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Research Report

Alternative Approaches to Cost Sharing for Water Service to Agriculture in Egypt

C.J. Perry

International Irrigation Management Institute

Research Reports

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Research Report 2

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Summary

Introduction

This paper combines and interprets results from a number of studies undertaken by the International Irrigation Management Institute (IIMI) for the United States Agency for International Development in Egypt during 1995. The studies were designed to help the Egyptian government formulate a rational approach to sharing the costs of water services among the beneficiaries—agriculture and other users—and government.

The major studies included (1) a detailed review of the actual costs incurred in operating and maintaining the infrastructure for water delivery and disposal; (2) an assessment of the allocation of these costs among beneficiaries, on the basis of the separable costs, remaining benefit (SCRB) method; (3) the ability of the accounting system currently in place to trace the disposition of costs; and (4) an analysis of the impact on the agriculture sector of alternative bases for imposing charges—flat-rate, volumetric, or crop-based. A number of other minor studies were commissioned in the course of the work, and reference is made to other published information and reports.

Sharing the costs for services rendered among beneficiaries has a number of potential benefits: First, where the alternative is a government subsidy, revenues from charges release government funds for use elsewhere; second, charge levels provide an indicator to the beneficiaries of how efficiently the service provider is operating; and third, where resource usage underlies the rate structure, an efficiency incentive for the user is introduced.

In Egypt, as in many countries, there are no direct charges for water services to agriculture. Up to the late 1980s, substantial government revenues from agriculture were derived through implicit taxes on production: Marketing and cropping patterns were controlled and the government captured substantial profits from the sale of commodities (especially cotton) in world markets. More recently, these controls have mostly been removed: Farm incomes have risen by about 25 percent in real terms, and government revenues have fallen. Although prices were adjusted for some inputs, water has remained free. There is, however, a limited degree of cost recovery for infrastructural improvements (installation of drainage, improvements to *mesqas* or private field channels), and the farmers are also responsible for maintaining the mesqas.

Cost allocation and accounting procedures

The study of cost allocation among beneficiaries was complex—water is used nonconsumptively to generate power and for navigation; water is consumed by domestic, industrial, and agricultural users. Much of the water infrastructure—storage, barrages, canals and drains—serves multiple purposes. The SCRB method, which provides a standardized approach to this type of problem, was applied here. The complexities of Egypt's water resource sector and the difficulties of applying the SCRB method to a situation where development is already virtually complete resulted in numerous analytical and conceptual challenges. But it was found that the level of system operational costs attributable to agriculture was very stable across wide ranges of assumptions, primarily because agricultural use dominates total use. The share of costs attributable to agriculture, amounting to US$52/ha annually, is the dominant share of total costs.

The parallel study of current accounting procedures showed that allocation of these expenditures among physical locations and purpose is not possible. This does not imply inaccuracy in the accounts; rather the present accounting categories are unsuited for providing the basis for establishing user fees in relation to costs at any local level. This conclusion is important to the extent that cost sharing is planned to induce efficiency in the provision of the service. If the relationship between local services and locally incurred costs cannot be traced, then the appropriate change in charges due to improved service efficiency will also be impossible to allocate.

The third study undertaken was designed to test the impact on crop selection and production of alternative approaches to service charges. The assessed charges were introduced into a proven simulation model of Egypt's agriculture sector to measure impacts on farm income, crop choice, the value of production, and the productivity of water.

Cost recovery mechanisms

Three charging mechanisms were evaluated: (1) a flat rate, independent of crop type or cropping intensity, (2) a crop-based charge, broadly relating the service charge to water consumption, and (3) a volumetric charge. The structure of the model is adequate to make these distinctions meaningful: Crop choices are specified in great detail with numerous options of underirrigation, and short and long varieties and planting dates are available. The structure of the model was modified to more accurately reflect the impact of unequal access to water in case of shortage.

The results showed that full recovery of allocated costs to agriculture would reduce farm incomes by about 4.5 percent. As expected, imposition of flat rate charges has no impact on crop selection.

