experts, the methodological framework for estimating irrigation is proposed to guide the development of an initial set of country case studies. The methodological framework should not be taken as representing the official views or positions of those previously mentioned organizations, or participants who attended the workshop, but rather those solely of the GSI. The framework attempts to provide a method for the empirical estimation of irrigation subsidies in a manner that will be internationally comparable across a range of developing and developed countries. The methodology does not try to calculate all of the costs or benefits (indirect or direct) associated with water provision, as identified in the literature review contained in the discussion paper (see n. 2). It does aim to provide a clear and transparent method specifying the building blocks or components incorporated in the methodology (and those that currently are missing), which were assessed in generating subsidy estimates. As methodological frameworks and research techniques improve and develop, and the boundaries of this analysis are expanded to include other building blocks, it is hoped that this methodology will be expanded to tackle previously unaddressed issues.

The methodological framework, as outlined in this paper, should provide researchers with the necessary guidance, if followed, to generate country case studies that are comparable in their format, in the information they contain and in the subsidy estimates they generate. The GSI encourages other researchers to use and provide feedback on the methodological framework proposed here. Any feedback can be sent to the following email address info@globalsubsidies.org.

[2] The discussion paper can be accessed on the GSI's website at www.globalsubsidies.org/en/research/irrigation-subsidies.

1.3 DEVELOPING MEANINGFUL AND COMPARABLE COUNTRY CASE STUDIES

Given that a significant amount of irrigation infrastructure has been built in different countries over time, deriving country-level estimates of subsidies by summing up estimates for individual projects may not be feasible unless massive human and financial efforts are put into deriving such estimates. At the Addis Ababa workshop, this issue was discussed and a number of ideas were put forward for developing statistically meaningful and comparable studies. They included:

- Adopting a bottom up approach—applying the methodology to a statistically significant number of sample projects and then extrapolating the estimates derived from this selected analysis to a national-level estimate; or
- Applying the methodology as a minimum to all the projects in a province or district where there is a significant proportion of the country's irrigation infrastructure, and then extrapolating this sample upwards to include provinces or districts that were not assessed.

Given each country case study will vary based on the support provided to the country's irrigation sector, researchers are encouraged to set out the extent of the research they undertook, and the method they adopted in generating district, provincial or national subsidy estimates.

1.4 PROBLEMS ASSOCIATED WITH DEFINING AND MEASURING IRRIGATION SUBSIDES

Multiple definitions of subsidies are in use primarily because the nature, form, context and purpose of giving them. The use of subsidies also varies with countries' economic and policy goals, among sectors and over time. The definitions of a subsidy and approaches to its estimation have also often been customized to suit the nature of available data and the amenability of different parameters to quantification. A small change in their characterization or in how they are estimated can cause the calculated value to vary considerably. Consequently, estimates of subsidies in a given sector, across countries or across different sectors within a country, have frequently not been consistent and comparable. The methodology proposed in this paper aims to define specific criteria or building blocks quantified by the methodology in order to try and estimate irrigation subsidies in a comparable way.

Available estimates of irrigation subsidies are generally derived as the difference between cost of supplying irrigation water and the revenue realized from the sale of irrigation water. Measuring the cost to government requires overcoming several issues, for example, the apportioning of capital costs in multi-purpose projects. Other issues such as measuring the opportunity cost of irrigation, or off-budget environmental externalities, positive or negative, are not dealt with in this methodology. Given the array of elements that could be assessed in measuring an irrigation subsidy, and the difficultly in quantification that some of them posed, the Net Cost to the Supplier Approach, was adopted as the methodological approach for this paper. This is based on its applicability for a diverse range of countries, its transparency and the fact that it allows for ongoing monitoring and evaluation of the methodology and subsidy estimates.

Other methods to measure irrigation subsidies, such as the Net Benefit to Recipient-Willingness to Pay Approach, measure irrigation subsidies from the point of view of the end user. This approach measures irrigation subsidies based on the actual value of water to the beneficiaries rather than the amount of public expenditure incurred in making water available. This method is not, however, easily updated or comparable across countries, and would need to be periodically replicated as the participants' willingness to pay (WTP) may depend on changing variables relating to the quality of the water, consistency of supply, season or institute from which the water is being sourced.

Other issues associated with natural resources costs and groundwater extraction create challenges for calculating comparable subsidies. Groundwater property rights, for example, relate to a state's allocation of natural resources and would need to be clarified on a case-by-case basis. Issues relating to the fairness of quotas and government allocations would need to be addressed. Accurate data for groundwater abstraction (data may also include water destined for non-agricultural use, thereby preventing the disaggregation of data) are also difficult to obtain, limiting the effectiveness of any methodologies trying to determine a WTP on behalf of the users of irrigated water.

With the Net Cost to the Supplier Approach, there are still many unresolved issues. On the revenue-realization side, the benefits of supplying irrigation water may stretch further than just farmers, arguably creating benefits not captured in this methodology, and changing the cost parameters or components for providing irrigated water. Methods employed in arriving at some of the currently available estimates of irrigation subsidies suggest that an assortment of methods have been used. While some estimates equate the cost of irrigation with the current operation and Maintenance (O&M) cost of irrigation works, others equate irrigation cost with O&M cost plus some fraction of capital cost—without clarifying how the costs of multi-purpose projects have been apportioned and how the capital invested in the past has been accounted for. There is invariably no accounting of opportunity cost or the cost of externalities in any of the available estimates. Since the available estimates differ conceptually and methodologically, and documentation of the data is usually poor, the estimates so derived are neither transparent nor comparable. That said, achieving 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, useful and comparable across nations.

1.5 OVERVIEW OF THE PAPER

Having discussed the concept of subsidies as applied to water provisioning, and the methodological problems associated with developing a uniform measure of irrigation subsidies in the Introduction, Section 2 outlines the methodological approach proposed in this paper, the Net Cost to the Supplier Approach. Section 3 examines the issues that need to be addressed when calculating the cost to government, such as the valuation of capital expenditure and operation and maintenance costs. Section 4 examines the revenues received by government as a result of provisioning irrigation water. Section 5 discusses the data required to measure the costs and benefits of irrigation. It also looks at data scarcity, data collection efforts and analysis. Section 6 looks at expanding the methodology to include other elements. Further annexes provide information on defining the "full economic cost" of irrigation provisioning, and building blocks or components for measuring support to the irrigation sector that are currently excluded from the methodology.

2. METHODOLOGICAL FRAMEWORK

2.1 HISTORICAL DEVELOPMENT OF IRRIGATION SUBSIDIES AND POLICY OBJECTIVES

The nature, form and objectives of providing water subsidies differ across water-using sectors within a country and for a given water-using sector across countries. Developing countries' objectives for using irrigation subsidies could be a combination of rural development and encouraging technological adoption by resource-poor farmers, among others. Developed countries' objectives for providing irrigation subsidies may often be to increase farm incomes and rural employment, and to make their products more competitive on the international market, thereby increasing agricultural exports. The following "methodological guidance" sets out the areas relating to policy design and policy objectives to be included in the application of the methodology and development of a comparative country case study.

Methodological guidance

An outline of the historical development of irrigation, and support to the sector, should be undertaken.

