Valuation of Irrigation Water for Different Crops In the Gezira Scheme

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by

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INTRODUCTION

COSTS OF OPERATION, maintenance and development of large irrigation schemes are steadily increasing. This puts pressures on governments and aid donors to find ways and means to charge the beneficiaries with a substantial share of the costs of the services they enjoy.

The purpose of this paper is to review some general economic concepts regarding the valuation of irrigation water. Some water pricing considerations are discussed. The method of water charging used in the Gezira is then described and finally, a program aiming at the improvement of the existing water charges is proposed.

Economic Concepts and Allocative Pricing and Valuation of Irrigation Water

Efficiency objectives. The neoclassical economists have argued that the market system, under certain conditions, can efficiently allocate resources. According to the postulates of the market system, prices should be used to allocate water to its highest valued uses (where value corresponds to the Smithian value in exchange). This implies that the value (price or cost) of the last unit is the same in all uses to achieve economic efficiency. However, in real world situations the prerequisites of the market system are frequently violated -- economies of scale, decreasing average costs, mobility, solvent properties, sequential use, social values, etc. (Young and Haveman 1985: 469-71). The market failure leads to the need for collective action, in the form of public intervention. The Pareto-optimal pricing policy would use marginal cost (MC) as the price schedule (Figure 1):

$$P = MC$$

The optimal quantity to supply and consume is at q*, where marginal cost equals marginal benefit (or marginal value):

$$MC = MB$$ (Young 1986: 155-60])

Equity objectives. From a pricing perspective there are two approaches to equity:

The Benefit Approach, which considers that it is fair that the beneficiary should pay all the cost of a service, and the Ability-to-Pay Approach which on the other hand, addresses in general terms, the income distribution but violates the efficiency assumptions.

Administrative objectives. To achieve allocative efficiency and equity, through the implementation and maintenance of a pricing system, some administrative costs are incurred. Hence, care should be taken to ensure that the benefits introduced by a pricing system exceed its costs.

Slippage (corruption and administrative in efficiency) is the second concern of administrative objectives, while administrative complexity is the third one.

Achievement of multi-objectives. Conflict between objectives in water resources management confronts those involved in irrigation development with some difficulties. Nevertheless, the problem of multi-objectives can be solved by the use of multiple policy instruments where there are at least as many instruments as objectives (Bowen and Young 1983:5). Policy instruments are prices (including alternative rate structures), quotas, permits and transferability in water rights. In an interdisciplinary approach other institutional and structural instruments can also be used.

A unified approach is usually suggested to draw the framework for valuation of irrigation water. If the curve MB in Figure 1 represents the marginal benefit or demand for water reflecting marginal willingness to pay (with shadow prices as points along it) and the curve MC represents the opportunity cost of the incremental water supply (willingness to pay for foregone opportunities), Pareto-optimality will be achieved at point q, where, P = MB = MC. The rate setting (P^1) is left to the political decision maker on condition that it shall not exceed the maximum willingness to pay. Allocative efficiency losses are incurred to the degree that p^1 differs from MC (Young 1986:156-62). Non-price retiming (i.e., quotas) will be needed to distribute the limited water supply in the months with the highest water values.

Other Water Pricing Considerations

There are other considerations which affect the water pricing system.

Estimation of shadow prices. The classical method is the use of production functions in which irrigation water is the explanatory variable. The value marginal product of water (the derived demand function) represents the shadow price of water.

Residual Imputation - the essence of the method is to allocate the total value product (TVP) among all resources used in production. If all inputs but one can be assigned their appropriate prices, the remainder of the TVP is imputed to the residual resource.

Linear Programming Procedures - are mathematical approximations of the residual imputation, where the value of water is derived as a benefit function using parametric variation of the water supply.

Rate setting. Different rate-setting principles are used or proposed to satisfy one of the major objectives.

Marginal Cost Pricing Principle - is applied where allocative efficiency is the primary concern.

Ability-to-Pay Principle - emphasizes the equity objective. Only operating costs plus a small fraction of the initial investment are usually recovered.

Net Benefit Principle is a rent aiming at capturing all or part of the incremental benefits of irrigation.

Average Cost Principle is used when cost recovery is the main objective. It charges each unit received according to an average cost.

Charging Vehicles and Structures

As stated earlier, no one instrument can achieve multi-objectives simultaneously. Nevertheless, the use of alternative rate structures helps to realize as much of the objectives as anticipated. The more common charging vehicles are given below.