More interestingly, a crude crop-based charge (water charges set at levels proportional to typical farm demand, by crop) is almost exactly as efficient as full volumetric pricing in inducing beneficial shifts in cropping pattern toward more water-efficient crops. This conclusion has important implications. Irrigation deliveries in Egypt are essentially unmeasured—historically, since the construction of the High Aswan Dam, supplies have been plentiful and thus little attention is paid to formal allocations. Any attempt to introduce water measurement (which would be required for volumetric pricing) would therefore have enormous implications on how the system is operated, the infrastructure needed, and the formalization of water rights.

Impact of charges on demand

This impact of charges on demand was explored further in an experiment with the agriculture sector model to simulate the impact of a reduction in supplies of 15 percent. Two issues were explored. First, the level of volumetric charges required to induce a fall of 15 percent in demand for water for agriculture was explored. The resultant water service charge would be 25 percent of farm incomes—hardly a politically feasible option.

Alternatively, by rationing water among farmers, efficient use can be induced. Farmers will choose water-efficient cropping strategies to minimize the loss in production even in the absence of water charges. In one solution, the model simulated uniform rationing of water, and production was predicted to fall by 4 percent. In a second scenario, water shortages were concentrated in tail-end reaches, so that head-end farmers continued to grow water-intensive crops, while tail-end farmers suffered the full 15 percent cut. In this case, production fell more sharply—by 7.1 percent—giving an indication of the benefits that will accrue to better management if shortages arise. In fact, the benefits are surprisingly low. The infrastructure required to enforce rationed deliveries corresponds rather closely to an ongoing investment program—the Irrigation Improvement Project—that allows strict allocation of water at the farm level. The benefit accruing to better management for an assumed irrigation deficiency of 15 percent can be translated into a 3.5 percent return on investment in the improved infrastructure, ignoring all the administrative costs of such a system.

Conclusions

It is concluded that charges for water services will not induce significant changes in cropping patterns, or improvements in system performance, because the cost of system operation is low in relation to the benefits of irrigation. Further, until revised accounting procedures are in place, there is no scope for meaningfully linking charges to service at the local level. Thus, reducing the financial burden on government is the only likely impact of introducing water service charges.

An analysis of the potential improvements in productivity, should irrigation water become scarce, from more equitable water distribution—forcing farmers to select water-efficient crops—shows that the benefits are small in relation to the likely financial costs of infrastructure. Administrative complications and the associated need for more clearly defined water rights further reduce potential benefits, suggesting that maintaining the balance between supply and demand for water should be a high priority.

Alternative Approaches to Cost Sharing for Water Service to Agriculture in Egypt

C.J. Perry[1]

Introduction

The International Irrigation Management Institute (IIMI) was engaged by the U.S. Agency for International Development (USAID) in late 1994 to examine USAID's past and ongoing support to water resources development and management in Egypt. One component was a review of cost recovery policies in the water sector and an analysis of the impact of alternative approaches to water service charges on the agriculture sector. This paper brings together IIMI's work in these areas, drawing on specific reports prepared during IIMI's study program (Cestti 1995; Hutchens 1995; Lofgren 1995; Lewis and Hillal 1995) and integrating their findings with other information to address questions related to cost-recovery policy in Egyptian irrigated agriculture.

Service charges are potentially important and useful because (1) recovering costs from beneficiaries of the service relieves the government of a financial burden and provides revenues to support operation and maintenance (O&M), (2) linking payment to the service provided should encourage efficiency in the *provision* of the service, as well as (3) encourage efficiency in the *use* of resources provided.

These last two issues are quite distinct. First, a direct connection between the cost incurred in providing irrigation services and the charges to users should induce them to exert pressures for increased efficiency in the delivery agency or to suggest rearrangements of responsibilities in exchange for reduced fees. These pressures work toward efficiency in the *provision* of the service. Second, service charges that are linked to the quantity of service (water) provided should induce users to economize in its *use* by choosing water-efficient crops or water-saving irrigation technologies.

In assessing alternative approaches to cost sharing, three separate elements should be addressed: the *financial* objective—to recover from beneficiaries the cost of providing water-related services—and the two *efficiency* objectives—to encourage efficient, cost-effective provision of the water service and to encourage efficient use of the resource provided.

