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## RHETORIC AND REASON IN THE EGYPTIAN "NEW LANDS" DEBATE

The role of land reclamation in Egypt's development plans has become one of the country's most controversial and widely debated policy issues. Hardly a day passes without some reference in the press to a proposal for yet another "New Lands" project that will make hundreds, sometimes thousands, of additional hectares available for cultivation. Unfortunately, the actual rate of implementation in recent years has fallen well below levels envisaged by early reclamation planners, and in the last 10 years, only about 200,000 acres have been added to the cultivated area. According to some estimates, during the past decade substantially more high-grade agricultural land has gone out of production from increased urbanization than has been brought into production through reclamation.<sup>1</sup>

To appreciate the charged rhetoric surrounding the reclamation issue, some familiarity with the background against which the debate is taking place is essential. First and foremost, there is the problem of continued population growth. Egypt's population now numbers 43 million and continues to increase at the rate of roughly 2.5 percent per annum. With only six million arable acres available for settlement, this has meant constantly increasing population densities and rapid urbanization. Cairo, a metropolis of 4.8 million people in 1960, was estimated to contain nearly 8 million in 1976. The next largest city, Alexandria, had grown from 1.5 million to 2.3 million people in the same period. It is understandable, under these circumstances, that promises of several million acres of additional land strike a responsive chord in the hearts of all Egyptians, be they city dwellers or *fellahin* from the countryside.

Equally significant has been the recent emergence of massive food deficits. As late as the mid-1960s, Egypt was virtually self-sufficient in livestock products, and the cotton crop was more than sufficient to pay for imports of wheat and flour. In 1979, on the other hand, the net import bill for food was roughly US \$500 million. Imports of 5.4 million tons of wheat were triple the level of domestic production. Additionally, over \$300 million worth of maize, vegetable oil, and meat were also imported. At this level of food imports, the export of cotton can no longer cover even a third of the food deficit, and Egypt

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<sup>1</sup> The impact of urbanization itself is a controversial issue. The only systematic effort to evaluate the effect of urban encroachment on agricultural lands is contained in M. Ragga (1979).

must dip into foreign exchange earned by revenues from the Suez Canal, oil, tourism, and remittances to buy food. (The impact on foreign exchange reserves has, of course, been dampened considerably by \$300 million annually in commodity aid supplied by the United States.)

Such reliance on nonagricultural earnings to cover food deficits is common to many developed and developing countries, but the perception of "vulnerability" created by these circumstances is relatively new in Egypt and has brought forth repeated, albeit totally unrealistic, commitments to food self-sufficiency.

The increasing deficit in agricultural commodities therefore points to the desirability of "making the desert bloom." If land, water, and people are available, as they are, why has there been such vigorous—if often carefully veiled—opposition to further reclamation efforts? The answer is again twofold. First, the history of reclamation efforts since the construction of the High Dam has not been a happy one. For a variety of reasons discussed in greater detail below, only about 34 percent of the 1.1 million acres thus far reclaimed are actually producing a "surplus," i.e., are covering the variable costs of production.

A second major problem is the emerging recognition that, in addition to low productivity, large-scale land reclamation in Egypt faces rising costs. The land is available, but much of it lies a considerable distance above the floor of the Nile Valley. Substantial amounts of energy are therefore required to raise the water and to pressurize the sprinkler systems required for sandy soils. At today's prices, the opportunity cost of oil used to generate electricity needed for massive pumping operations makes many projects planned in another era of dubious economic merit. When energy costs are coupled with costs of developing additional water supplies, the development of another 2.5 million acres seems unrealistic.

Debate prepared for political consumption, particularly in the presence of possible large-scale involvement of foreign aid agencies, often obscures the development potential that does exist. Clearly, there are some lands with soil types, elevations, and markets that make them worthy candidates for reclamation. But they are likely to be limited to thousands, not millions, of acres.