An assessment of the country's policy goals as they relate to the provision of irrigation water should be undertaken with a synopsis of stated objectives provided. Irrigation sector policy design should be scrutinized and discussed. Sources of information for this discussion may include:

- **government policy statements;**
- **government websites;**
- **reports from governmental conferences or meetings; and**
- **proposed or agreed legislation.**

Researchers should flag any issues related to irrigation and water management,

2.2 INVENTORY OF PROGRAMS AND SUPPORT FOR THE IRRIGATION SECTOR

2.2.1 DEVELOPING AN INVENTORY OF PROGRAMS

Methodological guidance

In providing an inventory of the programs of support to the irrigation sector, the following steps should be carried out:

- a review of agencies responsible for water policies should be undertaken by researchers to help better identify all relevant water policies with a support element (and thus sources of data);
- an understanding of institutional arrangements and the political economy of water projects should be provided in order to better understand the support granted to the agricultural sector through water policies; and
- any programs or measures that provide support to irrigation should be described in a short narrative and costed or estimated as far as possible, with descriptions of how these estimates were derived. Where quantification is not possible, this should be clearly flagged and the elements of the support measure described.

2.2.2 DEVELOPING AN OVERVIEW OF AVAILABLE DATA

Methodological guidance

In creating an inventory of the programs for support to the irrigation sector, data should, where possible, be collected on the following topics:

- total water uses;
- share of irrigation water in water use;
- irrigated and agricultural area, broken down regionally or by crop if available;
- irrigation water application rates;
- total agricultural and irrigation groundwater use or abstractions;
- groundwater abstractions related to recharge rates, particularly at a local, basin, aquifer or regional level where there are problems of over-abstraction or other environmental issues;
- prices, charges, fees, etc. for irrigation water and other water uses. Specify any detail, for example, where irrigation water may not be available during times of water shortage and whether prices for water of similar quality and characteristics are available or could be calculated;
- the reliability and nature of services should be assessed, that is, within an adopted scheme, is water supply insufficient for the total scheme as it is constructed?

Continued

- the quality of the irrigation water should be assessed against factors such as salinity, biological and chemical content; and
- it should be specified whether water-use data are in terms of total use or consumptive use, given the differences between some countries in reporting water use data.

Within programs, it may be that various parameters are set so that they effectively provide support for irrigation. This information could include the following:

- interest rates—for example, administered rates may be set below market rates;
- repayments may be delayed;
- discount period;
- grant programs;
- low interest loans;
- whether non-payment is enforced or penalties levied;
- capital charges[3];
- maximum payment levels;
- input subsidies—for example, diesel or electricity provided at a lower cost for agricultural or irrigation-specific uses; and
- cross-subsidization—flag where certain classes of users might be paying the costs of other users, for example from household and industrial users for farming, from rich to poor, large to small farms, etc.

Support can include payments from (any level of) government to the service provider (for example, investment subsidies), co-financing of water services or operations (operational subsidies), and direct to water users (for example, lowering prices/charges for users), as well as indirect subsidies such as cross-subsidies where one class of user pays the costs of another user (irrigators). For example, in some water projects in the Western United States, capital costs allocated to irrigation facilities can be repaid using power generation revenues, instead of through irrigation charges where the Secretary of the Interior determines that such charges would be beyond the ability of irrigators to pay (United States General Accounting Office, 2000).

An example of cross-subsidization is provided below:

> *Under the Central Valley Project Improvement Act in California operated by the United States Bureau of Reclamation, water rights are purchased from irrigation districts for, for example, environmental flows. In the Modesto Irrigation District, the first 3.5 acre/feet (A/F) of water are charged at USD 23.5 (2008),[4] with charges declining on a sliding scale above this. For environmental flows under the CVPIA, irrigation districts are paid on average USD 71 A/F (2006/07).[5] The higher prices received by the irrigation district serves to reduce the costs charges to irrigators. (United States Fish and Wildlife Service, n.d.)*

[3] For example, capital costs that are supposed to be recovered from users over a 50-year period and are subject to a low interest rate. In practice, charges have not been adjusted for inflation, i.e. they have not increased over time, so water underpricing has occurred, in that the water's true market value has not been realized. This has led to implicit subsidies to the users of irrigation water (OECD, 2002). (The example in this case is Turkey.)

[4] Information accessed on this news website on 4 November 2008 from: http://www.modbee.com/1526/story/233510.html

[5] Reference document from the US Fish and Wildlife Service – Department of the Interior Water Acquisition Summary

Sources for this information may include the government, water agencies, project-specific data, academic literature, farm organizations and donor or funding organizations. Within governments, data are often available from ministries with responsibilities for agriculture, environment or water. Regional or local governments can also provide useful data in some cases. Budget data from government Treasury Departments, as well as various other ministries, regional governments and river basin districts should be accessed if possible. While the level of subsidy can be derived from government accounts (and this information should be used to help evaluate the estimates calculated under this approach), it should be supplemented by other sources of data where possible in order to determine its accuracy. The data obtained may be used at a later date by other organizations for modelling uses.

2.3 ESTIMATING IRRIGATION SUBSIDIES

2.3.1 SELECTING A METHODOLOGY

The selection of the Net Cost to the Supplier Approach[6] for this methodological framework was based on the advantages it provided in the computation, interpretation and understanding of any final subsidy estimates. The Net Cost to the Supplier Approach is based on the well-known Net Cost to Government Approach. As some suppliers of irrigation water are private enterprises, the word "government" was replaced with "supplier." There were also a number of important data availability considerations, which had to be reconciled with the resources available to take on this type of project. The preference of this over other methods was also expressed by the participants of the Global Subsidies Initiative–International Water Management Institute workshop (Addis Ababa, March 2008), held to review the discussion paper written by Dr. Ravinder Malik.

2.3.2 NET COST TO THE SUPPLIER APPROACH

The Net Cost to the Supplier Approach is set out below:

From the perspective of the irrigation water-supplying agency – Net Cost to the Supplier Approach: An irrigation subsidy is defined as the net cost to the (government) supplier in making irrigation water available. An irrigation subsidy is conceptualized as the difference between the cost of making irrigation water available and the revenue received as payments from the beneficiaries of irrigation water.

This concept is akin to that of "losses" incurred by the irrigation authority or supplier in delivering irrigation water. There are three major issues that need to be clarified in determining the measure of "loss" or subsidy from the perspective of the supplier. The first concerns defining precisely the concept "cost" of irrigation water and identifying the relevant components that make up this cost. The second concerns identifying the users or beneficiaries of the water. The third concerns defining the "revenue" realized from the beneficiaries of this water.

The net cost to the supplier or subsidy (S) on account of making irrigation water available can be derived by deducting from the gross cost to the government (C), the revenue realized in the form of payments (R) received from the beneficiaries of this water. Thus:

$$S = C - R$$

Defining the components that build up the subsidy estimation

[6] From 1994 to Present by Water Year, accessed on 4 November 2008 from: http://www.usbr.gov/mp/cvpia/3406b3_wap/docs/latest_water_acq_sum.pdf

The Net Cost to the Supplier Approach for measuring irrigation subsidies depends upon identification and measurement of three key constituents—cost, beneficiaries and revenues. Depending upon the perspective of the analyst, the meaning and methods of measurements of the three key constituents can differ. Keeping in view the data and methodological constraints in estimating some of the costs in making irrigation water available and the revenue realized from sale of this water, the annual cost of making irrigation water available has been defined as the sum of the following costs:

The total cost to government:

- annual capital cost (interest and depreciation charges) of irrigation infrastructure;
- O&M costs;
- opportunity cost of electricity used for irrigation pumping; and
- cost of environmental externalities (insofar as they can be quantified and attributed to government expenditure).

The total revenue to the government from investments made in the provisioning of irrigation water[7] comprises:

- revenue realized on sales of water;
- revenue realized from the sale of hydropower;
- revenue realized from the sale of fishing rights;
- revenue realized from the sale of electricity to the agricultural sector for irrigation pumping; and
- revenue from the imposition of pollution taxes, insofar as they relate to the provision and use of irrigation water.

The estimation of each of these components of costs and revenues is in itself a complex process. The paper describes in detail the methods that can be employed to deal with some of these complexities and the approach that can be used to quantify various costs and revenues.