The analysis is ordered as follows:

1. A brief background to cost recovery in Egypt's agriculture sector is presented, and present policies are summarized.
2. The procedures for allocating the costs of O&M are reviewed, and the results of the analysis summarized.
3. Various mechanisms for cost recovery for irrigation services are assessed and analyzed.
4. The scope for utilizing water service charges as a means of restricting demand for water is explored.
5. The results are brought together and the conclusions related to the potential impact and usefulness of water service charges are set out.

The options for, and impacts of, introducing water service charges in Egypt have been extensively studied (Young 1983; Bowen and Young 1983, 1986; Abu Zeid and Seckler 1992a). Consideration has been given to flat rate charges (imposing an ad-

[1]The author is grateful to reviewers of earlier drafts of this report, particularly Dr. Wadie Fahim of USAID, Cairo, and Drs. Douglas Merrey and David Seckler for their constructive and insightful comments.

ditional tax, similar to the existing land tax, which is independent of the crop grown or water consumed), to imposing taxes that are crop specific and reflect the assumed water consumption (thus introducing a degree of linkage between the extent of the service provided and the water charge), and to a volumetric charge, directly linking the quantity of water delivered to the charge. Some studies have also considered combinations of charges.

The conclusions have generally been similar. Most studies argue that as long as water is sufficient for agricultural needs, a flat land tax is the simplest and most convenient way of recovering service charges. A crop-related charge gives farmers an incentive to seek more water-efficient cropping practices. Volumetric charges are most effective in the case of scarcity, but involve high administrative costs. Bowen and Young (1983) also considered the option of water rationing through fixed seasonal or annual allocations. They argued that this would induce an efficient response from farmers while avoiding the administrative costs of volumetric measurement and charging. A question raised at the 1992 Roundtable Conference held in Alexandria (Abu Zeid and Seckler 1992b) was whether any useful purpose would be achieved by the introduction of service charges. Each of these options is considered in this paper, based on a more complete picture of what the actual costs should be, what information there is on the appropriate allocation of these costs, the responsiveness of the sector to alternative charging mechanisms at the rates implied by full cost recovery, and the implications for system operation (and infrastructure) of introducing volumetric charges.

Cost Recovery Practices

Charging users for water and water services is a sensitive issue in Egypt, as it is in many countries, involving political, historical, social, religious, and economic factors. Beneficiaries tend to prefer low or zero charges, and this preference is reflected by their political representatives. This position may be reinforced when investments have been made in the national interest—to ensure food security, develop new areas, or diversify the economy—thus implying some higher goal than the direct productive impact on those receiving the service. In agriculture and in a predominantly agrarian economy, the combination of these factors is often powerful, and the recovery of service charges rare.

When direct revenues from a service are low or zero, the probability that the service will be underfunded is correspondingly high. The agency providing the service is seen as a consumer rather than a provider of funds to the government, and its claim on scarce resources is weak.[2] The subsidy required to meet the gap between revenues and expenses will be under constant pressure, and with staff costs essentially fixed, funding shortfalls will tend to be absorbed by the physical works component of the maintenance costs so that infrastructure, and eventually the quality of the service, deteriorate.

Such "savings" in public funds are often expensive. The cost of routine and preventative maintenance is usually much lower than the cost of major rehabilitation.[3] The lost production (when irrigation facilities are not working properly) and damage to land (when drainage facilities are poorly maintained) may greatly exceed the cost of proper O&M.

[2]The Government of Egypt's policy incorporates this factor explicitly by setting employee pay rates for revenue-generating sectors at higher levels than for non-revenue-generating sectors such as irrigation.

[3]In the transportation sector, for example, a rule of thumb is that US$1 of delayed maintenance results in the need for US$3 in repairs.

Cost recovery from agriculture—background

In Egypt, until the late 1980s, government revenues from agriculture were derived from implicit taxes on agricultural production: Prices of farm products were low, marketing was controlled, cropping patterns were set to meet government priorities, and the government captured substantial profits from sales of commodities (especially cotton) in world markets. These policies, combined with increasing domestic demands, resulted in a rapid deterioration in the agricultural trade balance. To restore farmers' incentives, agricultural policy was radically reformed in 1986 (see Hazell et al. 1994 for a summary of the process of liberalization). Much closer correspondence between international and domestic prices for major crops was allowed, and controls on cropping patterns were for the most part eliminated. The effect of this policy change has been dramatic: Yields and production of major crops are sharply higher, and farm incomes have increased (after allowing for the increased cost of inputs) by 25 percent in real terms (USAID 1995).

