TMD DISCUSSION PAPER NO. 7

THE COST OF MANAGING WITH LESS: CUTTING WATER SUBSIDIES AND SUPPLIES IN EGYPT'S AGRICULTURE

Hans Löfgren

Trade and Macroeconomics Division

International Food Policy Research Institute
1200 Seventeenth Street, N.W.
Washington, D.C. 20036-3006 U.S.A.

July 1995
Revised April 1996

THE COST OF MANAGING WITH LESS:
CUTTING WATER SUBSIDIES AND SUPPLIES IN EGYPT'S AGRICULTURE

by

Hans Löfgren

Abbreviated title: Cost of Managing with less

April 3, 1996

International Food Policy Research Institute
1200 17th Str., N.W.
Washington, D.C. 20036
Ph: (202)862-5630
Fax: (202)467-4439
E-mail: h.lofgren@cgnet.com

ABSTRACT

In Egypt, water scarcity is likely in not-too-distant a future. Government budget constraints and reduced farmer taxation have put the removal of water subsidies on the policy agenda. Using a mathematical programming agricultural sector model, this paper explores the impact on Egypt's agriculture of alternative mechanisms for allocating scarce water (a result of water supply cuts) and for charging the farmers for the Operation and Management costs of the irrigation and drainage system. For cost recovery under water scarcity, a volumetric water charge or a "crop-water" charge (based on crop water consumption per land unit) have the advantage of discouraging water consumption. A crop-water charge is administratively easier to implement but does not encourage long-run water-saving technical change. If water is abundant, the land tax is the simplest way of recovering the cost. The effects of cost recovery on real value-added, employment, the consumer surplus, and the agricultural trade balance are negative but minor. A cut in agricultural water use by 15% (permitting a 79% increase in non-agricultural water use) has no negative effect on aggregate farmer incomes but generate declines by 3-7% in real value-added, employment and the consumer surplus; 30% reductions in water use lead to disproportionately larger negative effects, including large increases in the agricultural trade deficit. Compared to the inefficient alternative (half of the farmers are forced to cut their water use), the efficient market-based allocations yield a considerably higher level of real output while they avoid the inequity of unequal water access. However, while boosting government revenues, government sales of water at prices reducing demands by 15-30% would lead to declines in farm net incomes

by 20-35%. This suggests the need to explore institutional reforms endowing the farmers with tradable water rights.

ACKNOWLEDGEMENT

An earlier version of this piece of research was initially presented as a consultancy report to the International Irrigation Management Institute (IIMI), Sri Lanka, within the context of a research project at Egypt's Ministry of Public Works and Water Resources, financed by USAID, Cairo. The author would like to thank Chris Perry, IIMI, for insightful comments on an earlier draft. Research assistance from Monica Scatasta and Moataz El-Said is highly appreciated.

INTRODUCTION

The efficient management of increasingly scarce water resources is one of the major challenges facing the Arab countries. In recent decades, Egypt has been in a relatively favorable position: the water supply from the Nile and the High Dam has been abundant and reliable. Currently, the agricultural sector absorbs some 84% of total supplies. However, as non-agricultural domestic water demands grow (partly reflecting population growth by 2% per year), Egypt's will join other Arab states in having to cope with water scarcity while its agriculture will face increasing competition from other sectors. In Egypt, the government has so far subsidized agricultural water, providing sufficient quantities of water to the sector at no charge. This situation may have to change, not only because of an increasingly tight water demand-supply balance, but also because the government, in its pursuit of fiscal austerity, is looking for new means of financing the costs for the irrigation and drainage system. The removal of implicit farmer taxation via controlled output prices has made the removal of agricultural water subsidies politically more palatable.

Against this background, this paper addresses the impact on Egypt's agriculture of alternative mechanisms for allocating scarce water (a result of water supply cuts) and for removing the subsidy on water services. The latter involves charging the farmers the Operation and Management (O&M) costs of providing irrigation and drainage,[1] henceforth referred to as government recovery of water costs. The analysis of these two issues is based on simulations with a version of an agricultural model of Egypt that was developed at the International Food Policy Research Institute (IFPRI) (Hazell *et al.*, 1995). Although water policies have been addressed in earlier model-based studies of Egyptian agriculture, none of the earlier analyses dealt with the two specific issues that are at the center of this paper.[2] To provide some context for the analysis, we will first briefly discuss water in Egypt with emphasis on the agricultural sector. After this, the model structure is described and the model simulations are defined and analyzed. The main findings are summarized in the concluding section.

BACKGROUND

The management of Egypt's water resources, some 95% of which stem from the Nile, remains a critical factor in the nation's development. In recent years, demands for water have grown with increases in population, incomes, and cultivated areas. In spite of large investments and improved water management (with the High Dam at Aswan as a potent symbol), water scarcity is highly likely in not-too-distant a future, and was felt during a spell of exceptionally small inflows to the High Dam between 1979 and 1988 (Abu-Zeid 1993 p. 72; Richards 1995, p. 5).[3]

As shown in Table 1, Egypt's water use in 1990 was 59.2 bn. m^3, with the agricultural sector absorbing 49.7 bn. m^3 (84% of the total; World Bank 1993, p. 24). For the year 2000, projected total agricultural sector needs are 58 bn. m^3. Whether supplies can be generated at this level is questionable and uncertain--it depends on a large number of factors, some of which are beyond the control of Egypt, most importantly rainfall and water consumption in the states with which Egypt shares the Nile. Moreover, Egypt's agricultural water demand itself (as well as general sector performance) depends on developments in the areas of irrigation and drainage. Underlying much of the analysis in this paper is the premise that water will become scarce and that agriculture, in which the marginal value of water tends to be below that of other sectors, will face a binding water constraint. The current absence of water charges, except for the cost of pumping from local canals, provides little incentive for farmers to conserve water, either through the selection of water-efficient crops or through technical innovation. From the perspective of the government, revenue constraints limit outlays on maintenance and investments in system improvements.

TABLE 1 ABOUT HERE

Accordingly, the recovery of irrigation and drainage costs and the response of the agricultural sector to reduced water supplies have become two major issues facing Egypt's policy makers. Cost recovery is in part motivated by the need to reduce the fiscal burden of operating and maintaining the existing system as well as of carrying out new investments--inadequate investment in irrigation and drainage partly reflects inadequate funding. The argument for letting farmers carry a larger share of this burden has been strengthened as recent reforms have almost completely removed implicit agricultural taxation by means of distorted prices--the contention that the farmers indirectly pay for irrigation and drainage is today much less relevant than 10 years ago. The case for cost recovery would be further strengthened if charges could be linked to quantities of water consumed, thus assuring that agricultural producer decisions are made with a stronger awareness of the economic value of water.

The impact of a shortfall in water supplies on the agricultural sector is a related issue. A well-designed water cost recovery program may, in itself, reduce quantities demanded sufficiently to avert scarcity. However, if cost recovery falls short of removing excess demands, some other mechanism(s), price or non-price, must be relied upon to ration scarce water among competing demands. Presently, in the absence either of physical water rationing or of allocation in accordance with productivity considerations, water shortages fall disproportionately on tail-enders in the system (Richards 1995, p. 12).