The three key constituents—cost, beneficiaries and revenue—on which this approach is based need to be clearly defined, identified and understood. To avoid analysts interpreting these three terms differently, and the generation of subsidy estimates varying over a wide range, the following sections attempt to define these three key components.

2.3.3 THE SUBSTANCE OF THE SERVICE

In defining the water service provided, a number of issues need to be addressed and clarified. The supply pattern of water provided will generally be from government providers, but will include those organizations that are not government owned, or are partially state-owned public utilities and collectives filling the role normally filled by the government as a provider of water to the agricultural sector. The service provided may not include flood control, waterlogging prevention or drainage, but only essential issues relating to the provision of water for agricultural purposes. The administration services measured should pertain to services linked directly irrigation, as opposed to other functions relating to the provisioning of water for commercial or city

[7] In Section 3, several approaches for separating out the non-irrigation components of water projects are presented in order to capture the revenue derived specifically from irrigation.

use. In terms of upstream and downstream services, upstream services should include dams or canal infrastructure, which provides water in the support of irrigation services.

2.3.4 TIME PERIOD UNDER ANALYSIS

In determining the extent of irrigation subsidies for a given country, the time period under analysis when assessing capital expenditure is 1 January 1958 to 31 December 2007. For capital projects, those that were started after that date shall also be included in the methodology.

For all other costs and revenue, data is sought for the calendar years 2000 to 2008.

3. COST COMPONENT

3.1 COST OF WATER PROVISION

The methodology at this point in time is designed to measure the full supply cost.[8] The cost of making irrigation water available under the full supply cost is equated with the financial costs associated with the provision of water. The financial costs have been set out in Section 2.3.2. Attempting to equate the cost of irrigation water with the financial cost of making this water available implicitly assumes that water is a free gift of nature, it is available in abundance and there are no competing uses for it. Also, its use for irrigation causes 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).

This initiative recognizes the value in assessing the other two costs (full economic and social costs), but due to constraints involving resources, availability of data and flanking methodologies, a measurement of these costs is not attempted (a fuller description of these costs are contained in Annex 1). The full supply cost is outlined as follows:

Methodological guidance

Full supply cost

The full supply cost includes the costs associated with the supply of irrigation 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: capital charges and O&M costs.

Capital Charges: Includes capital costs of new projects, as well as the upgrading or expansion of existing facilities. More formally, new investment is defined as that which improves collective infrastructure, that is, new infrastructure or upgrading the capacity or capability of infrastructure, for example, increasing the height of a dam to increase a reservoir's supply capacity. These include capital consumption (depreciation charges) and interest costs associated with reservoirs, treatment plants, and conveyance and distribution systems, spread over the normal lifetime of the facility.

O&M Costs: These costs are associated with the daily running of the supply system and maintaining them in good working order until the end of their useful working life. Typical costs include: purchased raw water; electricity for pumping; labour; repair materials; and input cost for managing and operating storage, distribution and treatment plants, including the administrative costs related to water resource management. Examples of operational costs include: monitoring river flows; preparing annual operating plans; co-ordinating operations with other organizations; environmental compliance activities; and administering contracts and legal issues. Examples of maintenance

Continued

[8] Rogers, Bhatia and Huber (1998) distinguish three cost concepts—the full supply cost, the full economic cost and the full (social) cost. The full economic cost of water is the sum of the full supply cost as described below, 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. The social cost of water supply is not just the cost of the goods and services that are required 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 up to a level that is considered sufficient for long-term sustainability (Massaruto, 2002).

costs include: replacement of equipment; adding to facilities; and testing and inspecting equipment and facilities. It should be noted that maintenance costs typically rise over the life cycle of a project (United States Government Accountability Office, 1999).

There are also other costs that can be measured, including:

Cost of Supplying Discounted Electricity: This can be calculated as the market rate minus the rate charged to farmers.

Cost of Environmental Externalities: This is calculated as the identifiable costs from government expenditure.

3.1.1 VALUATION OF CAPITAL EXPENDITURE OF IRRIGATION INFRASTRUCTURE

Construction of water resource projects is an ongoing process, with the majority of projects constructed decades ago still in service. The capital invested in these projects can still yield benefits by providing water. Also, the water that is currently being provided by these water resource structures cannot be attributed to the current capital expenditure alone. Researchers must take into account the capital invested at different points of time in the past several decades to calculate a capital base. This will form the basis for estimating the annual cost of capital—interest and depreciation. The following outlines the method by which the capital base should be brought to a current value.

Methodological guidance

The attributable annual cost of capital invested in irrigation infrastructure comprises two components: the annual interest cost and the annual depreciation. In determining the "capital base," this methodology adopts a procedure for its determination that should form the basis for determining the annualized capital cost vis-à-vis the depreciation and interest cost.

Current value—that is, the value of all assets constructed in the past measured at current prices—is computed by multiplying the value of the asset at historical value by an inflation index.

A method based on current value raises the question of an appropriate inflation index to compound the historical value of assets to their current prices. The methodology addresses this issue later in the paper. The current value method does not, however, take into account technical progress over time: with improvement in technology, a similar irrigation system might actually cost much less to build today than it would have 20 or 30 years ago.

The discount rates, depreciation rates, etc., used by government agencies should be reviewed. They may hide a hidden transfer to irrigators by understating various metrics. For example, in Spain, a discount rate of 0 per cent is applied on some projects (reducing the capital to be paid back by beneficiaries). Presenting the assumptions behind capital charges to users could also help define a standard set of variables (for example, project life, discount rates, etc.), which could help researchers and analyst's understand the economic principles underlying the financing of projects.

The source of financing for capital investments is not relevant, as this exercise is assessing subsidies for irrigation. Both debt and budget financing of projects can involve subsidies. In practice, the issue is whether irrigators are paying the cost of capital, not how the initial investment is financed.

TREATMENT OF THE COSTS OF INCOMPLETE PROJECTS

There are always investments in the construction of new projects or the rehabilitation of existing ones. Given the nature of irrigation projects, especially medium and large projects, construction may be spread over a long period of time. In industrial projects, there tends to be a clear concept of commencement of commercial operations, while in the case of irrigation projects, because of their special nature, such a clear-cut concept is difficult to apply. It would therefore support the principle that investments in projects that have been completed and commissioned should enter into calculations for determining the capital base of investments in irrigation (Vaidyanathan, 1992). The use of any arbitrary factor or rule to account for partially completed or ongoing projects being constructed may not be desirable and could be subject to criticism.

Methodological guidance

In order to calculate the current capital base, an inventory of capital investment in irrigation facilities and assets should be constructed, including the date construction started and was completed for the facility, and ideally its expected lifespan. This audit of past expenditures needs to be converted to current prices. The information is required for calculating the annual capital cost of expenditure, explained later in the section entitled "Calculating annualized capital costs."

3.1.1.1 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, simultaneously providing some or all of the following services: irrigation water; municipal water supply; flood protection; hydroelectric power; recreation; navigation; fisheries and so forth. While some of these demands are competitive (such as agricultural and industrial consumption), others are complementary.[9] It is easier to apportion costs of new capital projects, as opposed to older projects, to different users. New capital investments typically specify who the beneficiaries are, which should provide a key to estimating water allocation for the agricultural sector.