This period of rapid adjustment, during which government revenues from the agriculture sector fell sharply, also provided an opportunity to adjust other prices to more appropriate levels. To some extent this was done—subsidies for farm inputs were reduced. But charges for water services (to agriculture or to other users) were not introduced.[4]

Present practices

The recovery of capital investment costs is often treated separately from the recovery of operating costs, and this is the case in Egypt. This study focused on operational costs, but a brief summary of policies for investment cost recovery in the agriculture sector is provided below. The approach recently agreed upon with the World Bank (1994)[5] provides the basis for this summary.

Capital costs are recovered for *mesqa*[6]-level investments such as the USAID-supported Irrigation Improvement Project according to a formula that requires repayment of the full capital cost, excluding interest, over a period of 10 to 20 years. Pump costs are fully recovered during the initial 5 years. Assuming 4 percent inflation—an average of the World Bank (1994) estimates—and 12 percent opportunity cost of capital, cost recovery amounts to about 30 to 50 percent, depending on the recovery period, for costs for civil works. No costs are recovered for improvements above the mesqa level, which account for about 25 percent of civil works expenditures. Thus, the subsidy on capital investments is 60 to 75 percent.

A similar approach is followed for drainage investments, which have been made over large areas of Egypt during the last 20 years. Recovery from these investments currently totals about $4.5 million per year, or about $7.50 for each hectare served.[7]

In the New Lands, farmers are also responsible for investment costs for all infrastructure including, and downstream of, the booster pumps that draw from the distributary canals, serving areas about 40 to 100 hectares. Such investments may either be undertaken independently at the farmers' expense or by the government with cost recovery according to the rules set out above.

Thus, government policy on capital cost recovery is to recover no charges above the delivery point (mesqa head in the Old Lands, booster pump in the New Lands) and a small proportion of investment costs below the delivery point.

In contrast, operation and maintenance costs below the delivery point are the responsibility of farmers. Failure to fulfill this obligation results in the work being undertaken by the Ministry of Public Works and Water Resources (MPWWR) and charged

[4]Water is provided free in bulk to all users by the Ministry of Public Works and Water Resources. Intermediate services of treating water for domestic consumption are charged for by the agencies concerned.

[5]Law 218 is the formal definition of the points summarized here.

[6]The mesqa is the tertiary delivery channel, which is communally owned and operated by the farmers.

[7]Throughout this report, values are in U.S. dollars (US$1= £E 3.4), and area is in hectares (1 ha = 2.5 feddans).

to the farmers. Examples of this were encountered during a field survey of "other expenses" undertaken during the study (Khouzam 1995). On average, farmers pay $12/ha annually for mesqa maintenance in the Old Lands, either to the cooperative or as a contribution of labor.

Allocation of Operation and Maintenance Costs

Water resource investments on the Nile constitute a multipurpose development, serving the needs of power, navigation, municipalities, and industries, as well as farmers. Some of these demands are competitive (agricultural and industrial consumption) and others are complementary (releases for agriculture can be passed through turbines to generate power and used by ships for navigation without detriment to the other consumers).

Two common approaches for allocating costs in cases such as this are (1) the use of facilities method, and (2) the separable costs, remaining benefits method (see Hutchens 1995 for a detailed comparison).

The use of facilities approach is conceptually simple: Costs incurred in system operation are allocated among purposes in proportion to the extent to which each facility is utilized for the purpose in question. Thus for canals that provide water to municipal and agricultural users, associated costs would be divided in proportion to the water delivered to each user. The transparency of the approach is appealing, but difficulties arise in relating consumptive to nonconsumptive uses (navigation and hydropower, for example). The approach is also highly dependent on disaggregated data, which at present are almost completely absent (Lewis and Hillal 1995). The attempt to apply the use of facilities method to the Nile system (Allam 1987) was severely hampered by the lack of detailed information on the actual application of MPWWR funds by purpose and on nonagricultural demands.