In principle, a strong case can be made for creating an incentive system where each farmer makes decisions on water use on the basis of the water opportunity cost, including a charge covering the long-run marginal cost of delivering the water to the local canal and draining the excess: this would promise to generate an efficient allocation with each user demanding water up to the point of equality between the water opportunity cost and its marginal value product, discouraging waste and water-intensive crops in times of scarcity.[4,5] Environmental problems caused by over-irrigation would be mitigated. However, in practice such a scheme faces various obstacles, including the difficulties of measuring individual farmer water consumption and administering a volumetric charge. Hence there is a need to consider the impact of alternative and simpler mechanisms for water cost recovery. In addition to a volume-based charge, cost recovery may, for example, be achieved by means of a supplementary land tax or a differentiated crop charge. Differentiation may reflect length of land occupation (a rough indicator of water consumption) or expected water use (a more precise indicator). Scarce water may, *inter alia,* be rationed by reducing the supply for a subset of the farmers or through some pricing mechanism that limits the quantity demanded to the available supply.

MODEL DESCRIPTION

This section briefly describes the model of Egypt's agriculture that is used for the analyses in this paper. The history of this model goes back to the late 1970s when the initial version was formulated (Kutcher 1981). It was further developed and updated in Kutcher *et al.* (1986), McCarl *et al.* (1989), and Humphries (1991).[6] Here, the starting point is the most recent version (Hazell *et al.* 1995), henceforth referred to as the Hazell model, in which a number of improvements were introduced: an endogenous livestock sector; technology choices for crop and livestock production; the addition of new land regions; and parameter updating to 1990.

The Hazell model simulates the behavior of Egypt's agriculture, assuming profit-maximizing producer behavior and competitive output markets, with flexible prices assuring that the quantities demanded and supplied balance. Its ability to simulate a competitive market equilibrium stems from the fact that the objective function, the value of which is maximized, defines the sum of consumer and producer surpluses, with the former represented by the sum of the areas under a set of linear national demand curves.[7] With the exception of intermediate demands from agriculture, the demand curves cover all categories of domestic demands for agricultural output--private and government consumption, investment demand, and intermediate demands for non-agricultural sectors. The model is comprehensive; it covers crop, livestock and processing activities, including the complex links between these activities (arising from competition for scarce resources and one activity's use of outputs from other activities as inputs). By dividing the country into eight regions, regional differences are taken into consideration.[8] There are activities for 37 crops whereas the livestock activities cover five animal types (buffalo, cattle, sheep and goats, broiler chickens, and laying hens). The production activities use Leontief technology: each activity unit requires fixed quantities of a set of inputs (factors and intermediates), and generates fixed quantities of one or more outputs. For each crop, there is a total of nine activities, exhausting the permutations of three levels of water application and three planting dates; in this way, the restrictiveness of fixed coefficients has been circumvented. Outputs are sold in national markets, exported, or used as inputs in other agricultural activities. In the national market, domestic output is supplemented by imports. Except for wheat imports, exports and imports are included on an endogenous basis with constraints on increases compared to the base level. These constraints are aimed at capturing the effects of trade policies, as well as marketing and infrastructural bottlenecks. Some restrictions are imposed on the production activities, reflecting, *inter alia*, agronomic considerations (upper limits on regional area shares for cotton) and the structure of the irrigation system (upper limit on rice areas). For intermediate inputs, supplies are infinitely elastic at exogenous base-year prices. The model includes four primary factors: family labor, hired labor, land and water. Both types of labor are available at fixed wages (lower for family labor);[9] the farmers face no charge for land and water (except a water-lifting cost). While the supply of hired labor is infinitely elastic at the prevailing wage, family labor and land are available in fixed quantities for each month and region. For water, there is an annual sector-wide water constraint. If the constraints for water, land or family labor are binding, the resource in question is allocated across different production activities in the manner that maximizes profits.

In order to make it more appropriate for an analysis of cost recovery and responses to water scarcity under alternative systems for water rationing, the Hazell model was extended and modified in four areas:

(1) Water cost recovery charges of four types were added: per unit of land held; per unit of land cropped with higher charges for the two major cash crops, cotton and sugarcane (twice the basic level for cotton and three times the basic level for sugarcane); per unit of crop water consumption; and per water-unit consumed.

(2) In each region, the assumption of a single representative farm was replaced by a flexible treatment which, in addition to permitting single regional farms, made it possible to split the resources of each region across two or more farms.

(3) In addition to the model version with a sector-wide water constraint, an alternative version with region- and farm-specific constraints was formulated.

(4) The fixed procurement quota for rice was removed since it is no longer in force.[10]

(5) A distinction was introduced between short- and long-run simulations. For the short-run, the areas of the two major perennials, sugarcane and citrus, were held fixed; for the long-run, these constraints were removed.[11]

Like any other study, this one is subject to various limitations. Perhaps most importantly, by imposing constraining upper limits on export and import quantities (except for wheat imports), the model rules out trade responses that could mitigate the effects of water scarcity, including increased imports of water-intensive crops. Although alternative rates of water and fertilizer applications are permitted, the reliance on fixed input coefficients in other areas may underestimate the flexibility of sector response to changes in the availability or cost of water, in particular over longer time periods. In addition, the treatment of hydrology is highly simplified.[12] If these limitations were overcome, the impact of water charges and supply cuts would most likely by weaker without reversing the over-all qualitative conclusions that are presented.

MODEL SIMULATIONS

In this section, the modified Hazell model is applied to the analysis of two sets of issues facing Egypt's agriculture, water cost recovery and sector response to water scarcity. Each issue is addressed in short- and long-run simulations. First, we present the short-run and long-run base simulations, providing the benchmarks against which the results from the other simulations are assessed. After this, we turn to simulations of the effects of alternative water charges and different ways of rationing scarce water.

Base Simulations

The base simulations are represented by the 1990 solution to the modified Hazell model, with unconstrained water, a single representative farm in each region, and all water cost recovery parameters set at zero. The assumption of unconstrained water is appropriate given relatively high average inflows to the High Dam since 1988.[13] The only difference between the short- and long-run benchmarks lies in the treatment of the areas of the two perennial crops of the model, sugarcane and citrus. For the short-run base simulations (and for all other short-run simulations), these areas are fixed at observed 1990 levels; for the long-run base simulation (and for all other long-run simulations), these areas are flexible.

Tables 2 and 3 summarize the base results.[14] The main difference between the two simulations is the disappearance of sugarcane from the cropping pattern in conjunction with a drastic increase in the area of sugarbeet, the alternative source of sugar in the model. This implies that, in the absence of area controls, long-run adjustment to 1990 conditions would lead to gradual disappearance of the sugarcane crop.[15] This and other developments would lead to significant increases in real value-added (aggregate and per water-unit) and farm incomes.[16] Employment, cropping intensity (number of crops per land unit and year), the livestock population, and the consumer surplus would also go up.[17] The agricultural trade deficit declines because of lower wheat imports.