Methodological guidance

When incorporating the allocation figures provided by government or other official sources, researchers should, where possible, undertake an independent assessment of the allocation breakdown provided, setting out the logic for their conclusion. In practice, this may be skewed by political or other factors, for example, by boosting the costs allocated to environmental flows or other non-agricultural uses. In this case, and where this information is not available, a judgment will need to be made on apportioning capital costs. Again, assumptions should be clearly specified. Researchers should provide information on the political economy of a project or institutional

Continued

[9] For example, in some cases, releases for agriculture can be passed through turbines to generate power and be used by ships for navigation without detriment to other consumers (Perry, 1986).

background to ensure that the allocation provided was accurate. Attention should be paid to whether planned beneficiaries and actual beneficiaries are in fact the same.[10]

When measuring the subsidy value in relation to cost recovery policies for an individual irrigation project, it is recommended to:

- **Either accept a proportion of capital costs allocated to "public goods" or make an alternative estimate;**
- **Estimate economically rational distribution of remaining costs among different uses (for example, hydroelectricity, flood control, environmental flows) and classes of water users, and contrast with actual allocation to estimate cross-subsidies; and**
- **Apply an alternative cost-recovery model and compare with actual to measure shortfall in recovered costs attributable to irrigation.**

Before discussing the two methods used for determining the allocation of capital costs, some of the relevant terms used in these allocation methods are discussed below.

Benefits: Quantifiable gains resulting from the use of the facilities.

Investment costs: Cost of all inputs required to construct the facilities.

O&M costs: Costs to operate and maintain the facilities.

Separable costs: The combination of specific single-purpose costs and imputed single-purpose costs.

Specific single-purpose costs: The cost of a part of the facility that functions exclusively for a single service function, but is not an integral part of the common works of the facility, for example, a power plant that is specifically separable from other integrated infrastructure, such as a dam. Removal of that part of the facility would not impact the cost of or service from any other component of the facility.

Imputed single-purpose costs: The cost of a feature that is an integral part of the common works. A hydro power penstock that is built into the dam is an example. It is integrated into the dam, but it serves only the power purpose. Such a cost can be separated from the dam, but in so doing, the cost of the dam itself would be changed. Such costs can be separated by comparing the cost of the dam without penstocks with the cost of the dam with penstocks. The difference in the cost of the dam with penstocks and the dam without penstocks is the imputed separable cost that is assignable to the hydro-energy function. This requires a major effort in engineering design, which is normally conducted during the planning stage prior to construction.

Joint costs: The joint cost is the cost remaining after subtracting all separable costs from the total cost of the facility.

Single-purpose alternative costs: The cost of the most likely alternative way of providing the same level of benefits of a single-purpose facility if the proposed (existing in this case) multi-purpose facility were not built. An example would be the cost of the most likely way the same level of power benefits could be provided if the multi-purpose facility being evaluated were not built.

The two main methods are: (1) alternative justifiable expenditures (AJEs); and (2) separate costs, remaining benefits (SCRB) methods (Easter and Liu, 2003; Young, et al. 1982; Young, 1985). These methods are explained

[10] For example if the capital cost allocation to one set of beneficiaries appears, in the opinion of the researchers, to be disproportionate, then this should be clearly set out and an alternative set of criteria (for example, volumetric flows) could be applied.

in the following sections, and guidance is provided to researchers on the circumstances in which they are best applied. Researchers should provide to the extent possible the reasons for their selection of approach.

ALTERNATIVE JUSTIFIABLE EXPENDITURES (AJES)

The AJE method allocates joint costs based on remaining benefits after subtracting specific costs, where specific costs refer to costs directly attributable to a single purpose (for example, irrigation) and exclude the costs of a change in project design due to the inclusion of a particular purpose.

AJE is easier to calculate than the second approach included in the methodology, the separate costs, remaining benefits approach (SCRB), because it relies on specific costs rather than separable costs (Easter and Liu, 2003). To elaborate, specific costs in multi-purpose projects are the project components and costs that are specific to only one purpose, such as the cost of a pipeline to deliver water to a city. Separable costs in multi-purpose projects are the extra costs that are incurred when an additional purpose is added to a multi-purpose project. If irrigation is added as a project purpose, the separable costs would be the cost of the irrigation canals plus the costs of increasing the reservoir capacity. The latter cost is not a specific cost, but it is separable in that the reservoir would be smaller without the irrigation purpose. The separable costs are calculated by comparing project costs with and without each purpose separately. The steps involved in joint cost allocation are outlined as follows:

Methodological guidance

The steps involved in the AJE method, are as follows:

1. **Derive the benefits for each purpose served by the facility (hydropower, irrigation, flood control, etc.).**
2. **Derive the alternative costs of single-purpose projects for each purpose served that would yield the same level of benefits as the multi-purpose facility would provide for each of those purposes.**
3. **Identify the specific costs.**
4. **Deduct the specific costs for each purpose from either the benefits or the alternative single-purpose costs, whichever is less, to determine the remaining justifiable expenditure for each purpose.**
5. **Deduct the separable costs (sum of all specific and imputed separable costs) from the cost of the total facility to determine remaining joint costs.**
6. **Allocate the remaining joint costs to the purposes served in proportion to the remaining justifiable expenditures derived in step 4.**
7. **Sum the specific costs and allocated remaining joint costs to get the total allocated costs for each purpose served.**

SEPARATE COSTS, REMAINING BENEFITS (SCRB)

The SCRB approach assigns costs that serve a "single" purpose to the benefiting purpose, including the costs of any project design changes, which are required to include the added purpose. The remaining "joint" costs are assigned in proportion to the remaining benefits derived for each type of use after subtracting the separable costs (Perry, 1986). The approach explicitly deals with competing and complementary demands; and it is transparent, allowing beneficiary groups to understand the underlying assumptions and the derivation of the assigned cost.

Methodological guidance

The methodology recommends that the SCRB approach be adopted in a planning context, where investments are yet to take place, and options exist to change the configuration of the investment and hence the groups, sectors and areas to be benefited. It should be noted that for some projects, beneficiaries may have changed between the planning stage and the actual implementation phase. The application of SCRB to a system that has been in place for many years introduces a number of difficulties. The approach, for example, allows no cost allocation to any user in excess of the cost of the alternative minimum cost solution. In addition, the linkage of cost allocations to benefits derived makes the result sensitive to the time at which the analysis was done.

Between the various methods discussed above, it is necessary to choose rationally the most appropriate method. Apart from some of the considerations discussed above, the choice of the method should take into consideration the simplicity in terms of its practical applicability and computational and informational demands.

3.1.1.2 BRINGING CAPITAL COSTS TO A CURRENT VALUE: AN APPROPRIATE INFLATION INDEX

Due to inflation and other factors, the value of capital invested 20 years ago is not the same as that invested today. It is therefore important to bring the capital invested during different years to some common denominator.

Methodological guidance

Based on ICID guidelines for evaluating the full economic costs of irrigation, presented by Rieu and Gleyses (2003), bringing the capital costs incurred on different projects over a period of time to current-value terms requires data and information from Public Works Indices (PWI), taking into account inflation and allowing for an estimation of the current value of infrastructure assets. In the absence of any specific price index for irrigation assets, the general practice has been for analysts to use either the general price index or some sectoral price index.

3.1.1.3 CAPITAL COST DETERMINATION

Accounting for the interest on capital invested

Funds for most irrigation projects have been, 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. These loans or bonds issued by the state to raise money in most cases were not specifically meant for the purpose of irrigation, but formed a general pool of state borrowing. Such 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. Some of the lending from these international donor and lending institutions is provided in the form of grants, however 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 that are generally much lower than those of commercial financial institutions. The following sets out the approach adopted by the methodology in determining an appropriate interest rate.

Methodological guidance

Due to complexities relating to the different timeframes during which such funds are raised, the basket of sources which constitute these funds, the length of time for which the funds are raised and the differential interest rates at which the funds are borrowed at different times, it is difficult to assign a unique interest rate that could be used to evaluate the cost of borrowing. Taking into account the specific but complicated traits of financing of irrigation infrastructure, the preferred approach is to assess interest costs uniformly on a middle-of-the-road basis, such as the average interest rate paid on the outstanding public debt by the state or the average yield on a Negotiable Certificate of Deposit.