The separable costs, remaining benefits approach (SCRB), which was applied comprehensively in a report by the Irrigation Support Project for Asia and the Near East (ISPAN 1993), consists of assigning all costs that serve a single need (i.e., a powerhouse only serves the power sector, a lock only serves for navigation) to the benefiting sector. The remaining "joint" costs are assigned in proportion to the benefit derived by each user from that service (for example, costs associated with a navigable canal are allocated to both agriculture and transportation beneficiaries).

The SCRB method, as applied here, ensures that charges to any user must always be less than the benefit derived. It explicitly deals with competing and complementary demands; and the approach is transparent, allowing beneficiary groups to understand the underlying assumptions and the derivation of the assigned cost.

However, the approach is normally applied 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.

The application of SCRB to a system that has been in place for many years introduces a number of difficulties. First, the approach allows no cost allocation to any user in excess of the cost of the alternative minimum cost solution. On that basis, no costs were assigned to users whose needs could have been met from direct withdrawals from the Nile, so that for example, the city of Cairo and the industries along the Nile would not be charged for withdrawals. Although this may have been true at the time of construction of the High Aswan Dam, the logic is far less clear now. The scale of subsequent development in all sectors, and the size of Cairo itself, are intrinsically linked to the construction and effects of the High Aswan Dam, and current water requirements could not be reliably met by the uncontrolled flows of the Nile and might in any case have been captured by upstream users within Egypt.

Second, a number of major investments were treated as "sunk" costs and excluded from the analysis. Capital costs, for example, were included in the analysis for new areas but excluded in the analysis for old areas. (In practice, this may correctly reflect the implicit cost recovery that went on in the recent past, but the transparency of the analysis is reduced.)

Third, the linkage of cost allocations to benefits derived makes the result sensitive to the time at which the analysis is done. Benefits to agriculture, for example, have increased rapidly over the last decade as a result of changes in government policy.

Aside from these difficulties of application to an already developed system, some important additional shortcomings of the SCRB approach were identified during IIMI's review.[8] The ISPAN study (ISPAN 1993) contains a mixture of O&M and investment activities on the cost side (including development of New Lands and a number of activities that resulted in service improvements and thus constitute investments). On the benefit side, as a basis for projecting the sectoral benefits to agriculture, the report assumes that benefits of the Irrigation Improvement Project will be achieved over a wide area. This increases the cost allocated to agriculture on the Old Lands through the mechanism of the higher derived benefits.

Finally, the ISPAN study embodies some assumptions about alternative costs that are difficult to confirm, particularly the cost of alternative sources of water for domestic use. Consequently, the following changes were made to ISPAN's SCRB model (Cestti 1995):

Updated actual costs of O&M were introduced.

Benefits were updated.

Capital investment components were deleted from the cost projections.

Impacts of capital investments were deleted from the benefit projections.

Cost allocations for main-stem users were determined on the basis of derived benefits rather than on the assumed alternative cost.

Revised estimates of alternative costs for municipal and industrial supplies provided through canals were included.

Revised estimates of municipal and industrial demands based on a more comprehensive approach to the determinants of growth were introduced.

The revised model allowed extensive exploration of a variety of underlying assumptions and sensitivity tests to differing levels of benefit in agriculture, different assumptions about New Lands development, and alternative estimates of benefits to other sectors.

An important conclusion of the reexamination of the ISPAN model was that agricultural cost allocation is relatively insensitive to changes in the underlying assumptions. The ISPAN estimates of cost allocation to agriculture in the Old Lands ranged from 75 to 83 percent of total costs, and with the changes mentioned above they range from 70 to 81 percent.

Given the magnitude of the changes introduced into the analysis, the consistency of these results may be surprising, but it should be noted, first, that the cost that is being allocated is the cost of operating the system (plus in the case of ISPAN, some limited investment costs), so that the total amounts being allocated are similar. Second, irrigated agriculture is by far the most significant user of water, accounting for perhaps 85 to 90 percent of total use. Third, the reevaluation of other uses increased their share in the total, but the overall effect was small because the actual volume

[8]Hussain et al. July 1994. Strategic Research Program, NWRC (National Water Research Center).

assigned to such uses is minor. In fact, the revised treatment of municipal and industrial demands led to much higher cost allocations to these sectors than in the original analysis by ISPAN (a total of about 11%, compared with the original 0.2%). However, this increase was offset by declines in the allocations to hydropower as a result of improvements in the non-hydro generation capacity that reduced the need for special releases from Aswan for power and reduced the benefits to tourism based on updated estimates. Representative results from the updated model are presented in table 1.