TABLE 2 ABOUT HERE

TABLE 3 ABOUT HERE

In each simulation, one of the four water charges, aimed at recovering the O&M costs of the irrigation and drainage system, is set at a level generating aggregate predetermined revenues of LE541 mn. (Perry 1995)).[18] The other charge parameters are kept at zero.

Short Run

Table 4 states the alternative parameter values for water charges used in the short-run simulations (with each alternative generating the basic revenue) while Tables 5 and 6 show the main results for the short-run basic-revenue simulations. Compared to the short-run base simulation, the charge imposed for the basic-revenue simulations corresponds to 6.0% of farmer cost and 4.5% of farmer net income. For the land-tax alternative, the simulated impact is limited to these cost and income changes since, as expected for a partial equilibrium model, the land tax is a lump-sum tax with no impact on economic activity.[19] Thus, this tax serves the purpose of generating government revenue without any impact on the production pattern. However, compared to the other simulations, the income cut is larger, reflecting the fact that larger production volumes raise costs and, given price-inelastic demands for most agricultural outputs, lead to reduced revenues.

TABLE 4 ABOUT HERE

TABLE 5 ABOUT HERE

TABLE 6 ABOUT HERE

In addition to lower farm incomes and higher farm costs, the remaining three simulations all lead to declines in real value-added, water consumption, employment, and the consumer surplus as well as an increase in real value-added per water unit. The changes are quite moderate, given the relatively small addition to total farmer costs. There is little change in agricultural trade. The fall in real value-added follows from reduced use of all primary factors, for land reflected in a lower cropping intensity. Livestock holdings also decline as the prices of fodder products go up. The differences between the crop charge and the last two simulations stem from the varying degrees to which they directly penalize water use--the declines in water consumption and the increases in real value-added per water unit are most pronounced for the last two simulations.

The effects of a crop-water charge (discouraging water-intensive crops) and a water charge (discouraging water consumption) are virtually identical; suggesting that, at least in the absence of technical change, the main source of water savings is a change in the cropping pattern, not in crop water use per feddan.[20] The implication is that it is not necessary to impose a volumetric charge (requiring that individual farmer consumption is measured); an almost identical short-run effect can be achieved by imposing crop charges that are proportional to crop water use. However, if the time frame were long enough to permit technical change, the effects of the two charges would probably differ since only a volumetric charge encourages the development and adoption of water-saving techniques. If a crop-water charge is imposed, the government would face more of the burden of encouraging less water-intensive techniques using means other than water charges. On the other hand, if water is abundant, it may be preferable to impose the administratively simplest and least distorting means of recovering the cost: a land tax.

Throughout the short-run water cost simulations, the major changes in the cropping pattern are declines in the areas of cotton and soybeans. For the crop charge, cotton is singled out with twice the basic rate whereas soybeans, with a comparatively short period of land occupation (four months), faces a relatively large increase in marginal land cost. Both cotton and soybeans have above average water coefficients, as a result of which they are penalized more than other crops in the last two scenarios. However, the fact that there is only a minor decline in the area of rice (a water-intensive crop) shows that other aspects, including output demands and the profitability of substitute crops, influence the results.

Long Run

A summary of the results from the long-run simulations of basic-revenue water charges is provided in Tables 7 and 8. When compared to the *long-run* base, the changes in the indicators for the long-run simulations quite closely match those of the short-run simulations--they are all in the same direction and of similar magnitudes. Once again, the differences between the crop-water charge and the water charge are very minor. However, the changes reported in Table 7 are quite substantial if compared to the *short-run* base (although only the part appearing in Table 7 can be attributed to the water charges). For example, water consumption is cut by a total of 6.8-7.3%.

Thus, a combination of liberalization and water charges would, under base-year conditions, generate substantial water savings.

TABLE 7 ABOUT HERE

TABLE 8 ABOUT HERE

The changes in crop area shares are also more substantial and more widespread, including the two remaining crops with the highest rates of water application, citrus (which had exogenous areas for the short-run simulations) and rice. (The most water-intensive crop, sugarcane, had already disappeared from the cropping pattern.) A noticeable difference between the last three simulations is that the perennial and water-intensive citrus crop has an area increase for the crop charge but a decline for the last two simulations. The primary reason is that, for the crop charge scenario, citrus only faces the standard per-feddan charge in spite of being a perennial crop--its relative increase in marginal crop land cost is small compared to other crops; for the last two scenarios, citrus is fully penalized for its high rates of water application.

Water Supply Cuts

For these experiments, aggregate water supply is cut by 15% or 30% compared to the unconstrained short-run base level. Given that agriculture initially consumes 84% of the total water supply, these cuts would permit substantial increases in non-agricultural water consumption, by 79% and 158%, respectively (assuming an unchanged aggregate national water supply). Both supply cuts are simulated under long-run assumptions while, for the short-run, only the 15% cut is implemented.

Two mechanisms for rationing the resulting scarce water supply are simulated. For the alternative labeled "inefficient," half of the farmers are forced to reduce their water consumption by 30% or 60% (the farmers at the tail of the local canal), while the other half is constrained to stay at its base year consumption level (the farmers at the head of the local canal). The latter is a stylized representation of the fact that, in times of scarcity, cutbacks in water use fall disproportionately on farmers with fields at the end of local canals. For the efficient alternative, two aggregate water supply constraints are in place, for Nile-fed and (the relatively insignificant) groundwater-fed areas.[21] Within each system, water is allocated so as to assure that its marginal value product is the same for all production activities. A comparison between the efficient and inefficient simulations gives a rough idea of the potential importance of taking efficiency into consideration in the allocation of scarce water.

Short Run

Tables 9 and 10 display aggregate results for the two short-run simulations. As expected, both simulations show declines in real value-added, employment, cropping intensity, and the consumer surplus. The declines are significantly larger for the inefficiently distributed cut. Most of the adjustment burden is absorbed by the domestic demanders as prices go up and quantities demanded decline. The burden is mitigated by an increase in the agricultural trade deficit, the result of higher wheat imports (especially for the efficient cut). The fall in cropping intensity is echoed in substantial cuts for all major crops except berseem (Egyptian clover), signaling a shift toward berseem as a source of animal nutrients and pointing to potential costs of trying to raise self-reliance for the strategic wheat crop. For these as well as for the other simulations of water cuts, planting dates and rates of water application shift to realize water savings.

TABLE 9 ABOUT HERE

TABLE 10 ABOUT HERE

Aggregate farm incomes go up, showing that a drought is not necessarily an unfortunate event for farmers. This income increase is the result of lower production costs and higher revenues (in its turn due to low price-elasticities of output demand). For the inefficient water cut, the disaggregated farm-level impact is, not surprisingly, uneven. Farmers with an unchanged supply of the scarce resource record an income increase by 19% (as they capture more of the rents of scarce water) whereas those facing the supply cut see their income decline by 7%. Given that each farm type initially received 50% of all income, the result is an increase in aggregate farm income by 6%. The over-all implication is that the farmers as a group have little reason to worry about reduced water availability within the range considered in the above simulations. This also applies on the individual level if scarce water is allocated efficiently across the farmers.