Subsequent sections of this paper demonstrate the kind of relationships between physical and economic parameters that would produce acceptable internal rates of return on projects, and the kind of information necessary to estimate these relationships. Before turning to detailed economic calculations, however, it is desirable to pursue in somewhat more detail the institutional environment within which all subsequent project assumptions must be evaluated. The debate over the future is often rancorous, not because of disagreements about technical calculations, but because of differing interpretations of the past.

## PAST RECLAMATION EFFORTS

Difficulties with the reclamation process are known and acknowledged within government circles. They have also been the topic of parliamentary debates, and several recent studies by outside consultants, some accompanied by extensive personal observations, have made the historical record available to the general public (Hunting Technical Services, 1979b).

TABLE I.—YIELDS ON OLD AND SELECTED NEW LANDS  
(Kilograms per feddan)

Crop	Old Lands, estimated national average, 1979	New Lands			
		El Nahda	North Tahrir	Mechanized farm	Idleu
Wheat	1,320	800	540	710	980
Barley	1,110	620	450	650	960
Broadbeans	990	650		320	1,000
Maize	1,580	950	640	700	800
Rice	2,220	n.a.	n.a.	n.a.	1,800
Sea cotton	1,010	n.a.	n.a.	n.a.	640
Watermelons	11,160	370	n.a.	48	n.a.
Long berseem	25,000	16,200	4,360	grazed	10,500

Source: Reproduced from Hunting Technical Services (1979), *Suez Canal Region Integrated Agricultural Development Study, Special Report #2, Appendix C, Table C2, Cairo.*

That only about 34 percent of the 1.1 million acres “reclaimed” since 1952 currently recover the variable costs of production results partly from low procurement prices, an inflated wage bill, and a variety of subsidies on inputs. The major difficulty with the schemes, however, is the inability to increase productivity per acre. A rough estimate—perhaps a generous one—would be that yields on the New Lands are about half those obtained on the Old Lands (Table 1). When combined with high energy costs and the effect of remoteness on the costs and returns of all commodities, the drain the projects have placed on the government budget was inevitable.

Various explanations have been given for the poor performance of the state farms. For example, the basic premise that if additional water could be made available, there would be sufficient land on which to use it, was overly optimistic. Groups that had worked on soil classification of areas scheduled for reclamation warned that many soils were Class Three and below and that their structure and chemical composition would make them extremely difficult to reclaim. These reports were largely unheeded when first made because of their political implications. Failure to take them into account resulted in efforts to reclaim land with the traditional farming methods of the Delta; this is now recognized as a major error.

Inconsistency between technology, farm size, and social organization has plagued the projects from their inception. Initially, the plan was to have the land farmed by smallholders, and the first reclamation efforts under this scheme were fairly successful. Subsequently, a drastic policy shift was implemented to treat newly reclaimed lands like Russian-style state farms. Still later, farms that had been laid out for extensive, mechanized agriculture were distributed among smallholders, often without making adequate provision for farmers to have access to the machines used to cultivate the lands under the previous regime.

The incentive structure for workers and managers alike has consistently

worked against increases in productivity. On one hand, labor costs were inflated by the government's insistence that an excessive labor force be maintained as a way to provide employment for landless laborers. At the same time, managers were required to deliver produce to the government procurement system at prices below those of the marketplace. Admittedly, the state farms also received many inputs at less than market prices, but the economic outcome of most projects was that they did not generate a surplus for investment and were starved of the capital equipment needed to raise productivity.

Failure of the government to complete infrastructural investments, particularly for drainage, caused some farmed areas to go out of cultivation. Equally significant was the failure to provide operations and maintenance funds so that infrastructure investments could be utilized. This was especially acute in the social sector where buildings were provided for community centers, schools, and medical clinics, but no funds were made available to staff them.