For the agriculture sector, the stability of these results was tested for sensitivity to the major variables: benefits to the agriculture sector, various scenarios of New Lands development, rates of growth in industrial production, and revised assumptions about population growth rates. The variation in the costs allocated to agriculture was in all cases marginal. A 15 percent change in estimated agricultural benefits, the most sensitive variable, produced only a 3 percent change in the computed service charge.

However, within the agriculture sector, results are particularly sensitive to pumping costs. Pump lifts for agriculture and municipal and industrial uses are highest in Upper Egypt, and specifically allocating this cost by region results in per hectare agricultural service costs of $95 in Upper Egypt, $60 in Middle Egypt, and $45 in the delta.

TABLE 1.
Representive results from the updated ISPAN model.

Sector	Cost (US$)
Municipal and Industrial (per '000 m^3)	
Canal delivery	3.63
Direct intake or groundwater	0.48
Industrial direct intake	0.69
Old Lands agriculture	
Land basis (per ha/year)	52
Volume basis (per '000 m^3)	3.44
New Lands agriculture	
Land basis (per ha/year)	53
Volume basis (per '000 m^3)	3.34

Note: Results are based on the SCRB approach, following ISPAN methodology, updated as indicated in the text. The cost of O&M was based on MPWWR's 1994 budget, which is overestimated, in that staff costs are not disaggregated between O&M and other activities, and underestimated to the extent that budgetary requests are less than required for adequate O&M.

Impact of Water Service Charges on Agriculture

An analysis was undertaken using a model of Egypt's agriculture sector developed by the International Food Policy Research Institute (IFPRI), which is a modified, extended, and more complete version of the agro-economic model developed as part of the Water Master Plan (UNDP 1984). The analysis was designed to explore (1) the actual relationship between farm incomes and service charges, (2) the impact of alternative charging methods on farm income and crop production, and (3) the impact of volumetric charges on demand for water. In each case, the charges were set so that total revenue remained equal to actual average O&M costs, estimated at $52/ha annually.

Impact on farm incomes

Annual net farm income estimates based on the IFPRI model average about $1,200/ha (that is, income to the farm enterprise, excluding the cost of family labor). This is quite consistent with other estimates. The World Bank (1994) estimated that farm incomes range from $1,200 to $1,500. Individual crop returns (Hussain et al. 1994)[9] range from $375/ha (flax) to $1,700/ha (cotton), with most crops in the $600 to $1,000

[9]Adjusted for comparability to exclude family labor and land rent.

range. With a cropping intensity of about 180 percent, net farm incomes would thus range from about $950/ha to $2,000/ha annually.

Assuming a net farm income of $1,250/ha as representative, full cost recovery of water services for irrigation would reduce farm incomes by about 4.5 percent on average. A brief field survey (Khouzam 1995) uncovered several additional costs borne by farmers, most of which are minor except for land rent. Farm rents for land average $450/ha annually. This would reduce annual farm income to about $800/ha, and increase the proportion of water service charge to about 6.5 percent of net income for farmers who rent their land.

Impact on production of alternative charging systems

To determine the impact on production of alternative charging systems, the following options were analyzed:

- a fixed rate per hectare, irrespective of crop or water use
- crop-specific rates, charging higher rates for more water-intensive crops
- volumetric charges on the basis of actual water use

The first option is a simple undifferentiated annual tax of $52/ha, and the result was a fall in farm income of 4.5 percent. This solution is self-evident: a flat land tax has no impact on the choice of crops or technology.

The second option simulates a crop-water charge per hectare, proportional to the calculated average water consumption. Since the IFPRI model allows a wide range of crop choices in terms of planting dates and in "stressing" the crop by underirrigating, this option gives the farmer considerable incentive to fine-tune his cropping. The result was greater efficiency from both the farmer's perspective (farm income falling only 2.4%), as well as the national perspective (water demand falling by 3.5%), while returns to water increased by 2.7 percent.