In the income calculations, no charge is imposed for water. The price (scarcity value) per m^3 of water for the efficient cut is LE0.065 in the Nile-fed regions and LE0.061 in the groundwater region. This price is quite high, approximately five times as large as the water charge for the basic cost recovery simulation. If the government were to sell the water to the farmers at these prices, aggregate farm costs would go up from LE8.8bn. to LE11.5bn. (by 32%) while net incomes would fall from LE12.1bn. to LE9.4bn. (by 22%). Given that, on average, urban incomes are higher than rural and agricultural incomes, equity considerations suggest that there is a need for complementary measures recycling part of the government revenue to the farmers (World Bank 1990, pp. 11-12 and 161). Endowing the farmers with transferable water rights is an alternative system that may be more attractive; it does not impose a burden on aggregate farmer incomes while it, at least in principle, generates an identical (efficient) allocation of agricultural resources.[22] In point of fact, reported farmer incomes are valid if it is assumed that the water rights of each farmer are equal to the quantities used in the different simulations. However, the payment from the farmers would be reflected in a corresponding decline in government revenue. In a broader analysis, the economic outcomes of alternative systems for water allocation should be assessed in conjunction with an analysis of the costs of introducing and operating each system.

Long Run

Results for the long-run simulations are displayed in Tables 11 and 12. For the 15% water cuts, changes in real value-added (both aggregate and per water-unit), the consumer surplus and farm incomes are similar to the short-run case.[23] Once again, there are substantial income increases for the farms with an unchanged water supply (by 22%) whereas the farms that faced the cut only face a strong decline (by 14%).

TABLE 11 ABOUT HERE

TABLE 12 ABOUT HERE

The ability of the sector to withstand the 30% cuts is more limited. Real value-added, employment and cropping intensity all decline by 10-20% and there are drastic increases in the trade deficit. For the inefficient cut, a strong negative impact is felt by the farmers that faced the water cut (income decline by 30%) whereas the more fortunate farmers do much better (income increase by 30%), leaving aggregate farmer income virtually unchanged.

Except for disaggregated farmer incomes, all indicators in Tables 11 and 12 have the same sign for efficient and inefficient cuts. The performance of the efficient cuts is, however, superior according to most criteria: real value-added (aggregate and per water unit), employment, cropping intensity, and the consumer surplus fall by less, there is no water-induced inequality in farm incomes, and the increase in the trade deficit is smaller. Thus, also in the long run, it is not necessary to trade off equity against other performance indicators if an efficient mechanism for water allocation is selected. One significant exception to better performance is aggregate farm incomes: for each of the two cuts, they end up lower for the efficient cut since, with a smaller fall in production, revenue increases (reflecting inelastic demands) are smaller.

With average area cuts between 5.5% and 16.8%, areas decline for many crops, especially for those with above average water consumption coefficients. (Water coefficients are shown in Table A-1 of the Appendix.) Across all long-run simulations of water supply cuts, wheat, cotton, soybeans and rice register substantially lower areas.[24] Berseem is the only major crop with significant area increases for most long-run simulations.

Table 13 summarizes data on water prices, farm costs, and farm net incomes for the short- and long-run simulations of efficient water supply cuts. For the 15% cut, the short- and long-run values are of similar magnitudes; the long-run effect of the 30% cut is roughly twice as large. Data on water prices and consumption for the efficient 15% and 30% cuts (see Tables 11 and 13) indicate that, for the long run, water demand is fairly inelastic: the computed arc-elasticity is -0.29.[25] The results confirm the earlier observation that a straightforward implementation of scarcity pricing under conditions of drastic cuts in water supply would impose excessive burdens on the farmers. The establishment of a system of transferable farmer water rights could overcome this drawback.

TABLE 13 ABOUT HERE

CONCLUSIONS

This paper explores the impact of cutting O&M water subsidies and water supplies on Egypt's agriculture using a sectoral mathematical programming model. In 1990, the O&M cost for the irrigation and drainage system amounted to 6% of total farmer cost. If water is scarce, it would be preferable to recover this cost using some mechanism that at the same time discourages water use. Among the alternatives explored, a water charge (per m^3 consumed) or a "crop-water" charge based on crop per-feddan water consumption are most effective according to this criterion; declines in water consumption are around 3-4%. A crop-water charge may be preferable since its administrative and informational prerequisites are less burdensome. The volumetric charge would, however, have the advantage of encouraging long-run water-saving technical change. Apart from the cut in government spending, the broader repercussions of eliminating O&M subsidies using these approaches are negative (but quite minor). If water is not scarce, a land tax would provide an alternative with minimal distortionary effects.[26] However, it is noteworthy that, because of low output demand elasticities and higher production, farm net incomes fall more for the land tax than for the other alternatives.

The second part of the analysis addresses the effects of reducing agricultural water supply by 15-30%, ceteris paribus permitting increases in water use in the rest of the economy by as much as 79-158%. The results suggest that the sector can reduce water use by 15% without prohibitive negative effects. Aggregate farmer incomes do not suffer while the declines in real value-added, employment, the consumer surplus range between 3% and 7%. However, for the 30% cut, the declines in these indicators (except farmer incomes) are disproportionately larger.

The analysis shows that there are clear advantages to applying efficiency criteria to the allocation of scarce agricultural water. When compared to the simulated inefficient alternative (half of the farmers are forced to cut their water use), the efficient allocations yield a considerably higher level of real output while they avoid the inequity associated with unequal access to water. The efficient outcome could result from assigning tradable water rights to the farmers or, alternatively, from assigning the water rights to a government agency that charges the farmers for water. While the outcomes may be identical in terms of efficiency, the distributional contrast is stark. With a government agency charging prices sufficient to reduce water consumption by 15-30%, government revenues are boosted (under 1990 conditions by 11-18%)[27] while farm net incomes decline by as much as 20-35%. Given Egypt's income distribution, this suggests that it may be worthwhile to explore institutional reforms endowing the farmers with tradable water rights.

APPENDIX

TABLE A1 ABOUT HERE

NOTES

REFERENCES

TABLES

NOTES

1. In addition, approximately 85-90% of the investment costs for the irrigation and drainage system are subsidized (IIMI 1995, p. 4-5). Investment costs are not covered in this study which is limited to O&M costs.

2. Kutcher (1981) made projections up to 2000, investigating the extent of water scarcity under alternative scenarios for land reclamation and urban encroachment into old lands in the Nile McCarl (1988) and Humphries and Löfgren (1991) analyze operational policies for the High Dam at Aswan. Kutcher (1993) develops alternative projections for Egypt's water balance and optimal water allocations using an optimization model that combines economic and hydrological features. Hazell *et al.* (1995, pp. 11-13) analyze responses to reduced agricultural water supplies, assuming that available water is allocated efficiently across crops and regions.