Throughout the entire history of the program, there appear to have been difficulties in securing the coordination of the Ministries of Reclamation and Irrigation and Power. Each has a crucial role to play in the reclaimed areas, but jurisdictional disagreements have to this day prevented their cooperation.<sup>2</sup>

In 1976, the Government began a series of decisive steps aimed at reorganizing the entire system. One of the most important changes was the decision to permit smallholders to play a larger part in the reclamation program. Although the smallholder program has taken various forms, the dynamic performance of individual farmers has given credibility to proposals that all land be turned over to smallholders as soon as the necessary irrigation infrastructure is in place.

Unfortunately, few of the difficulties mentioned above are addressed in the design of new projects. Most troublesome is the lack of systematic agronomic experimentation on desert soils like those in the New Lands. As a result, the evaluation of new projects has had to rely to an unusual degree on assumptions about yields, prices, and cost assumptions that were poorly anchored in past experience.

It will take years to make good the lack of data. If experiments have not been conducted, accurate records maintained, or surveys undertaken, they cannot be manufactured by recall or guesswork. However, because of the time required to carry out new projects, there are strong pressures to continue at least some reclamation project evaluations even though the data on which the results depend are limited. The question is how best to organize what is available and how to develop a screening mechanism that both makes clear what assumptions are being used and also points toward the types of investments that have the best chance of yielding economic returns.

A first step in this direction, undertaken in the following section, is to construct a multi-period linear programming model of a reclamation project.<sup>3</sup> The calculations in the exercise, in addition to providing evidence regarding the im-

<sup>2</sup> A similar jurisdictional problem plagued Pakistan's SCARPs (Johnson, 1982).

<sup>3</sup> Data for the model are taken largely from studies done by various consulting groups. Most helpful was work undertaken by Pacific Consultants (1979) and Hunting Technical Services (1979a).

pact on the economics of reclamation of energy costs, levels of lift, optimal cropping patterns, and water costs, also delves into difficulties created for project evaluation by distortions in output and input prices. Admittedly, even in a first-best world in which international prices are used throughout the model, the current yields are such that serious doubts arise regarding the rates of return on many proposed sites. When economic costs and benefits are evaluated under the assumption that current financial incentives will dictate resource allocation, the results are even less favorable.

The analysis centers on parametric variation of the ingredients of benefit-cost analyses, namely, yields, energy costs, cropping patterns, wage rates, and levels of lift. Because the model is linear, most of the effects are additive and graphs can be developed that permit the combined effects of alternative parameter values to be assessed directly. For example, the effect on the internal rate of return of an assumed increase in yields plus a change in the level of lift can be obtained (within limits) by adding together individual effects without having to redo the calculations in the model.

In a final section, the implications of the results for further research and data collection and experimentation are assessed. It is clear that at the moment insufficient information on such crucial parameters as yields make broad judgments about the amount of area that potentially could be reclaimed impossible. Until the necessary experiments and agronomic trials are conducted, further appraisal of the economics of various reclamation programs rests on a series of arbitrary assumptions. The modeling exercise also suggests that learning more about experimental yield potentials is one of the simpler problems. More difficult for project planners is determination of a cropping system that may, in fact, be implemented. So long as financial incentives diverge significantly from economic incentives, there is no presumption that what farmers actually produce will be desirable. "Action experiments" that would permit the implementation and observation of different types of pilot schemes seem to be the obvious answer to uncertainties of this sort.

#### A MULTI-PERIOD LINEAR PROGRAMMING MODEL OF RECLAMATION

Much of the debate about reclamation of the New Lands has turned on questions of fact. Abstract assumptions about markets and the impact of government policies have gone unchallenged because virtually every consulting group has observed the conventions of a partial budgeting approach in the calculation of economic rates of return. The optimization framework of the programming methodology, however, is more sensitive than partial analysis to assumptions about production costs and returns and makes the arbitrary nature of such assumptions more obvious.

The weaknesses and strengths of the linear programming algorithm are by now well known. Appearing on the negative side of the ledger are such shortcomings as linear production functions, perfectly elastic input supply and output demand curves, and deterministic futures under assumptions of profit maximizations. These problems are also present in a partial budgeting approach.