Capitalization of interest paid during construction

In determining the capital base, the treatment of interest paid on capital during the construction phase of the project needs to be addressed. The following sets out the approach adopted by the methodology in estimating the capitalization of interest during the construction of an irrigation infrastructure project.

Methodological guidance

To the extent access to data is available, and the resources researchers have available to estimate some of these costs, interest paid during construction, given the opportunity costs associated with its allocation need to be determined. If, however, reliable information on some of these aspects is not available and or cannot be accounted for, it is best to ignore these components.

Calculating annualized capital costs

Having discussed in Section 3.1.1 the modalities for estimating the capital base to be used as the basis for the computation of the annual cost of capital invested, the methodology now describes the process for estimating the annual cost of capital (annualized capital comprises depreciation and interest costs). Depreciation can be defined as the annualized cost of replacing existing assets in the future.

The first issue the methodology deals with is:

• Estimation of depreciation

Estimating rates of depreciation requires estimating the value of existing assets and making suitable assumptions about the length or life of the project and the method and rate of depreciation.

Methodological guidance

The historical value of assets (i.e., the price at which they were originally purchased) may be an unrealistic assumption for valuation, for example, due to inflation. Given that technical progress in water provision is less dynamic than a sector such as IT, using the current value of existing capital assets might be a suitable assumption and is typically the most straightforward to calculate. Where the calculation of depreciation based on current values does not apply, and data is available to create estimates, then the present value of an asset could be derived from the cost of replacing it to an identical service level.

• Life of the irrigation project

Estimating depreciation rates as part of determining the capital base of an irrigation sector depends on the life of the project. Factors associated with the design and the construction of a project affects its life. Others factors include: the level of attention paid to issues such as sedimentation; the quality, adequacy and regularity of maintenance; the extent of rehabilitation and restoration works undertaken; and so forth. 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. The following sets out the approach adopted by the methodology in determining the life of an irrigation project.

Methodological guidance

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, it is difficult to assume a common length of life for all irrigation projects for the purpose of calculating depreciation. Based on these considerations, the methodology recommends using an average service life of 50 years for medium-to-large irrigation projects (though that timeframe is admittedly subjective and arbitrary). This timeframe is on the conservative side but may not call for any substantial revision since maintenance costs may increase substantially after some time.

• Method and rate of depreciation

Depreciation is an important concept in the long-term management of assets, addressing the issue of asset replacement at the end of an asset's service life. 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. The following sets out the approach adopted by the methodology in measuring the rate of depreciation.

Methodological guidance

The straight-line method, which suggests the use of linear depreciation following the service life of the asset, should generally be used to evaluate depreciation. Adopting 50 years as the useful life of a project gives an annual depreciation of two per cent. Depreciation calculated in this way is obviously sensitive to the life cycle assigned to the project.

The following is an example of calculating capital costs, taken from Rieu (as cited in WATECO, 2003). The water infrastructure had been built up from 1977 to 2000, funded by the government. In order to calculate annual capital costs, the life of different assets was estimated, ranging from 10 to 100 years. Annual capital costs were based on this schedule and a discount rate of 3 per cent was assumed.

3.1.1.4 OVER-CAPITALIZATION OF PROJECTS

Actual costs tend to be inflated by a variety of factors such as time and cost overruns, defects in project design, deficiencies in management, waste and leakage. The extent of this over-capitalization could be 50 per cent or more of the efficient cost of construction. Strictly speaking, while it would be proper to adjust for these cost overruns when determining the capital base for calculating annualized costs, in the absence of any objective criteria for quantifying the magnitude of over-capitalization due to these factors, and to avoid any arbitrariness in adjusting these costs to some measure of a fair cost, it would be reasonable not to attempt any adjustment on this account (Vaidyanathan, 1992).

3.1.2 OPERATION AND MAINTENANCE COSTS

Operation costs refer to the costs associated with the operation of an irrigation 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 underwater, it may be difficult for researchers 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. The following sets out the approach adopted by the methodology in measuring O&M costs.

Operation and maintenance (O&M) costs are those connected with running water and irrigation systems and keeping them working. This can be viewed as the cost of the activities involved in ensuring a water service is provided, including the costs of power, materials, spares, labour and other inputs that are involved.

Methodological guidance

Calculating O&M costs

O&M costs are based on the running costs entered in the project accounts for any given reference year only. Operation and maintenance (O&M) costs are those connected with running water and irrigation systems and keeping them working.

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 is of crucial importance in irrigation (Tiercelin, 1998). The lack of data often hampers estimation of these costs. A complicating factor in obtaining the proper disaggregated records and their evaluation is if the responsibilities are being shared by more than one agency, such as public-sector agencies and Water Users Associations (WUAs), as the record-keeping of the latter may not be adequate. Researchers should obtain information from all relevant organizations holding records on O&M costs, and undertake an analysis to ensure there is no double counting; a general assessment of the records accuracy should be provided. While some countries keep separate accounts for O&M, often the two are put together as O&M costs in public-accounting systems. Researchers should assess government accounts in order to determine O&M costs.

Shortfalls from full-cost recovery of O&M expenses should be considered subsidies to irrigation. Where a government transfer, budget or action is involved in covering part of the costs of O&M, this should be classified as a subsidy.

O&M can also be taken to include renewals costs. These are the costs of renewing, replacing, or refurbishing existing (collectively called renewals in this section) infrastructure or operations. While this can also be considered capital expenditure, it is, in practice, part of the costs of operating and maintaining a water system. Examples include replacing pumps or relining irrigation canals. Renewals expenditure tends to be higher where maintenance has been neglected, and some capital expenditures may effectively be for renewals. In practice, renewals and new investments may be difficult to separate. If data is available, it can be separated out and measured as either capital expenditure or O&M based on the judgment of the researcher. Assumptions should be clearly set out. Accounting for infrastructure renewals (for example, upgrading infrastructure) can be measured from government transfers required to cover any shortfall in the recovery of costs from beneficiaries.

This quantifiable aspect of the methodology would also include expenditures on renewal of (existing) investments, for example, upgrading earth irrigation channels by lining them with concrete. Accounting for infrastructure renewals (for example, upgrading infrastructure) may still be problematic, requiring estimates of the level of charges required to cover the work. It is necessary to seek information on whether the full costs are recovered and the extent of any shortfall with clear definitions and explanation of how full costs and their recovery have been estimated.

By focusing on government budget transfers, it is possible to avoid having to make difficult estimations as to, for example, whether user charges cover costs or any estimates of asset value or depreciation.

Continued

Administration costs

Researchers should state the components O&M costs that they have measured. The costs of managing water administration, basin management or other similar costs may be substantial in some countries. These costs, where they are funded by governments and not water users, should be evaluated to ensure they constitute support. These costs also relate to the costs of regulating the water service, for example, through a water abstraction licensing system. They would include the salaries of government staff working in this sector. Any activities that researchers are aware of that might be considered part of O&M activities, while depending on the methodological perspective used, should be clearly indicated as either having been included or excluded, as part of any subsidy calculation. This may include certain prevailing practices implying no financial transaction (for example, cleaning or clearing of canals by farmers themselves). Such maintenance issues become crucial, as 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.

O&M includes the management and administration costs of providing the irrigation service, for example, this includes the costs of government water management boards. Where the costs of these organizations are not paid by the users but by the government, that should be counted as a subsidy. Contexts where one class of user, typically households or industry, pay a higher share of costs than irrigators (cross-subsidization), this should also be considered a subsidy, though in practice this may be difficult to reliably measure. Experience in Australia suggests that administration costs can be significant.