3. The position that future water scarcities are likely is supported by Kutcher (1993, pp. 24-25, 32). His model simulations indicate that the agricultural sector will face significant water shortages in the future, in particular if plans for future desert reclamation of new lands are fully implemented.

4. In the current relatively undistorted environment, second-best fears are less warranted. Thus, the removal of a major distortion does most likely raise economic efficiency.

5. In 1990, rice and sugarcane accounted for 35% of crop water consumption in spite of the fact that they represented no more than 12-13% of the cropped area and value-added (World Bank 1993, p. 28).

6. Starting from Kutcher *et al.* (1986), the models have been implemented using the GAMS

modeling software, described in Brooke *et al.* (1988). More detailed descriptions of the structure of these models are found in McCarl *et al.* (1989) and Humphries (1991). Löfgren (1993) provides an example of a GAMS-based model of Egyptian agriculture on the regional level. For a textbook on mathematical programming models of the agricultural sector, see Hazell and Norton (1986).

7. This is revealed by the first-order Kuhn-Tucker conditions which are necessary and sufficient for an optimal solution to this class of models. Earlier generations of agricultural sector models were normative, showing the allocation of resources that is optimal according to some criterion (for example maximizing producer income) without addressing how the farmers, given their objectives, could be induced to generate the optimal outcome. In contrast to such models, the current model is descriptive, simulating sector behavior on the basis of standard partial-equilibrium assumptions regarding the behavior of individual actors and the functioning of markets.

8. The eight regions are upper Egypt, middle Egypt, eastern Delta, middle Delta, western Delta, canal-irrigated new lands with sandy soil, canal-irrigated new lands with clay calcareous soil, and groundwater-irrigated new lands.

9. The wage for family labor, referred to as its reservation wage, is recycled to the farm family in calculations of farmer income. The fact that it is smaller than the market wage may be justified as follows: although family labor can work off-farm at the prevailing market wage, the net wage it would receive is smaller than the market wage because of additional expenses associated with off-farm work (for example time and cost of transportation and additional food expenses).

10. The purpose of the simulations is to better understand current sector response to changed

water policies. Given this, misleading results would be generated if it were assumed that rice production is regulated by quotas.

11. Thus, for the simulations of this study, the term long-run refers to long-run adjustment to 1990 conditions, including responses to exogenous changes in water policy and supplies.

12. The fact that much of the model data is based on one year (1990) is not a serious limitation. Given that the structure of Egypt's agriculture is relatively stable, the results from model simulations for another base year would be similar, especially for the aggregate numbers that are presented in the paper.

13. One advantage of not constraining water for the base simulation is that one avoids the assumption that scarce water is allocated across producers and activities in a manner mimicking the outcome for a price-clearing water market. Such an assumption, associated with a binding aggregate (national or regional) constraint, would clearly overestimate the efficiency with which water has been allocated in times of scarcity in Egypt's past.

14. As noted in Hazell *et al.* (1995, pp. 4-5), the model version that more fully captures 1990 conditions is able to replicate observed data to a satisfactory extent.

15. However, this is not a prediction of the actual disappearance of sugarcane a few years after 1990 since (1) government area restrictions for sugarcane have remained in force (contrary to what was assumed for the long-run base simulation); and (2) many exogenous factors affecting relative crop profitabilities have been in continuous change since 1990 (partly invalidating the assumption of otherwise unchanged 1990 conditions).

16. Real agricultural value-added is defined as agricultural revenue (from sales domestically and abroad) *minus* the cost of intermediate inputs and imports, with all quantities valued at base

prices. There are no charges for primary factors. Net farm incomes are computed on the micro level as farm revenues minus costs at simulated prices. Value-added is a broader concept than farm income since it also includes rents generated by constraints beyond the farm level, for example in the foreign trade area.

17. The consumer surplus is derived from prices, quantities consumed, and the demand curves, which represent all domestic demands except intermediate use in agriculture. Changes in consumer surplus may be considered an approximate indicator of welfare changes for these demanders.

18. Given a land area of 7.729 million feddans (1 feddan = 0.42 hectares), this value corresponds to LE70 per feddan of agricultural land; see also IIMI (1995, p. 9).

19. In a general equilibrium setting, a land tax would redistribute income from farmers to the government, with various repercussions. The assumption for the current model is that the impact of these repercussions on the agricultural sector are so small that they may be neglected.

20. For the water charge simulations, no cropping activity shifts to less than the highest rate of water application. There is, however, some adjustment in planting dates toward less water-demanding periods.

21. Only one of the eight regions, representing 0.8% of aggregate base-run water consumption, relies on groundwater.

22. Basic issues related to tradable water rights are discussed in Rosegrant and Binswanger (1994, p. 1615). Rosegrant and Gazmuri (1995) draw lessons for developing countries from case studies of tradable water rights in Chile, Mexico and California.

23. Note that, for the long-run simulations, the basis for the comparison is the long-run base.

24. Among these, all but wheat have above average water coefficients.

25. For a 10% cut in water consumption compared to their base run, Hazell *et. al* (1995, p. 11) report a short-run elasticity of roughly the same magnitude (-0.37).

26. Similar conclusions have been drawn in other studies of cost recovery. See IIMI (1995, p. 3) for references.

27. In 1990, total government revenues were LE23.435bn (IMF 1996, p. 220). The total water market value for the simulations of 15-30% supply cuts is between LE2.58-4.26bn.

REFERENCES

Abu-Zeid, Mahmoud (1993) "Egypt's Water Resource Management and Policies," pp. 71-80 in Mohamed A. Faris and Mahmood Hasan Khan, eds. Sustainable Agriculture in Egypt. Boulder, Colorado: Lynne Rienner.

Brooke, Anthony, David Kendrick and Alexander Meeraus (1988) GAMS: A User's Guide. Redwood, California: The Scientific Press.

Hazell, Peter B.R. and Roger D. Norton (1986) Mathematical Programming for Economic Analysis in Agriculture. New York: Macmillan.

Hazell, Peter B.R., Nicostrato Perez, Gamal Siam and Ibrahim Soliman (1995) Impact of the Structural Adjustment Program on Agricultural Production and Resource Use in Egypt. Discussion Paper No. 10, Environment and Production Technology Division, International Food Policy Research Institute, Washington, D.C. August.

Humphries, John W. (1991) The Egyptian Agricultural Sector Model (EASM91): A User's Manual. Cairo: Planning Studies and Models Component, Ministry of Public Works and Water Resources. July.

Humphries, John W. and Hans Löfgren (1991) Drought Policy Analysis. Cairo: Planning Studies and Models Component, Ministry of Public Works and Water Resources. May.

IIMI (International Irrigation Management Institute) (1995) Strengthening Irrigation Management in Egypt: A Program for the Future. Report Presented to the Ministry of Public Works and Water Resources, Cairo, Egypt. May.

IMF (International Monetary Fund) (1996) International Financial Statistics. March.

Kutcher, Gary P. (1981) Water Master Plan: The Agroeconomic Model. Technical Report No. 16, UNDP-EGY/73/24, March. Cairo: Ministry of Irrigation-UNDP-IBRD.