Volumetric charges. Though rarely adopted in developing countries the vehicle of volumetric charges "has been used extensively and successfully in the USA and Australia" (Carruthers and Clark 1981: 191). Water is also volumetrically delivered and charged to cooperatives in Israel and Taiwan which, in turn, allocate it to small holdings. Beside being the most precise method of assessing the units consumed, the volumetric charges have the further advantage of providing inducement to the cultivator to economize upon the use of water (Ansari 1968:107). Empirical evidence to this effect was presented as a case study on irrigation in Mexico by Schramm and Gonzales (1976).

Flat charges. The vehicle of flat charges is the more common charging structure due to its high administrative efficiency but, unless it is used with volumetric charges, it rarely achieves the equity objective. To promote allocative efficiency multi-part charges are used, in which one tariff is made to cover the indivisible costs, while another is charged to reimburse variable costs.

Area-based charges. Area-based charges are either based on the gross cultivated area or cropped area. This method is favored in developing countries due to its simplicity and consequently the use of this method enables to achieve the administrative objective.

Flat-land and flat-crop charges. Flat-land and flat-crop charges are the more common methods used for cost-recovery purposes. In schemes, like the Gezira, where the cropping pattern is dictated by the state, such charges are liable to distort the profitability of the different crops and accordingly the allocative efficiency of the water resource. To combat this difficulty, the flat-crop taxes are weighted by its water requirements. It is thought that neither equity nor efficiency can be guaranteed when this method is used, since farmers with better access to water deprive the tail-enders of their water allotments. The Indian Irrigation Commission (1972:430) recommended the association of crop charges with gross or net revenue.

Time-shares charges. Time-shares charges are mostly used in non-storage irrigation systems, where flow is neither stable nor certain. When the time- shares vehicle is based on the size of holding (as in the *warabandi* system in India and Pakistan, where the cultivator pays for an amount of water allowed to pass through a sluice at prescribed intervals of time) neither efficiency nor equity is guaranteed (Malhotra 1982:59). However, where water transfers are permitted, allocative efficiency may be realized.

Water Charges and Delivery Systems

Another important issue is the impact of the water delivery system on deciding which charging vehicle to use. Delivery systems are classified in different ways by different writers. The FAO Paper No. 40 [1982:65-8] uses the following nomenclature

i. *The on-demand system.* When the on-demand system is used water is supplied to the user at the demanded time and quantity. Israel and parts of USA use the on-demand system. In extensive gravity irrigated schemes with a large number of small holdings, the system is impractical and uneconomical, especially when the water value is not high enough to sustain the high costs involved. Volumetric charging is the more suitable form in the on-demand delivery systems.

ii. *The semi-demand system.* The semi-demand system is sometimes called the on-request system where the user's demand is fulfilled within a few days. The Gezira Scheme was originally designed to this system up to minor canal head level (taking the water indents as an estimate for the users' demand). In the presence of fairly accurate measuring structures, volumetric charging can be used.

iii. *The canal-rotation and free-demand system.* The canal-rotation and free-demand system is where the secondary canals receive water in turns. Farmers can take as much water at the time they wish. Flat land-based taxes are usually levied.

iv. *The rotational system.* The rotational system is where all the primary and secondary canals receive water by turn, while farmers at the tertiary canal level receive their water shares according to a preset schedule, proportional to their landholdings. The time-shares vehicle is widely associated with this system.

v. *The continuous flow system.* The continuous-flow system as the name implies gives the farmer a continuous flow to balance the water lost through daily evapotranspiration. It is practiced in rice fields in South East Asia, where excess water is drained from one field to another. It is depicted as the least efficient system, although it has the advantage of saving in labor and capital. Flat-land charges are the more customary levies here.

Water Charges in the Gezira Scheme

General. Water charges were established in the early days of the Tayiba Experimental Station (1911) at the rate of L.S. $2^{1/2}$ per *feddan* (1 feddan = 1.038 acres) (Gaitskell 1959: 69-72). A few years later it was changed to a partnership arrangement to the dissatisfaction of the tenants.

In 1981, the Joint Collective Account System (JCAS) was abolished and was replaced by an Individual Account System (IAS) incorporating a Land, Administration and Water Charge (LWC).

The Components of the LWC to Recover Water Charges

i. Capital costs of the irrigation system comprising depreciation, replacement cost reserve and interest on long-term loans.
ii. Operation costs which are the expenses of O & M.
iii. Overhead costs other than capital costs which include a proportion of the Ministry of Irrigation headquarters costs (Cost Recovery Committee 1980).

Administration Charges. Administrative charges consist of the same types of expenses as the water charges.

Land Charges. On the assumption that the government either owns the land or administers it for the general good, it is entitled to an income as a landlord which is obtained by enforcing land charges.