The great strength of the programming approach is, of course, that it permits the computation of optimal levels of activities and resource use, and that it provides a framework within which data can be systematically collected and evaluated. It also highlights the assumptions that underlie project benefit-cost analysis as it is practiced in the real, "second-best" world.

#### *Benefit-Cost Analysis with Linear Programming Models*

In the programming formulation, farmers are assumed to maximize profits calculated on the basis of financial or market prices. Acceptance of the status quo in terms of policy and institutions that is the basis for second-best analysis dictates that the incentives be those currently in existence.

While cropping patterns, levels of input use, and private investments are all assumed to be a response to private calculations, economic prices are applied to the activities and resources used to determine the social desirability of the project. Domestic resources, i.e., nontradable resources which are fixed to the economy and hence do not have an international market price, ordinarily enter programming models as quantity constraints. Indeed, a theoretical strength of the programming approach at the macro level is that shadow prices of domestic resources are determined by the model's optimal solution rather than inferred from exogenous information.

At the project level, however, very different degrees of mobility are attached to domestic factors. Land, for example, is surely fixed. On the other hand, the value of labor—and especially capital—is largely determined in national markets and hence must be entered in the model in much the same way as it is in partial budgeting studies. One does not get around the problems of assumptions regarding markets and fixed factors by using a programming approach, but the completeness of the framework makes the assumptions much more explicit.

#### *Need for a Multi-Period Framework*

The multi-period model is characterized by a series of rows that carry resources over from one period to the next. Activities performing the same function in different periods are treated as though they were different variables. When the model is solved, the results are the levels of resource use and of activities for each time period. This formulation is desirable for the Egyptian reclamation of the New Lands for several reasons.

Reclamation is an investment process and is highly dependent on time. Regardless of what procedures are followed, the first few years under cultivation are likely to produce returns to labor, management, and capital that are below the project's ultimate potential. Crops grown in generally inhospitable desert soils simply do not do well in the initial years, and normal yields are realized only after a certain period of cultivation. This waiting period can be characterized as an investment in land in which present efforts to improve soil quality are expected to contribute to an increased payoff in the future.

A multi-period framework also makes it possible to include livestock in the cropping system. Animals serve two functions in the Egyptian program. In addition to providing meat and milk, they permit concentration in the early years

on a cropping pattern that is weighted heavily toward fodder crops, and their manure adds badly needed organic matter to desert soils. The multi-period formulation is required to account for the increase in the value of the herd over time and for the increased use of inputs and other resources.

Finally, the multi-period framework makes it easier to incorporate investment in perennial crops into the cropping pattern. Orchards, especially citrus, are considered to be important in the New Lands, and some years are required in order to achieve full production.<sup>4</sup>

### *Specification of Activities*

The programming model contains four distinct sets of decision variables. The first consists of crop activities which, with the exception of fodders, make a positive contribution to the objective function. (Citrus, of course, has negative entries at the outset which are then replaced by positive elements as the trees mature.) A second series of entries simulates the production of livestock and livestock products. The model assumes that animals can be purchased during the early phase of the reclamation period and hence they are shown as producing positive returns in the first year of purchase. It is subsequently assumed that all animals will be replaced from within the farm herd, resulting in a number of negative entries in the model's objective function while animals are maturing but not contributing directly to income. (Power has been excluded from livestock's contribution because it has been assumed that tillage is by hired tractor services. This assumption is not only consistent with current practices in the area, but reflects trends in the Old Lands as well. Several of the latest farm management surveys indicate, for example, that 70 to 80 percent of the primary tillage is now being done by tractors.)

Two sets of resource-augmenting activities complete the model's decision variables. The first concerns labor, and it is assumed in most exercises that the farmer can hire labor to meet peak demands during planting and harvesting. The second set of resource activities deliver irrigation water to the holding. Water is free to Egyptian farmers, and its cost is not included in the financial analysis. The cost of delivering water is included in the social profitability calculation.

