THE ECONOMIC EFFICIENCY OF WATER USE IN EGYPTIAN AGRICULTURE: OPENING ROUND OF A DEBATE

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Introduction

In Egypt, the era of relatively abundant water supplies which followed the completion of the Aswan High Dam is now coming to an end. Plans to expand land cultivation appear to be on a collision course with Nile water availability. Ultimately, consideration will have to be given to where cutbacks can be made and how to reallocate water among existing and future uses. It will thus be necessary to rethink trade policy, cropping patterns, and agricultural regulation.

History records a long series of endeavours to control the Nile flow and increase its use. The Aswan High Dam and the draining of part of the Sudd Swamp, currently underway in the Sudan, are the most recent efforts. Egypt now releases the full 55.5 billion cubic metre allocation under the Nile Water Agreements of 1959. New projects under way in the Sudan will entail the full use of Sudan's quota of 18.5 billion cubic metres. Yet Egyptian policymakers, faced with expanding food import bills, now talk seriously of the need to irrigate two to three million more feddans (1 feddan = 0.42 hectares) by the year 2000, in addition to the six million currently used. Sudanese plans call for reclaiming another 1.5 million feddans in the 1980s, in addition to 4.5 million already irrigated or being developed. Moreover, although agriculture still accounts for more than 95 percent of consumption, both countries are rapidly increasing nonagricultural water uses.

Of all the water used for agriculture in Egypt, the largest quantity goes to irrigating the "old lands" along the Nile and in the Nile Delta. These old lands account for more than 85 percent of all current water use, and more than 95 percent of agricultural production. The average size of the operational unit in these lands is about three feddans (Radwan, p. 17-25). Typically, such units are broken down into smaller parcels where water is lifted by a variety of means, both modern and traditional. There is no metering of this water, nor is there a charge for it. While the farmer who uses greater amounts incurs greater costs from lifting, there is no other incentive for efficient use.

Aside from the issue of water pricing, there have been a number of forces which appear to have distorted resource allocation. The government has set prices substantially below international levels for cotton, basic food grains, and many other commodities, as part of a system of de facto taxation (Hansen and Nashashibi, p. 164). Low prices have been coupled with mandatory delivery quotas for grains and government control of all marketing channels for cotton, plus a system of obligatory acreage requirements. To avoid quota and acreage restrictions, some farmers have shifted to the production of orchard and truck crops. Probably because the government has not had effective means of controlling meat and fodder prices, there has been a marked shift to the growing of clover, which at almost three million feddans is now the country's largest single crop. In spite of mandatory acreage rules, cotton and food grain acreage has declined over the past twenty years, and grain production has fallen far behind consumption needs.

In 1974, Egypt became a net importer of agricultural products for the first time in history. This has naturally caused a debate about the wisdom of prevailing policies, and has raised questions about comparative advantage and efficiency of resource use. Some critics argue that Egypt should abandon its reliance on cotton exports and turn to producing more food for its expanding population. However, this debate has all occurred during the time when the extra water from the High Dam made land the binding constraint on production.

This paper seeks to determine how the picture of resource use efficiency is likely to change as water becomes the binding constraint on production. In particular, we examine the impact of water restrictions on the old land areas.

Measuring the Value of Water in Egyptian Agriculture

Under conditions of efficient resource use, water would be reallocated from lower to higher value uses until the values of the marginal products were equated. One way to estimate marginal values would be to start with prevailing water prices and then adjust these to take account of externalities and other distortions in the pricing system. Since Egypt has no water prices or charges of any significance, this approach is not practical. The alternative chosen in such circumstances frequently has been to use mathematical programming models, especially linear programming. Such procedures are, however, data intensive and usually take a long time.

The approach here is to measure the value of water as a residual--the return from a given crop rotation after charges for all factors except water are counted. Calculations were made at both domestic market and accounting prices. For accounting prices, a variety of adjustments were made, following the procedures for shadow pricing normally used to determine comparative advantage for production of tradeable commodities (Pearson, Akrasanee, and Nelson).

In Egypt, double cropping is the standard practice. It is not possible, however, to compare short term crops like maize and rice with crops like sugarcane due to the different durations they occupy the land and due to the different periods in which they consume water. It was decided to evaluate alternative full year crop rotations, to avoid problems of noncomparability. To account for regional agroclimatic variability, key rotations were chosen for each of the country's three main regions--the Nile Delta and Middle and Upper Egypt. The crops considered account for 79 percent of the cropped area nationwide.

In deriving accounting prices for outputs, international farm gate prices were obtained by adjusting for the various processing and marketing costs incurred between the border and the farm. The farm prices of several crops, such as wheat, where straw and fibres are important farm level byproducts, were increased to reflect their additional domestic market value. The shadow pricing of berseem clover, a nontraded good, was problematic. Here it was decided to use the domestic price as the shadow value, although meat does enjoy substantial effective protection in Egypt, and this undoubtedly augments the price of clover.