The main objective of the new LWC was cost recovery; however, some concessions were made to the tenants' trade unions. Moreover, when implemented, the LWC never incorporated a land charge (before 1990/91), nor were the proceeds of the water charges transferred to the Ministry of Irrigation or the Ministry of Finance.

CALCULATION OF WATER CHARGES

Costs

Capital cost.

i. Depreciation - To calculate depreciation "a straight line plus average interest on first cost with salvage value equal to zero" method is used; i.e.,

$$CR = \frac{P}{n} + \frac{Pi}{2}(n+1)$$

where n = life of asset

I = minimum attractive rate of return (6 to 8%)

P = initial cost

n is usually estimated as follows:

Capital works, buildings and consulting fees	50 years
Major items of mechanical equipment and plant	25 years
Roads	20 years
Vehicles and minor plant	10 years

Most of the fixed assets of the Gezira mains are considered sunk. The contribution of the Roseires Dam is estimated to equal 35 percent. The fixed capital assets of the Managil extension and the received gates of Sennar Dam are also depreciated.

ii. Replacement Cost Reserve -- The Replacement Cost Reserve should be credited with the difference between the cost of replacing a capital item at the end of one accounting year, and what it would have cost at the end of the previous year. However, this item was never included in the calculation.

Operating costs. Operating costs are all costs needed to operate and maintain the irrigation system in the scheme. Chief among these items of expenses are:

Salaries and payroll expenses
Silt clearance
Weed clearance
Maintenance and operation of civil works
Maintenance and operation of mechanical works
Minor renewals
Vehicles and plants

Overhead costs (other than capital costs). Overhead costs other than capital costs include a proportion of the Ministry of Irrigation headquarters, dams and hydraulic research costs.

Areas. The details of the areas under each crop are supplied by the Agricultural Managements.

Crop water requirement (CWR). The CWR is fixed according to the recommendations of the research workers of ARC. Until 1989/90, a predetermined number of irrigations for each crop were used.

Cost allocative. As the Roseires and Sennar dams are multipurpose ones, costs are assigned to irrigation and hydropower according to the "Separable Costs - Remaining Benefit" (SCRB) method.

Estimation of water charges. Each crop area is multiplied by its CWR to give its water consumption. These products are aggregated to give the total water consumption. Then total annualized costs (net of costs allocated to hydro- power) are multiplied by the ratio of total crop water consumption to the aggregate water consumption to give the cost recovered from each crop. The annual cost recovery of each crop divided by its area gives the water charge per feddan.

From the foregoing description it is clear that the vehicle used is an area-based charge weighted by CWRs, and that the rate setting is made according to a combination of average cost and ability-to-pay principles, because the farm-gate prices of cotton and wheat are determined according to a cost-plus criterion including LWC costs. Certain deductions are allowed to compensate for the inefficiencies of the irrigation system.

Improvement of the Existing Water Charging System

Many people dismiss volumetric pricing on the assumption that water measurement is either expensive or inaccurate. However, the Gezira Scheme is readily adaptable to volumetric charges with little additional costs. Such a move toward volumetric charging was looked forward to enhance economic efficiency, engineering efficiency, equity and cost recovery. The following alternative management procedures are suggested to be implemented one after another, every two or three years, giving enough time for monitoring, evaluation and amendment:

1. The existing head regulators of minors have to be calibrated, the side angles to be marked to show the gate-opening and the downstream water gauges renovated. This will enable reasonably accurate volumetric measurement at the head of the minor level. Simple meteorological screens can be erected at Ministry of Irrigation subdivisional headquarters to estimate CWRs. The BI should be enabled to verify the quantities of water supplies passed to him. Similarly, the Assistant Divisional Engineer (ADE) should be enabled to examine the progress of the agricultural operations schedule, in order to develop mutual accountability. Multidisciplinary teams should conduct experiments of crop-water production functions. These functions have to show the impact of the availability and timeliness of the different inputs and agronomic practices.

2. The flat annual volumetric system can be extended to the AXX level. The FOPs should be calibrated at this stage.

3. The volumetric pricing can be extended to the AVI level. The discharge through an individual AVI can be measured using V-notches. The estimation of E^0 will remain as before, but the crop factors can be amended to suit the actual crop stands after consultation with BIs. Automatic level gauge recorders at minor canal heads can be erected at this stage.

To enhance equity and obviate social and political pressures exerted by strong groups for unnecessary maintenance of the stretches of the irrigation system serving them, the cost recovery can be based on the actual O & M for each individual major canal. Later, the accounting unit can be reduced to the minor canal level.

To ascertain the success of the above procedures, similar efforts should be made at the Block Offices to comply with the agreed agricultural operations.

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