Kutcher, Gary P., Alexander Meeraus, and Gerald T. O'Mara (1986) Agricultural Modeling for Policy Analysis. World Bank. Mimeo. September.

Kutcher, Gary P. (1993) Water Security Project: Nile Economic Model (Nilecon). Final Report presented to the World Bank; United Nations Development Programme; and Ministry of Public Works and Water Resources (Planning Sector), Egypt. July.

Löfgren, Hans (1993) "Liberalizing Egypt's Agriculture: A Quadratic Programming Approach," Journal of African Economies, vol. 2, no. 2, pp. 238-261.

McCarl, Bruce A. (1988) An Examination of Lake Nassar Operating Policies and Associated Cropping Patterns. College Station, Texas:Texas A & M University. Mimeo. January.

McCarl, Bruce A., Bayoumi Attia, and Leroy Quance (1989) Documentation of the Egyptian Agricultural Sector Model EASM89: How It Works and How to Use It. May. Mimeo. Cairo.

Perry, Chris (1995) Personal communication.

Richards, Alan (1995) Management Strategies for Coping with Water Scarcity: An Exploration of Issues. Prepared for Strengthening the Planning Sector Project, Ministry of Public Works and Water Resources, Delft Hydraulics, EAC/RAND, and RIZA. Cairo. July.

Rosegrant, Mark W. and Hans P. Binswanter (1994) "Markets in Tradable Water Rights: Potential for Efficiency Gains in Developing Country Water Resource Allocation," World Development, vol. 22, no. 11, November, pp. 1613-1625.

Rosegrant, Mark W. and Renato Gazmuri S. (1995) "Reforming Water Allocation Policy Through Markets in Tradable Water Rights: Lessons from Chile, Mexico and California," Cuadernos de Economia, vol. 32, no. 97, December, pp. 291-315.

World Bank (1990) Egypt: Alleviating Poverty During Structural Adjustment. A World Bank Country Study. Washington, D.C.

World Bank (1993) Arab Republic of Egypt: An Agricultural Strategy for the 1990s. A World Bank Country Study. Washington, D.C.

Table 1. Egypt's water balance in 1990 (actual) and 2000 (projected)

Water Use	1990 (actual)	2000 (projected)
Agriculture	49.7	58.8
Consumptive Use	32.9	n.a.
Non-agriculture	9.5	11.2
Total	59.2	70.0

Note: n.a. = not available
Sources: Abu-Zeid (1993, p. 74) and World Bank (1993, p. 24)

Table 2. Base simulations for the Short- and Long-run: General Data.

ITEM	Short-Run Base	Long-Run Base (*)
Real agricultural value added (billion 1990 LE)	13.06	4.46
Agricultural water consumption (billion cubic meters)	49.70	-3.22
Real agr. value added per water unit (LE per cubic met	0.26	7.93
Agricultural employment (million man-days)	1276.07	1.28
Farm net income (billion LE) (**)	12.12	4.11
Cropping intensity (cropped area/land area)	1.79	1.84
Livestock population (million units)	11.34	1.19
Consumer surplus (billion 1990 LE)	26.24	0.48
Agricultural trade deficit (billion 1990 LE)	2.52	-7.27

(*) % change from Short-Run Base.
(**) Includes return to family labor.

Table 3. Base simulations for the Short- and Long-run: Crop Data.

CROP	Short-Run Base (*)	Long-Run Base (**)
Berseem (Egyptian Clover)	9.24	8.54
Wheat	34.90	1.72
Onion	0.55	0.05
Sorghum	1.21	0.95
Maize	17.15	-0.50
Citrus	2.00	7.87
Rice	5.79	5.73
Vegetables	7.58	4.60
Cotton	8.93	3.39
Favabean	2.46	0.07
Soybean	5.13	0.05
Sugarcane	1.90	-100.00
Sugarbeet	0.97	132.53
Other	2.20	-0.14
Total %	100.00	

(*) % of total cropped area.
(**) % area change from Short-Run Base.

Table 4. Parameter values for short-run water cost recovery (basic revenue)

Experiment name	Charge parameter value
Land-tax	Tax at LE70 per feddan held
Crop-charge	Standard charge at LE36.3 per feddan and crop; doubled for cotton; tripled for sugarcane
Crop-water-charge	Crop-specific per-feddan charge at LE0.012 (per m^3) *times* expected per-feddan water consumption*
Water-charge	Charge at LE0.012 per m^3

* Expected values are assumed equal to average crop value for the short-run base simulation. This tax is differentiated by region. It is based on a weighted average of per-feddan water consumption for the activities of each crop, across different planting dates and water application rates.

Table 5. Short-run simulations of water cost recovery (basic revenue): General data.

ITEM (***)	Short-Run Base	Land Tax (*)	Crop Tax (*)	Crop-Water Tax (*)	Water Tax (*)
Real agricultural value added	13.06	0	-0.68	-0.87	-0.88
Agricultural water consumption	49.70	0	-2.85	-3.48	-3.50
Real agr. value added per water unit	0.26	0	2.23	2.70	2.71
Agricultural employment	1276.07	0	-1.22	-1.57	-1.57
Farm net income (**)	12.12	-4.46	-3.37	-2.36	-2.31
Cropping intensity	1.79	0	-1.81	-2.14	-2.15
Livestock population	11.34	0	-0.15	-0.42	-0.42
Consumer surplus	26.24	0	-0.80	-1.35	-1.37
Agricultural trade deficit	2.52	0	0.96	0.48	0.47

(*) % change from Short-Run Base.
(**) Includes return to family labor.
(***) Units shown in Table 2.

Table 6. Short-run simulations of water cost recovery (basic revenue): Crop data.

CROP	Short-Run Base (*)	Crop Tax (**)	Crop-Water Tax (**)	Water Tax (**)
Berseem (Egyptian Clover)	9.24	1.76	0.55	0.57
Wheat	34.90	-0.51	-0.42	-0.41
Onion	0.55	-0.20	-0.27	-0.29
Sorghum	1.21	-1.51	-2.69	-2.73
Maize	17.15	-1.07	-1.63	-1.64
Citrus	2.0	0	0	0
Rice	5.79	-0.79	-2.17	-2.21
Vegetables	7.58	-0.41	-0.55	-0.57
Cotton	8.93	-10.04	-9.80	-9.80
Favabean	2.46	0.03	-0.03	-0.07
Soybean	5.13	-10.77	-13.16	-13.21
Sugarcane	1.90	0	0	0
Sugarbeet	0.97	-0.01	-0.46	0.46
Other	2.20	-2.86	-0.96	-0.96
Total %	100.00			

(*) % of total cropped area.
(**) % area change from Short-Run Base.

Table 7. Long-run simulations of water cost recovery (basic revenue): General data.