Wages, draft animal prices, and organic fertilizer prices were taken at market value in the shadow valuing of the costs of production. Costs of utilizing machinery provided by cooperatives were adjusted upward to reflect the average government subsidy. Pest control and chemical fertilizer costs were adjusted for both direct price subsidies and indirect subsidies, such as from foreign exchange dealings. Seed costs were adjusted upward in proportion to the ratio of the international farm gate price of the commodity to the domestic price.

It is difficult to determine an appropriate accounting price for land. Rights to water are, in effect, attached to land ownership in Egypt, and thus land values and rental charges would normally be expected to reflect the value of the accompanying water. In Egypt, however, land rents are controlled at levels which are probably below the value of the marginal product of land per se. Our approach is to use the estimated cost of reclaiming desert land as a replacement cost for old lands of low quality, and then to index this upward, following the patterns of average domestic rents paid for the various rotations, to reflect the variability in values for lands of different quality.

The returns to land and water are calculated on a unit of land basis. Land costs are then subtracted from these figures, and the remainder is divided by water use coefficients to obtain the returns on a unit of water basis. These returns are estimates of the values of product attributable to water when both land and water are scarce factors. Since the calculations are based on a 1977 cost structure and since water will probably not begin to become scarce until the mid-1980s, the current relative cost structure is assumed to continue into the future. Long run shadow prices are used based on the World Bank's 1985 commodity price projections, but indexed to 1977 prices.

Although it would be preferable to measure the marginal value of water in each crop rotation, we have been forced to rely on regional averages. The analysis assumes a fixed, linear technology and cost structure for crop rotation, including fixed water requirement coefficients. Finally, rotations are characterized by the total water required. System capacity constraints are not included.

Results and Conclusions

The results of the analysis are presented in the table. The returns to land and water (cols. 6-8) reflect the picture of resource use today. Land per se should be assigned the major portion of these residuals since it is currently the binding resource. The returns to the farmer (col. 6) favour devoting land to long term clover production in the Delta, in rotation with maize or rice. This explains why production and acreage of cotton and short term clover have declined in recent years. The soybean rotation predominates in middle Egypt, but the cotton-clover prevails in upper Egypt, where shorter staple cotton is grown and its yields are higher. The current price policy in Egypt is clearly directing the farmer away from the production of the most socially profitable crops. In terms of social profitability (col. 7), cotton was clearly king among the major crops under 1977 conditions. Based on this calculation, Egypt should be devoting more resources to producing cotton as well as to specialty crops like winter onions. Wheat, soybeans, and other grains ranked far behind the cotton-clover rotation. If clover had been shadow priced at a lower level, then wheat may have been somewhat more competitive than these findings indicate.

Surprisingly, with water a scarce factor in the long run (col. 12), the direction of resource reallocation does not change appreciably from when land alone is the limiting factor. Maize appears to be at less of a disadvantage to rice, its competing high water use summer crop. In middle and upper Egypt, sugarcane production should probably be expanded despite its high water requirements. Even if world sugarcane prices do not improve in the long run (as expected), sugar still seems to have an advantage over grains like wheat and sorghum. High valued vegetable crops would also be emphasized.

This analysis indicates that Egypt should deemphasize grain production, even after water becomes scarce, if social profitability is to be pursued. Grain imports will have to be drastically expanded, unless new lands prove to have a comparative advantage in grain. With Egypt currently importing two-thirds of its wheat needs, this raises the issue of food security, and presents a clear picture of the security-efficiency tradeoff which Egypt faces (Goueli).

The residual values of water derived here may serve other useful purposes in planning and project evaluations. For example, the one to two piastre value range for water could be used to evaluate canal linings and other devices for reducing water wastage. Indications are that such investments would be justified if their annual costs are less than 10 to 20 Egyptian pounds per 1,000 cubic metres of water saved.

Currently, new land reclamation projects are evaluated without assigning any cost to the water they consume. However, projects built now will operate in a water scarce future. We thus suggest that the opportunity cost of water should be assessed at approximately 1 to 2 piastres per cubic metre. This would help in sorting out those projects which are truly justifiable.

In the future, Egypt will need more sophisticated means of valuing water. In

Table. Cost and Returns to Land and Water for Major Crop Rotations in the Three Agricultural Zones of Egypt.