*Crop activities.* — Crop activities have been entered in the model in the conventional way. Net revenues are calculated by subtracting variable costs from gross revenues which, in turn, were calculated from yields and market prices. As noted earlier, perhaps the most crucial assumption in the entire analysis concerns the estimates used for crop yields. Obviously, if past performance is taken to represent future potential, i.e., yields shown in Table 1 are extrapolated, all projects would be doomed from the start. On the other hand, as the study done by Tahal Engineering has shown, acceptable rates of return are assured if optimistic assumptions are made about both the ultimate yields and the rate at which they can be attained (1980).

<sup>4</sup> In introducing citrus into the multi-period model used in these exercises, it has been assumed that there is little interaction between the maturation of the citrus trees and the progress of the reclamation process. That is, citrus yields normally obtained in any given period were decreased by the same amount as the yields of field crops. Full development of citrus was assumed to occur in the tenth year after reclamation began even though the trees may have matured earlier.



The real difficulty in trying to find an acceptable estimate of crop yields is that there literally are no figures from experimental plots that can be used as a guide to a reasonable estimate for the New Lands. The absence of such data is indicative of the poverty of management and administration on the New Lands projects.

In the absence of data rooted in the Egyptian experience, the approach of the present exercise is to assume that yields at full development will be equal to yields currently attained in the so-called "old" Delta lands. These yields incorporate some measure of Egyptian management skills and agricultural knowledge, albeit applied to soils that are vastly superior to those in the New Lands. They represent a reasonable compromise between what is attained in California and Israel and what has been attained in Egypt's New Lands where institutional and administrative difficulties appeared to doom new projects to failure.

*Livestock activities.*—The production of meat and milk has been included as an integral part of the model. Estimating inputs and outputs for livestock and production is inherently more difficult than for crop production. In part, this is a result of not really knowing how much animals eat. Concentrates can be measured, and it is even possible to make estimates of forage grown for animals. But in Egypt, a substantial amount of grazing on crop residues also contributes significantly to milk or meat production.<sup>5</sup>

An equally difficult research question involves the yield of milk. Daily production varies significantly over the lactation cycle, and an annual production figure requires either continuous monitoring or a series of assumptions about the pattern of production from one calving to another.<sup>6</sup>

The maintenance of the herd has been made an endogenous feature of the model. It has been assumed that heifers with calf can be purchased when the settlers are first taking up residence. Such options are limited to the first three years, and thereafter herd size is determined by the decision to raise or sell calves. In this formulation, the cost of raising animals is the opportunity cost of milk and fodder they consume rather than their periodic replacement cost.

*Water activities.*—In order to capture the comparative advantage of different irrigation methods, several types of water-related activities are incorporated in the model. These include the cost of lifting water and the cost of pressurizing water for sprinklers. Not all activities are included in all model runs.

Most consultants have assumed that the same cost would be incurred for furrow, sprinkler, and drip irrigation. The present model incorporates water costs for each crop, as estimated by the consumptive use for each crop.

*Labor-hiring activities.*—In the settler model, it is assumed that each family has two man-years of labor at its disposal. In the somewhat larger "graduate" farm model, it is assumed that all labor is hired.<sup>7</sup> This option was introduced

<sup>5</sup> Important new evidence on a whole range of issues involving the utilization of forage crops for livestock has recently been made available in Winrock (1980).

<sup>6</sup> For a discussion of the difficulties involved in estimating milk production from survey data, see Wayne Dyer (1982).

<sup>7</sup> "Graduate" farms refer to land given to graduates of agricultural universities as one of the programs aimed at breaking up the large state farms and returning the land to smaller cultivation units.

via a single labor-hiring activity that simulates the hiring of laborer families on an annual basis. (An alternative assumption that permitted hiring labor in response to seasonal demands was also explored, but it was felt to be less consistent with the realities of the local labor market than the permanent laborer formulation.)