3.1.3 COST OF PROVIDING IRRIGATION WATER THROUGH GROUNDWATER-BASED SYSTEMS

Large-surface water-based irrigation water systems and small groundwater-based irrigation systems are fundamentally different in respect to the size of the area they command, the pattern of ownership and operation, number of users of water, and the capital and operating costs of the systems. While surface-water-based irrigation systems are generally owned, and frequently operated and maintained, by public agencies, most groundwater-based irrigation systems—based on extraction of water through open wells, dug wells or tube wells—are owned, operated and maintained by individual farmers or an irrigation cooperative. Another important distinctive feature of groundwater-based systems is that they are single-purpose systems; in contrast, surface-water-based systems are more often multi-purpose in nature, thus creating the need for devising procedures for allocating joint costs.

In the context of comparing the cost of provisioning irrigation water from large surface-water-based systems and small groundwater-based systems, the important differences are in the case of large surface-water systems the capital costs are generally incurred by public agencies (generally governments) who also own the system, while the O&M costs are either borne fully by these agencies themselves or are partly shared with the water users. Since the costs are incurred by public agencies, these are required to be recovered from the users of the water. In the case of groundwater-based systems the capital costs are incurred by individuals who also own the system with the maintenance costs also borne by the owner-operator. The government often does not provide any upfront subsidy towards the installation cost of tube wells. Unlike surface-water systems, where there are a number of users from whom the capital and operating costs are recovered, in the case of groundwater systems there is often only one user, who is also the owner.

While the capital and maintenance costs of tube wells are typically self-supported by the farmers, the electricity required to operate these wells needs to be purchased. Most of these electricity suppliers, until recently, were owned and operated by governments or their agencies, with the governments setting tariffs below market rates. In the case of such groundwater-based systems, the cost to the government of making irrigation water includes the cost of electricity for pumping irrigation water. The unregulated supply of groundwater to the owner and operators of tube wells also infers many costs and benefits that are not calculated in this study. Just a few include the opportunity costs of water supply, environmental externalities and identifying a fair natural resource cost for supplying water.

Methodological guidance

Researchers should examine programs that provide:

- **any low interest loans to help set up bore wells;**
- **any grants to help purchase pumps or related equipment; and**
- **any subsidies, even nationwide ones, relating to the supply of discounted diesel (below the market rate) for irrigation water pumping.**

3.1.4 COST OF SUPPLYING DISCOUNTED ELECTRICITY

The electricity required to operate bore wells needs to be purchased. Most of these electricity suppliers, until recently, were owned and operated by governments or their agencies, with the governments setting tariffs below market rates. In the case of such groundwater-based systems, the cost to the government of making irrigation water includes the cost of electricity for pumping irrigation water. The unregulated supply of groundwater to the owner and operators of tube wells also infers many costs and benefits that are not calculated in this study. Just a few include the opportunity costs of water supply, environmental externalities, and identifying a fair natural resource cost for supplying water (OECD, 2002). This methodology will initially look at measuring the cost of supplying electricity as the difference in preferential rates offered to farmers, that is, using a price gap approach. The following sets out the approach adopted by the methodology in measuring the subsidy provided in supplying discounted electricity.[11]

Methodological guidance

Cost of supplying electricity below the market rate is defined as:

Market or commercial rate for supplying electricity normally minus the preferential rate charged to farmers—equalling the subsidy provided to the irrigation sector.

For example, in parts of California, agricultural contractors (irrigators) can purchase some electricity at a price of US$10 per megawatt hour (MWh), while the State of California purchases electricity on long-term contracts at a rate of US$78/MWh (National Resources Defense Council, 2004).

[11] The electricity used in a low-productivity agricultural sector has a huge opportunity cost in terms of the value of production lost in more productive sectors. In those economies where electricity needs for irrigation pumping are significant, such a prioritization of electricity for irrigation over industry is bound to have significant opportunity costs.

3.1.5 COST OF ENVIRONMENTAL EXTERNALITIES

The cost of environmental externalities represents the costs of damage or the loss of welfare that irrigation water services and their use impose on the environment and ecosystems and those who use the environment (it is important to distinguish general taxes from those used to correct for externalities). While some of these costs might be directly water-related, others may be indirectly related to water or even non-water-related (such as effects on soil or air). This loss in welfare may consider lost production or consumption opportunities as well as other, non-use values, which are difficult to quantify but nonetheless correspond to real costs for society. The following sets out the approach adopted by the methodology in measuring the cost of environmental externalities.

Methodological guidance

In attempting to measure these externalities, this methodology assesses the identifiable economic costs of prevention or mitigation. The costs of measures needed to prevent and mitigate damage to the environment and to maintain defined indicators of environmental health can be approximated to indicate what society should be willing to pay to avoid the environmental damage. Because of the difficulties associated with the availability of appropriate data coupled with the methodological problems of valuing environmental costs, the methodology incorporates those identifiable costs from government expenditure, which can include, for example:

- **surcharges linked to the cost of restoring saline water to its original condition; and**
- **where return flows from towns impose costs on downstream users. One approach involves the levy of a charge on urban consumers for restoring the wastewater to an acceptable condition.**

Government often makes some contribution towards private cost in the form of a subsidy to promote the supply of soil amendments such as gypsum or other inputs to deal with saline soils. The boundaries of government externalities can include increased costs of treating household water on account of reducing the nitrate count (but only if government has paid for the cost of treating the water—if it was all paid for privately by the households then there was no government externality). It is very difficult to produce estimates for this area; the methodology at this stage seeks to address key government on-budget externalities.

Where satisfactory monetary valuation of environmental externalities is not possible because of data deficiencies, researchers have often tried to identify and describe the effects in qualitative terms or in some other form of quantitative measure, such as the amount of land affected or abandoned as a result of irrigation. This information is not that useful for assessing the cost of environmental externalities associated with irrigation. This should not distract from the urgent need to collect data on these aspects (though undertaking new studies to collect such data is complex, time consuming and expensive). Until the time such detailed data become available, it would be useful if some of the environmental costs of water services could be estimated by drawing on the existing data, bearing in mind the need to exercise caution to clearly set out all the assumptions used in the analysis, the limitations and the uncertainties associated with such estimation.

4. GOVERNMENT OR SUPPLIER REVENUE COMPONENT

Revenue 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. It is recognized that while farmers may be the primary beneficiaries of irrigation water, they cannot be regarded as the sole beneficiaries. Comparisons of the economic activity in a region before and after the availability of irrigation show that the benefits of growth as a result of the availability of irrigation water are reaped not only by multiple sections of the rural population—both farm and non-farm—but often by residents of urban areas as well (Marts, 1956). It is recognized that there are problems associated with the quantification of benefits accruing to directly and indirectly benefited sectors, consequently the methodology incorporates the sources of revenue for the government or supplier from those directly benefited. Those components are now discussed in the following sections.

4.1 SOURCES OF REVENUE TO THE GOVERNMENT-SUPPLIER FOR PROVIDING IRRIGATED WATER

4.1.1 REVENUE REALIZED ON SALES OF WATER

Cost recovery for irrigation involves money recovered from farmers who are the primary beneficiaries of irrigation water. This form of irrigation charges is treated as revenue realized by the government or supplier as a result of making irrigation water available. The amount of irrigation charges recovered depends upon the price of water, the tariff regime and the efficiency of the water-supplying agency in collecting fees from users.[12] Apart from revenue realized in the form of water tariffs, the government or supplier occasionally also collects from users of irrigation water a fee in the form of a betterment levy (the incremental portion of land taxes attributable to irrigation investments). Additionally, in those countries or locations where the government may impose groundwater user charges, these charges would also add up to the cost of making irrigation water available through groundwater extraction. The calculations of such user charges links into resource scarcity costs, which are very difficult to estimate. In assessing such information, researchers may wish to examine the extent that these catchments are potentially over-licensed or over-abstracted, how licences have been allocated (e.g., on a first come, first served basis or auctioned) and whether there is a trading system and, if so, the extent of trades.