Zone/Crop Rotation	Production Costs		Gross Returns			Returns to land and water			Water use Per Feddan	Returns to Water		
	Domest. Prices	Shadow Prices	Domest. Prices	Int'l Prices 1977	Int'l Prices L.Run	Domest. Prices	Int'l Prices 1977	Int'l Prices L.Run		Domest. Prices	Int'l Prices 1977	Int'l Prices L.Run
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	...............Egyptian Pounds[b] per Feddan.........								M³	Piasters[b] per M³		
Nile Delta (Sharkia)												
Clover[a] (2)-Cotton	183	227	356	790	757	173	563	530	8,701	1.3	4.7	4.3
Clover (4)-Rice	153	166	405	542	661	252	376	495	12,422	1.4	1.4	2.4
Clover (4)-Maize	141	152	408	445	510	267	293	358	7,989	2.3	1.1	1.9
Wheat-Maize	156	178	257	351	479	101	173	301	8,362	0.7	0.7	2.2
Middle Egypt (Menia)												
Clover (2)-Cotton	194	246	329	736	705	135	490	459	10,066	0.7	3.2	2.9
Onion-Maize	217	229	402	1,253	1,329	185	1,024	1,100	8,220	1.7	11.1	12.0
Clover (4)-Soybean	120	123	454	466	474	334	343	351	8,312	3.1	1.8	1.9
Sugar Cane	168	190	298	590	1,309	130	400	1,119	11,879	0.7	2.4	8.5
Upper Egypt (Sohag)												
Clover (2)-Cotton	169	219	341	832	794	172	613	575	12,251	0.9	3.8	3.5
Wheat-Sorghum	144	159	257	361	489	113	202	330	11,137	0.6	0.8	2.0
Beans-Sorghum	127	135	253	353	496	126	218	361	9,839	0.9	1.2	2.7
Sugar Cane	169	192	271	534	1,189	102	342	997	14,880	0.4	1.6	6.0

a Clover grown in rotation with cotton yields two (2) cuts compared to four (4) in other rotations.

b International prices converted to pounds at the "parallel" market rate of L.E.0.70 = U.S $1. There are 100 piasters in the Egyptian Pound.

the meantime, these estimates will hopefully be useful in starting the opening round of the debate on the agricultural implications of Egypt's water limited future.

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OPENER'S REMARKS--Nigel T. Williams

The Egyptian government is facing a two faceted problem. First, it must decide how to encourage water conservation. Second, it must define the optimal product mix given the available water supply. This paper is useful in that it provides data that will help in the formulation of an answer to the second question.

The derived value measure for water is the net return to the crop after charges for all factors, excluding water, are deducted. The underlying assumption is that, at the margin, the value product of each factor is equated to its cost. How confident are the authors that this is so in reality? For example, if labour is in surplus, to value it at the market price would overstate its value product and therefore understate that of water.

It is unfortunate that the crop rotations were characterized by their total annual water requirements in the analysis. The availability of water and the water requirement of each crop varies from month to month. I feel that a mathematical programming model should have been used to provide monthly water use coefficients for each rotation. In this way, those crops with a high annual water use coefficient but with monthly requirements that do not coincide with periods of water shortage or with the peak requirements of competing crops could be given due weight in the results.

I think that this paper offers an excellent illustration of the dilemma facing many developing countries in having to achieve a balance between maximum social profitability on the one hand and food security on the other. It is a very useful first round in the debate.

RAPPORTEUR'S REPORT--Hiroyuki Nishimura

Water in the Middle East is a crucial factor, and should therefore be used in an efficient way. Sometime in the future, water will become a limiting factor of production in Egypt, and the regional distribution of cropping patterns will be affected.

Khedr agreed, at least theoretically, that mathematical programming techniques could provide better estimates of the shadow prices of water resources. However, there is a master plan for water in Egypt which is applying such a technique. The approach of measuring the value of water as a residual was taken in order to have a quick answer, relatively rough in nature, but one which uses the entire body of available information.

Egypt should set a price on water in order to prevent waste. To prepare for the future scarcity of water resources, new technology, such as drip irrigation, should be studied. Khedr responded that there should be some criteria for allocating water. Moreover, there is a need for a complete change in the technical structure and administrative system of water supply if there is to be less overuse of water. Such a change might be possible in Libya because of the dependence on wells, but is not possible in Egypt.

Khedr indicated that new techniques are not the solution to Egypt's water problems, nor are they the solution to the lack of rationalization of water use in most of the developing countries. Drip irrigation needs a large amount of capital investment. Moreover, it needs a very efficient maintenance system, in addition to highly skilled labour which is often not available in developing countries.

What is the possibility of the micro level rationalization of water use; that is, saving water on the farm? Khedr responded that emphasizing the role of agricultural extension would be a means of doing that.

Contributing to the discussion were Puran C. Bansil, Richard Fraenkel, Robin W. M. Johnson, Heinrich Niederboster, and Robert O. Rogers.