The third option imposes a volumetric charge and simulates the effect of measuring and charging for the quantity of water delivered. For the present situation, where water is not a severe constraint to crop choice and the service charges represent a small proportion of farm income, the results are virtually identical to those obtained through the second option described above.

Impact of Water Shortage

The role of management

Water is at present somewhat scarce, with a positive but small marginal value product of $0.02/m^3$, compared with an average productivity of $0.08/m^3$ (Lofgren 1995). In future, significant reductions in supplies to agriculture can be anticipated as a result of transfers to competing demands, further development of new lands, and full utilization of agreed-upon upstream riparian rights.

For purposes of analysis, a 15 percent reduction in supply was hypothesized. The IFPRI model was significantly revised to simulate the following options:

- present management, which would result in concentration of shortages at tail ends or otherwise disadvantaged locations
- efficient management, which would share shortages equitably among all farmers

The latter modification was important because the previous formulation presumes efficient management and uniform distribution of shortages. Under these circumstances, every farmer seeks an efficient response to shortage by changing cropping patterns to make the best use of the reduced supply. If shortages are not evenly distributed, farmers who have better access to water continue to seek maximum returns to land, and farmers who have worse access receive residual supplies and experience a more severe shortage, often exacerbated by unreliability. To formulate this issue within the model, an arbitrary decision had to be taken about the division of the area into those with "better" and "worse" access. Clearly, the most extreme case would occur where the tail-end mean is roughly equal to the shortage (that is, for a 15% shortage, the disadvantaged area is 15% of the command). Under these circumstances, deliveries to the tails would be zero because the full available supply is consumed in the advantaged areas.[10] As a first approximation, the advantaged and disadvantaged areas were assumed to be equal.

The results show that from the national perspective, a water shortage of 15 percent, if inefficiently managed (concentrated among tail-end farmers), would result in a 7.1 percent fall in agricultural production, but an efficiently managed shortage (evenly distributed among all farmers) would limit the fall in agricultural production to 4 percent. It is interesting to note that because the overall demand for agricultural commodities is inelastic, reductions in supply result in more than proportional increases in price, so that farmers as a group receive increased incomes.

The role of water pricing

Finally, the usefulness of volumetric water pricing as a mechanism to promote more efficient water use was explored. In the previous section, the impact of a reduction in supplies of 15 percent was assessed in relation to two levels of management, each of which was basically a rationing procedure. Here, the approach is to use market forces as a means of reducing demand. The analysis shows that the volumetric charge required to induce a 15 percent fall in demand would equal $300/ha, or about 25 percent of the net farm income.

Conclusions and Implications

The preceding sections have identified a number of conclusions:

The average annual cost of providing water services to agriculture is about $52/ha, which is about 4.5 percent of net farm income.

The above cost is little affected by likely variations in underlying assumptions governing the allocation of costs among sectors.

The present system of accounting does not allow accurate differentiation of costs by purpose and location.

Under present conditions of supply, volumetric charges for water are only marginally more successful in encouraging efficient water use than crop-based charges, which in turn are somewhat better than a flat land tax.

Volumetric charges are an unrealistic means of encouraging significant reductions in demand, because very high charges are required to have a significant impact.

Earlier in this report, three distinct objectives were identified as underlying the purpose of service charges: the *financial* objective—to recover from beneficiaries the cost of providing water-related services—and the two *efficiency* objectives—to encourage efficient use of the resource provided and to provide the water service at a reasonable cost.

[10]These relationships are approximate because the formulation of the model is complex, allowing extensive internal optimization of response in terms of labor assignment and endogenous prices.

The results of the analysis now allow some further consideration of these objectives. The first is straightforward. Any of the service-charge schemes assessed would meet the criterion of recovering the full financial cost of the service.

The two efficiency objectives have been partially addressed. The analysis indicates that the level of service charges required to meet the financial objective is so low (6% of farm costs and 4.5% of farm income) that their impact on cropping decisions by farmers will be minimal for any system of water charges.