4.1.2 REVENUE REALIZED FROM THE SALE OF HYDRO POWER

Irrigation projects may provide opportunities for generating hydroelectric power, a non-consumptive use of water. In locations where the gradient and quantity of water available is conducive, canal drops can often be used for hydroelectric plants. The economics of hydroelectric power generation depend upon the prevailing water and power availability policies, and the priorities given to the use of water between the two purposes.

[12] There are generally three alternative tariff regimes used in the irrigation sector: volumetric pricing methods, non-volumetric pricing methods and market-based methods. Area-based tariffs, one of the forms of non-volumetric methods of charging, are the most commonly employed tariff regime in developing countries.

Because the output of a hydroelectric power plant can be varied quickly in response to changing demand, it often commands a premium price.[13] Any income generated for government through the sale of hydroelectricity should be counted as revenue.

4.1.3 REVENUE REALIZED FROM THE SALE OF FISHING RIGHTS

Irrigation systems—which consist of dams, reservoirs, main irrigation canals and their distributaries' water bodies formed by seepage, drainage canals and often drainage water storage—offer a diversity of water bodies for fish production.[14] Among these water bodies, usually only dams and reservoirs are used for fish production (FAO, 2001). There is no organized, effective data collection system that could assist in determining factors contributing to sustainable use of irrigation systems for fisheries or the quantity of fish caught in these water bodies. The fishing rights for each compartment are annually auctioned by the respective agency owning and maintaining the system. The following sets out the approach adopted by the methodology in measuring revenue realized from the sale of fishing rights.

Methodological guidance

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. Also, the sale of fishing rights should be calculated and recorded as government revenue.

4.1.4 REVENUE REALIZED ON ACCOUNT OF THE SALE OF ELECTRICITY FOR IRRIGATION PUMPING

Four alternative regimes of electricity pricing for irrigation pumping are generally practiced in most of the developing and developed countries. One of the systems—is the flat rates (FR) system under which a pump owner is charged at a flat monthly rate per horsepower of the pump or a graduated flat rate according to the horsepower of the pump; in either case, rates are regardless of actual power use. In this method, the marginal cost of pumping more water is zero; the farmer has no incentive to conserve water, and may even pump water surplus to his own needs in order to sell it to other farmers.

Another pricing system charges the farmer per kilowatt-hour of power consumed on the basis of metered consumption of electricity. This may be a constant rate irrespective of the amount of electricity consumed or may vary according to the amount utilized (a block-rate tariff). Another regime, a two-part tariff system, is a mixture of the metered and fixed-rate tariff systems wherein users are charged a fixed amount based on the horsepower of the pump and a variable amount based on actual metered consumption. While farmers in some

[13] If a hydro-power plant is owned by a private entity, the revenue to the government based on the use of irrigation water for the generation of electricity is derived on the basis of a commercial agreement entered into between the irrigation department and the generator of the hydro power, which could be a lump sum or determined on a profit-sharing basis. In the case of the hydro-power plant being owned and operated by the irrigation department of the government, which also owns and operates the irrigation infrastructure, the revenue from hydro power would depend upon the commercial net value of the power generated.

[14] Fish production in irrigation works, however, sometimes comes at the cost of opportunities available for fish production in natural water systems, systems which often are destroyed by the irrigation works.

countries still receive electricity at no charge for running irrigation pumps, the flat-rate tariff system is the most common. The following sets out the approach adopted by the methodology revenue realized from the sale of electricity for pumping.

Methodological guidance

Whatever the charging system, or the size of the tariff, the revenue realized by the government or the power utility from the farmers as a result of supplying electricity to run tube wells is to be credited as revenue realized for providing irrigation.

4.1.5 REVENUE FROM THE IMPOSITION OF POLLUTION TAXES

Pollution taxes are used as a means of addressing environmental externalities. Following the "polluter pays" principle, the externality problem can partially 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.)

Methodological guidance

Environmental costs are costs external to the water user, including pollution control costs, and the costs of damage to the environment due to water services and water uses. For example, if water abstraction causes significant damage to the environment, this should be accounted for in the price paid for a water service. An example of an internalized cost would be where a welfare loss is compensated by the water user—for example, a polluter installs pollution control measures.

5. DATA REQUIREMENTS AND SOURCES

The volume of data needed for estimating irrigation subsides, even using the Net Cost to the Supplier Approach adopted by this methodology, is significant and should not be underestimated. The first-time data requirements for estimating irrigation subsidies following the methodology proposed in this paper are enormous and it may require substantial financial and human resources to collate data from different sources and put them into a useable format. After methods for estimating various parameters in the different approaches have been standardized, data gaps filled, and first-time estimates of subsidies derived, updating historical data sets should be relatively straightforward and obtaining estimates of subsidies during later years much easier. The following is a discussion of some of the issues relating to data access, sources and availability.

Data access: An important constraint in the estimation of irrigation subsidies is the non-availability or denial of access to detailed and disaggregated data on a large number of variables. Currently, available estimates of irrigation subsidies generally do not go into detail concerning cost allocation and often treat the cost of multi-purpose projects as attributable entirely to irrigation. Obtaining the requisite data for several decades from government agencies and project authorities in such detail is not an easy task since some of the data may be classified. If not classified, government agencies may simply refuse to provide data for political or trade-related considerations. Researchers attempting to estimate irrigation subsidies will need to work closely with government agencies to obtain the appropriate data and other related information. This may only be possible if governments agree to the proposed methodology and show their commitment and interest in estimating irrigation subsidies.

Data sources: Some data (such as on financial investments, O&M costs and revenue realized) should be generally available from government agencies or ministries. Local-level data, such as those involving WUAs, might be available only from local agencies. In the case of multi-purpose projects, for the purpose of joint-capital cost allocation, such aggregate data may not generally suffice and researchers may attempt to undertake as detailed as possible on-site evaluations of existing infrastructures. Some data may reside only in the original project documents, which may or may not be obtainable from the respective water agency. For allocating O&M costs to different users of a multi-purpose project, researchers may have to get the necessary data from the project authorities and make its allocation into different components in consultation with them.

Data disaggregation: Ideally, all estimates would be built up from data at no smaller than the river-basin level. The boundaries of basins do not always correspond with the boundaries of the administrative unit (such as a district or a state) where data required for the present purpose may be available. The methodological framework may best be applied for a country-level analysis, by dividing the entire irrigation infrastructure into two parts: (1) the system of dams, storage facilities and canals (main canals, branch canals and distributaries) that capture, store and distribute water to irrigated areas (the "primary and secondary" levels); and (2) the local system of field channels carrying water to farms (the "tertiary" level) (Hussain, 2004). Given the complexities of this approach, it would seem appropriate that the geographical unit for estimation may be treated flexibly and decided upon on the basis of specific conditions prevailing in a given country, as well as the system of data reporting and availability of data required.

Transparency: All documentation and subsidy data and the methods currently being followed to estimate these subsidies by official agencies should be made publicly available.[15]

[15] This would help initiate better-informed discussion on this issue and policy decisions regarding the sector, and, in the long run, would help improve the quality and comparability of the estimates of irrigation subsidies.