ITEM (***)	Long-Run Base	Land Tax (*)	Crop Tax (*)	Crop-Water Tax (*)	Water Tax (*)
Real agricultural value added	13.64	0	-0.88	-0.96	-0.96
Agricultural water consumption	48.10	0	-3.58	-4.10	-4.11
Real agr. value added per water unit	0.28	0	2.79	3.27	3.29
Agricultural employment	1292.39	0	-1.62	-1.76	-1.77
Farm net income (**)	12.62	-4.29	-3.09	-2.65	-2.60
Cropping intensity	1.83	0	-2.48	-2.20	-2.21
Livestock population	11.47	0	-0.32	-0.51	-0.51
Consumer surplus	26.37	0	-0.97	-1.23	-1.26
Agricultural trade deficit	2.33	0	1.38	1.01	0.96

(*) % change from Long-Run Base.
(**) Includes return to family labor.
(***) Units shown in Table 2.

Table 8. Long-run simulations of water cost recovery (basic revenue): Crop data.

CROP	Long-Run Base (*)	Crop Tax (**)	Crop-Water Tax (**)	Water Tax (**)
Berseem (Egyptian Clover)	9.85	0.27	-0.06	-0.04
Wheat	34.86	-1.15	-0.36	-0.35
Onion	0.54	-0.21	-0.23	-0.27
Sorghum	1.20	-1.41	-2.07	-2.18
Maize	16.76	-0.60	1.06	1.01
Citrus	2.12	4.66	-5.93	-5.91
Rice	6.0	-3.38	-7.82	-7.81
Vegetables	7.79	-1.46	-1.08	-1.08
Cotton	9.07	-10.79	-8.39	-8.47
Favabean	2.42	0.25	0.19	0.13
Soybean	5.04	-14.47	-15.07	-15.09
Sugarbeet	2.20	0.06	0.31	0.31
Other	2.16	-3.03	-1.62	-1.53
Total %	100.0			

(*) % of total cropped area.
(**) % area change from Long-Run Base.

Table 9. Short-run simulations of cuts in water supply (15% cut): General data.

ITEM (***)	Short-Run Base	Inefficient Cut (*)	Efficient Cut (*)
Real agricultural value added	13.06	-7.12	-3.96
Agricultural water consumption	49.70	-15.00	-15.00
Real agr. value added per water unit	0.26	9.27	12.99
Agricultural employment	1276.07	-7.10	-3.56
Farm net income (**)			
Aggregate	12.12	6.21	2.04
Farm with No Water Cut	6.06	19.10	2.04
Farm with Water Cut	6.06	-6.67	2.04
Cropping intensity	1.79	-8.05	-7.24
Livestock population	11.34	-2.83	0.11
Consumer surplus	26.24	-6.79	-2.32
Agricultural trade deficit	2.52	16.40	31.17

(*) % change from Short-Run Base.
(**) Includes return to family labor.
(***) Units shown in Table 2.

Table 10. Short-run simulations of cuts in water supply (15% cut): Crop data.

CROP	Short-Run Base (*)	Inefficient Cut (**)	Efficient Cut (**)
Berseem (Egyptian Clover)	9.24	9.27	23.92
Wheat	34.90	-8.49	-18.18
Onion	0.55	0.46	-0.84
Sorghum	1.21	-14.51	-7.93
Maize	17.15	-3.01	-2.33
Citrus	2.00	0	0
Rice	5.79	-13.97	-6.71
Vegetables	7.58	-3.88	-0.94
Cotton	8.93	-42.17	-15.77
Favabean	2.46	0.56	-3.60
Soybean	5.13	-9.96	-15.80
Sugarcane	1.90	0	0
Sugarbeet	0.97	15.92	26.52
Other	2.20	-1.76	-4.33
Total %	100.00		

(*) % of total cropped area.
(**) % area change from Short-Run Base.

Table 11. Long-run simulations of cuts in water supply: General data.

ITEM (***)	Long-Run Base	Inefficient 15% cut (*)	Inefficient 30% cut (*)	Efficient 15% cut (*)	Efficient 30% cut (*)
Real agricultural value added	13.64	-6.04	-17.00	-2.90	-11.26
Agricultural water consumption	48.10	-13.04	-28.38	-12.17	-27.67
Real agr. value added per water unit	0.28	8.05	15.89	10.56	22.70
Agricultural employment	1292.39	-6.50	-14.23	-3.30	-11.83
Farm net income (**)					
Aggregate	12.62	4.32	-0.38	1.93	-0.64
Farm with No Water Cut	6.31	22.22	29.70	1.93	-0.64
Farm with Water Cut	6.31	-13.58	-30.45	1.93	-0.64
Cropping intensity	1.83	-7.30	-16.85	-5.52	-16.25
Livestock population	11.47	-2.15	-3.45	0.51	-4.36
Consumer surplus	26.37	-5.49	-9.65	-2.21	-5.27
Agricultural trade deficit	2.33	12.71	66.62	24.38	57.10

(*) % change from Long-Run Base.
(**) Includes return to family labor.
(***) Units shown in Table 2.

Table 12. Long-run simulations of cuts in water supply: Crop data.

CROP	Long-Run Base (*)	Inefficient 15% cut (**)	Inefficient 30% cut (**)	Efficient 15% cut (**)	Efficient 30% cut (**)
Berseem (Egyptian Clover)	9.85	4.01	27.94	26.17	-5.72
Wheat	34.86	-7.31	-18.14	-11.75	-29.01
Onion	0.54	5.29	0.27	-0.41	5.27
Sorghum	1.20	-6.52	-16.53	-4.20	-3.59
Maize	16.76	0.21	-5.41	-1.30	1.00
Citrus	2.12	-0.69	-29.20	-22.82	-29.52
Rice	6.01	-15.63	-24.39	-11.78	-13.00
Vegetables	7.79	-8.10	-9.51	-2.61	-6.76
Cotton	9.07	-31.52	-59.21	-16.54	-30.43
Favabean	2.42	-2.62	3.13	-0.68	-3.22
Soybean	5.04	-12.53	-100.00	-15.67	-17.00
Sugarbeet	2.20	0.52	0.72	1.24	0.58
Other	2.16	0.35	44.87	2.95	-5.27
Total %	100.0				

(*) % of total cropped area.
(**) % area change from Long-Run Base.

Table 13. Water price, farm cost and farm net income changes for efficient water cuts.

ITEM	Short Run 15%	Long Run 15%	Long Run 30%
Price (LE per cubic meter)	0.07	0.06	0.12
Cost (% change)	31.51	29.54	51.09
Income (% change)	-22.29	-20.06	-33.95

Note: Percentage cost and income changes are computed relative to the values for each simulation (not relative to the long- and short-run base simulations). Water prices are for Nile-fed regions (not the groundwater region).

Table A1. Crop ranking according to consumptive water use ('000 m3 per feddan).

Crop		Crop	
Sugarcane	8.23	Onion	2.21
Citrus	4.55	Maize	2.16
Rice	3.75	Wheat	1.99
Cotton	2.57	Other	2.00
Sorghum	2.49	Favabean	1.65
Soybean	2.54	Sugarbeet	1.67
Average	2.37	Vegetables	1.68
Berseem	2.30		

Source: Model short-run base simulation.

Note: Consumptive water use is approximately 60-70% of gross water use, including losses.