The results of the study using the modified IFPRI model clearly show that even volumetric charges are unlikely to produce significant efficiency gains within the politically feasible range of charges. Furthermore, it is interesting to evaluate the benefits of volumetric supply in relation to possible costs. The present delivery system for the most part provides farmers with the water they need—unmeasured and undifferentiated—at the farm level. Any form of rationing or volumetric delivery will require quite a different infrastructure to allow the necessary measurement of individual supplies and the differentiation of deliveries between farmers.[11]

At present levels of water availability, the impact of volumetric delivery has been shown to be negligible. For a shortage of 15 percent, efficient management leads to a fall of 4 percent in sectoral production, while the present management would result in a fall of 7.1 percent—a benefit to the combination of service charges and management of 3.1 percent. The cost effectiveness of that benefit to efficient management can be interpreted as follows:

> Based on present agricultural production at $1,200/ha annually, the productive benefit would be $1,200 × 3.1 percent, or $37/ha.
>
> Achievement of these benefits would require the introduction of a system of water delivery capable of providing measured quantities of water to each farm. The infrastructure of the Irrigation Improvement Project would meet this need, and it is currently estimated to cost $1,150/ha for civil works.
>
> Ignoring all other effects, the return on this investment is 3.5 percent ($37/1,150), which would be further reduced by the substantial organizational costs of billing, measuring, and collecting differentiated service charges.

This conclusion applies with equal force to suggestions of rationing water allocations (Bowen and Young 1983) and tradable water rights (Lofgren 1995), because the infrastructural and management implications are similar in each case. This is not to say that improved management may not have numerous other benefits,[12] but rather to indicate that the benefits resulting from improved allocational efficiency are small in relation to the costs.

The question of how the introduction of charges may influence efficiency in providing the service has to be examined. A benefit of service charges is to make both the service provider and the service receiver conscious of the costs incurred. To achieve this linkage, service should be disaggregated to units where the link is transparent. For example, in the United States many *projects* are provided with water by federal agencies at agreed-upon (and often subsidized) rates. *Within the project* the farmers bear the full cost of O&M, and also set their own charges. At this lower level, the link between cost and service is direct and transparent; decisions on the allocation of responsibilities and levels of service are influenced by impacts on cost.

In Egypt, this might correspond to supplying water at a common rate to all directorates, and setting charges within the directorate to meet costs incurred at that level. As long as a central authority has responsibility for the delivering of water from

[11] This logic applies equally whether the system is fully operated by the government or by some combination of government agency and farmer group—whoever allocates water at the farm level will need the associated infrastructure.

[12] With the present arrangement, significant supply reductions would likely result in severe water shortages and, due to local concentration or shortages, salinization in tail-end reaches.

Aswan to the mesqa as well as associated responsibilities for water quality, maintenance of navigation flows, and so on, it will be difficult to establish a relationship that the beneficiaries can identify with and, as a group, exert pressure on to change the service and the associated cost of providing the service.

Three essential changes would underpin such a situation: (1) The introduction of accounting procedures to allow clear identification of costs incurred, (2) the definition of a service point above which the government agency provides water services at an agreed-upon cost and below which the beneficiaries pay service-related charges, and (3) the definition of the service to be provided at the service point (in terms of quantity of water, timing, rights in case of surplus or deficit, and so forth). Providing a defined service will involve infrastructural changes similar to those already discussed.

Some initial comments can be offered on future operational decisions, which are beyond the scope of this paper. The definition and introduction of defined services will be time consuming and especially difficult under Egyptian circumstances. The system currently operates as a demand system with enough water to meet the vast majority of needs. If this is to continue (that is, if water supply to existing agriculture is not going to be significantly cut by direct withdrawals for New Lands, by increasing demands for water-intensive crops, and by effective reductions in available water through high rates of pollution), it is doubtful whether formal water allocation would be required—the system can simply continue to be run as a demand system. However, if serious shortages are anticipated, far clearer legal definitions of water rights and water service will be required.

Thus, the driving logic for establishing service definitions will be future water demands and the consequent water balance rather than cost recovery considerations. The present cost of providing the water service is relatively low, and present evidence suggests that efficiency gains in the cost of the service would not justify the problems that will arise in the definition (and physical delivery) of water allocations and water rights.

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