6. EXPANDING THE METHODOLOGICAL FRAMEWORK

The adoption of the Net Cost to the Supplier Approach has generally be dictated by the availability of data and the ease with which estimates of various parameters can be derived. Ideally in the future, the methodology may employ the Net Cost to the Supplier Approach, running parallel to the Net Benefit to Recipient-Willingness to Pay Approach. This approach could initially be used to empirically estimate subsidies on a somewhat smaller scale (such as at the level of a province or district) to more clearly understand the complexities involved and the amount of effort required to derive these estimates. Advances have been made in terms of defining what is meant by support to water in agriculture, as well as getting data reporting in place following significant work in areas such as Australia16 and the EU. The hope is, this publicly available methodological framework may be expanded, and will evolve with more building blocks incorporated into the parameters of the analysis. In promoting the development of a methodology that is transparent, through setting out the parameters of the analysis undertaken, it is hoped the methodology will be adopted by other researchers to estimate and report irrigation subsidies. Estimates generated in a manner that is comparable across a range of developing and developed countries will then prove useful and sound when examining global trends in the support provided by different countries to irrigation. A related objective is for the results of this research to lead to the improvement in other research efforts (notably, policy modelling) and, ultimately, to improvements in both domestic policies and international trade rules.

To empirically validate the methodology suggested in this paper and to test its robustness in generating more comparable inter-country estimates of irrigation subsidies, it would be appropriate that at least two empirical case studies—one in a developing country and the other in a relatively developed country—be undertaken as part of testing the applicability of the methodology.

[16] More information on this issue can be found at the Australia: 2004 National Water Initiative website on the following: http://www.nwc.gov.au/www/html/117-national-water-initiative.asp

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APPENDIX 1. COST OF WATER PROVISIONING

Full-cost accounting versus full-cost recovery

The methodology recognizes the practical difficulties in estimating some components of the costs that make up the true cost of water provisioning, due either to methodological problems in their estimation and or the non-availability of requisite data needed for their estimation. Researchers have found it difficult to estimate either the full economic cost or full (social) cost with reasonable degree of accuracy. Thus, while not undermining the relevance and necessity of estimating the full or true cost of water provisioning as a basis for estimation of cost and subsidies, as a first approximation, the methodology does not attempt to calculate the cost components that cannot be estimated with a fair degree of accuracy. Apart from methodological and data problems mentioned above, another reason that weighs in favour of limiting consideration to full supply cost for the present purpose is the constraints that most researchers often face in terms of the availability of financial and/or time resources to undertake the research.

The methodology promotes the use of the full-cost principle as a basis for cost determination; it does not, however, promote full cost recovery. It has, for example, been argued that while full cost recovery may prove feasible in developed environments, for example in Australia (Briscoe, 1996), it may prove unrealistic in developing economies with subsistence-oriented smallholder irrigation schemes. Acknowledging that "the recovery of full cost should be the goal for all water uses," the ICID alternatively recommended that, in order to achieve sustainability, the full cost of water provision "need not necessarily be charged to the users" (Tardieu, 2005).

Full (economic) cost

The full economic cost of water is the sum of the full supply cost, 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 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 to, for example, the agricultural production in irrigated areas damaging the markets for upland non-irrigated agriculture, or forcing them to change their inputs. The standard economic approach to externalities is to define the system in such a way as to "internalize the externalities." A distinction has been made between economic and environmental externalities, realizing that in some cases it will be difficult to distinguish exactly between them. The externalities may be positive or negative, and it is important to characterize the situation in a given context, 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.

Full (social) cost

The full cost of the consumption of water is the full economic cost, given above, plus the environmental externalities. These costs have to be determined based upon the damages caused, where such data are available, or as additional costs of treatment to return the water to its original quality.

Environmental externalities: The methodology makes a distinction between economic and 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. As mentioned by Rogers, Bhatia and Huber (1998), the distinction between economic and environmental externalities is very narrow.

APPENDIX 2. COMPONENTS EXCLUDED FROM THE METHODOLOGICAL FRAMEWORK

The following topics have not been incorporated into the current methodological framework and the following is a brief discussion of some of those potential future elements.

Indirect beneficiaries: Existing methods for identifying indirect beneficiaries and estimating indirect benefits and how the total benefits of a project have been shared by different sections of the society have been quite cumbersome and lack widespread consensus. As such, it constitutes one of the most difficult problems in the economics of resource development and one of the many key issues that remain to be explored and require further methodological development. While appreciating the need to consider the benefits derived by sectors or sections of the society indirectly benefiting from the availability of irrigation water and accounting for the revenue realized from them on this account, they are excluded from the present methodological framework.

Opportunity costs: 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 (this also may be due to legal constraints as water cannot be resold). Ignoring the opportunity cost undervalues water, leads to under-investing in water conservation and causes serious misallocations of resources among users (Briscoe, 1996).

Cost of environmental externalities – positive or negative: As discussed in Briscoe (1996), some of the costs of negative environmental externalities are the costs of damage or the loss of welfare that irrigation water services and their use impose on the environment and ecosystems and those who use the environment. Positive externalities may include flood management, providing fish breeding grounds, aquifer recharge services, etc. Information on the environmental and resource costs caused by irrigation water supply and use is not systematically collected in any country, nor has the quantification or valuing of positive externalities. Very limited systematic research effort has gone into empirically quantifying the economic impacts of irrigation's environmental effects, but a number of specific incidences where researchers can try to quantify these externalities are mentioned in this paper.

THE GLOBAL SUBSIDIES INITIATIVE (GSI) OF THE INTERNATIONAL INSTITUTE FOR SUSTAINABLE DEVELOPMENT (IISD)

The International Institute for Sustainable Development (IISD) launched the Global Subsidies Initiative (GSI) in December 2005 to put a spotlight on subsidies – transfers of public money to private interests – and how they undermine efforts to put the world economy on a path toward sustainable development.

Subsidies are powerful instruments. They can play a legitimate role in securing public goods that would otherwise remain beyond reach. But they can also be easily subverted. The interests of lobbyists and the electoral ambitions of officeholders can hijack public policy. Therefore, the GSI starts from the premise that full transparency and public accountability for the stated aims of public expenditure must be the cornerstones of any subsidy program.

But the case for scrutiny goes further. Even when subsidies are legitimate instruments of public policy, their efficacy – their fitness for purpose – must still be demonstrated. All too often, the unintended and unforeseen consequences of poorly designed subsidies overwhelm the benefits claimed for these programs. Meanwhile, the citizens who foot the bills remain in the dark.

When subsidies are the principal cause of the perpetuation of a fundamentally unfair trading system, and lie at the root of serious environmental degradation, the questions have to be asked: Is this how taxpayers want their money spent? And should they, through their taxes, support such counterproductive outcomes?

Eliminating harmful subsidies would free up scarce funds to support more worthy causes. The GSI's challenge to those who advocate creating or maintaining particular subsidies is that they should be able to demonstrate that the subsidies are environmentally, socially and economically sustainable – and that they do not undermine the development chances of some of the poorest producers in the world.

To encourage this, the GSI, in cooperation with a growing international network of research and media partners, seeks to lay bare just what good or harm public subsidies are doing; to encourage public debate and awareness of the options that are available; and to help provide policy-makers with the tools they need to secure sustainable outcomes for our societies and our planet

www.globalsubsidies.org

The GSI is an initiative of the International Institute for Sustainable Development (IISD). Established in 1990, the IISD is a Canadian-based not-for-profit organization with a diverse team of more than 150 people located in more than 30 countries. The GSI is headquartered in Geneva, Switzerland and works with partners located around the world. Its principal funders have included the governments of Denmark, the Netherlands, New Zealand, Norway, Sweden and the United Kingdom. The William and Flora Hewlett Foundation have also contributed to funding GSI research and communications activities.

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