LIST OF TMD DISCUSSION PAPERS

No. 1 - "Land, Water, and Agriculture in Egypt: The Economywide Impact of Policy Reform" by Sherman Robinson and Clemen Gehlhar (January 1995)

No. 2 - "Price Competitiveness and Variability in Egyptian Cotton: Effects of Sectoral and Economywide Policies" by Romeo M. Bautista and Clemen Gehlhar (January 1995)

No. 3 - "International Trade, Regional Integration and Food Security in the Middle East" by Dean A. DeRosa (January 1995)

No. 4 - "The Green Revolution in a Macroeconomic Perspective: The Philippine Case" by Romeo M. Bautista (May 1995)

No. 5 - "Macro and Micro Effects of Subsidy Cuts: A Short-Run CGE Analysis for Egypt" by Hans Löfgren (May 1995)

No. 6 - "On the Production Economics of Cattle" by Yair Mundlak, He Huang and Edgardo Favaro (May 1995)

No. 7 - "The Cost of Managing with Less: Cutting Water Subsidies and Supplies in Egypt's Agriculture" by Hans Löfgren (July 1995, Revised April 1996)

No. 8 - "The Impact of the Mexican Crisis on Trade, Agriculture and Migration" by Sherman Robinson, Mary Burfisher and Karen Thierfelder (September 1995)

No. 9 - "The Trade-Wage Debate in a Model with Nontraded Goods: Making Room for Labor Economists in Trade Theory" by Sherman Robinson and Karen Thierfelder (Revised March 1996)

No. 10 - "Macroeconomic Adjustment and Agricultural Performance in Southern Africa: A Quantitative Overview" by Romeo M. Bautista (February 1996)

No. 11 - "Tiger or Turtle? Exploring Alternative Futures for Egypt to 2020" by Hans Löfgren, Sherman Robinson and David Nygaard (August 1996)

No. 12 - "Water and Land in South Africa: Economywide Impacts of Reform - A Case Study for the Olifants River" by Natasha Mukherjee (July 1996)

No. 13 - "Agriculture and the New Industrial Revolution in Asia" by Romeo M. Bautista and Dean A. DeRosa (September 1996)

No. 14 - "Income and Equity Effects of Crop Productivity Growth Under Alternative Foreign Trade Regimes: A CGE Analysis for the Philippines" by Romeo M. Bautista and Sherman Robinson (September 1996)

No. 15 - "Southern Africa: Economic Structure, Trade, and Regional Integration" by Natasha Mukherjee and Sherman Robinson (October 1996)

No. 16 - "The 1990's Global Grain Situation and its Impact on the Food Security of Selected Developing Countries" by Mark Friedberg and Marcelle Thomas (February 1997)

No. 17 - "Rural Development in Morocco: Alternative Scenarios to the Year 2000" by Hans Löfgren, Rachid Doukkali, Hassan Serghini and Sherman Robinson (February 1997)

No. 18 - "Evaluating the Effects of Domestic Policies and External Factors on the Price Competitiveness of Indonesian Crops: Cassava, Soybean, Corn, and Sugarcane" by Romeo M. Bautista, Nu Nu San, Dewa Swastika, Sjaiful Bachri, and Hermanto (June 1997)

No. 19 - "Rice Price Policies in Indonesia: A Computable General Equilibrium (CGE) Analysis" by Sherman Robinson, Moataz El-Said, Nu Nu San, Achmad Suryana, Hermanto, Dewa Swastika and Sjaiful Bahri (June 1997)

No. 20 - "The Mixed-Complementarity Approach to Specifying Agricultural Supply in Computable General Equilibrium Models" by Hans Löfgren and Sherman Robinson (August 1997)

No. 21 - "Estimating a Social Accounting Matrix Using Entropy Difference Methods" by Sherman Robinson and Moataz-El-Said (September 1997)

No. 22 - "Income Effects of Alternative Trade Policy Adjustments on Philippine Rural Households: A General Equilibrium Analysis" by Romeo M. Bautista and Marcelle Thomas (October 1997)

No. 23 - "South American Wheat Markets and MERCOSUR" by Eugenio Díaz-Bonilla (November 1997)

No. 24 - "Changes in Latin American Agricultural Markets" by Lucio Reca and Eugenio Díaz-Bonilla (November 1997)

No. 25* - "Policy Bias and Agriculture: Partial and General Equilibrium Measures" by Romeo M. Bautista, Sherman Robinson, Finn Tarp and Peter Wobst (May 1998)

No. 26 - "Estimating Income Mobility in Colombia Using Maximum Entropy Econometrics" by Samuel Morley, Sherman Robinson and Rebecca Harris (Revised February 1999)

No. 27 - "Rice Policy, Trade, and Exchange Rate Changes in Indonesia: A General

Equilibrium Analysis" by Sherman Robinson, Moataz El-Said, and Nu Nu San (June 1998)

No. 28* - "Social Accounting Matrices for Mozambique - 1994 and 1995" by Channing Arndt, Antonio Cruz, Henning Tarp Jensen, Sherman Robinson, and Finn Tarp (July 1998)

No. 29* - "Agriculture and Macroeconomic Reforms in Zimbabwe: A Political-Economy Perspective" by Kay Muir-Leresche (August 1998)

No. 30* - "A 1992 Social Accounting Matrix (SAM) for Tanzania" by Peter Wobst (August 1998)

No. 31* - "Agricultural Growth Linkages in Zimbabwe: Income and Equity Effects" by Romeo M. Bautista and Marcelle Thomas (September 1998)

No. 32* - "Does Trade Liberalization Enhance Income Growth and Equity in Zimbabwe? The Role of Complementary Polices" by Romeo M. Bautista, Hans Lofgren and Marcelle Thomas (September 1998)

No. 33 - "Estimating a Social Accounting Matrix Using Cross Entropy Methods" by Sherman Robinson, Andrea Cattaneo, and Moataz El-Said (October 1998)

No. 34 - "Trade Liberalization and Regional Integration: The Search for Large Numbers" by Sherman Robinson and Karen Thierfelder (January 1999)

No. 35 - "Spatial Networks in Multi-Region Computable General Equilibrium Models" by Hans Löfgren and Sherman Robinson (January 1999)

No. 36* - "A 1991 Social Accounting Matrix (SAM) for Zimbabwe" by Romeo M. Bautista and Marcelle Thomas (January 1999)

No. 37 - "To Trade or not to Trade: Non-Separable Farm Household Models in Partial and General Equilibrium" by Hans Löfgren and Sherman Robinson (January 1999)

No. 38 - "Trade Reform and the Poor in Morocco: A Rural-Urban General Equilibrium Analysis of Reduced Protection" by Hans Löfgren (January 1999)

No. 39 - " A Note on Taxes, Prices, Wages, and Welfare in General Equilibrium Models" by Sherman Robinson and Karen Thierfelder (January 1999)

TMD Discussion Papers marked with an "" are MERRISA-related papers.

Copies can be obtained by calling, Maria Cohan at 202-862-5627 or e-mail m.cohan@cgnet.com