### *Model Constraints*

A goodly number of constraint rows in the model represent the seasonal use of domestic resources of land and labor. In a partial analysis, these resources are ordinarily dealt with on an annual basis. Single coefficients indicate that a crop uses so much labor or so much water, irrespective of the seasonal distribution of both supply and demand. In the economic analysis, for example, there is typically only one value for the shadow price of labor. This despite the fact that labor use is highly seasonal, and that a zero marginal product through half the year is perfectly consistent with very high productivity in those seasons of the year in which agricultural activities like planting, weeding and harvesting are concentrated.

In the light of these observations, it is clear that the seasonal disaggregation of resource use—a strength of the linear-programming approach—makes direct comparisons of the economic value of labor with partial approaches very difficult. However, some notion of the annual opportunity cost of a resource may be obtained by comparing a weighted average of the monthly values with the estimates used in the more conventional benefit-cost analysis.

Even the most ardent advocate of linear-programming methods is aware that optimal solutions push the notion of comparative advantage beyond what might be regarded as a “reasonable” basis for judging what farmers are likely to do. Consequently, a number of computational experiments were undertaken to ascertain just how sensitive the internal rate of return was to the imposition of various types of constraints designed to simulate a more realistic cropping pattern. These constraints took two forms:

*Soil disease constraints.*—Continuous intensive cropping of vegetables like tomatoes and melons increases substantially the likelihood of soil-borne diseases, e.g., nematodes, that would permanently impair the productivity of the land. The imposition of nematode constraints restricted the total amount of land that could be planted to certain vegetables in a given year and forced an agronomically sound cropping pattern into the final solution.

*Marketing constraints.*—In addition to constraints dictated by agronomic considerations, it quickly became apparent that certain high-value crops would dominate the cropping pattern despite the fact that it was generally acknowledged that crops like melons, tomatoes, and lupines had only limited markets. The result was the introduction of two levels of marketing constraints which limited the amounts of these crops that could be grown.

For comparison with a traditional cropping pattern, the model was run under constraints that forced its cropping pattern to equal that contained in the recent Pacific Consultant’s report on the potential productivity of the New Lands (1979). There has been considerable debate over the extent to which cropping patterns assumed by the consultants have been too conservative or too radical in relation to what farmers have done traditionally. Successive

TABLE 2.—OPTIMAL CROPPING PATTERNS IN THE NEW LANDS MODEL  
(Five-feddan, furrow-irrigated holding)

Crop	Period 1				Period 3				Period 5			
	PC <sup>a</sup>	M1 <sup>b</sup>	M2 <sup>c</sup>	N <sup>d</sup>	PC <sup>d</sup>	M1 <sup>b</sup>	M2 <sup>c</sup>	N <sup>d</sup>	PC <sup>d</sup>	M1 <sup>b</sup>	M2 <sup>c</sup>	N <sup>d</sup>
Cereals												
Wheat	.5				.5				.5			
Maize	1.5				1.5	.5			.9	.6	.1	
Barley	.3				.3	.2	.5	.4	.3	.5	.4	.6
Oilseeds												
Peanuts	1.6	.2			1.6	.7	.9		1.6	.8	.9	
Sesame	.3	.5	1.0	4.2	.3	.5	1.0	2.9	.5	.5	1.0	2.9
Berseem	1.6	2.6	2.3		1.6	1.9	1.4	.1	1.4	.9	.9	.1
Summer fodder	1.0	2.1	1.9		1.0	1.4	.92		.8	.9	.7	
Pulses												
Cow peas	.4				.4				.4			
Green peas	1.8		.2	.3	1.8		.2	1.0	1.5	.1	.4	1.2
Lupines	.5	.4	1.0	4.7	.5	.5	1.0	3.5	.5	.5	1.0	3.1
Vegetables												
Summer tomatoes	.2	.6			.2	.1			.8	.4	.2	
Winter tomatoes	.3	.8	.4		.3	.6	.4		.8	.4	.1	
Melons		.5	1.0	.8		.5	1.0	2.0		.5	1.0	2.1
Citrus <sup>e</sup>		1.2	1.1			1.2	1.1			1.2	1.1	
Cropping intensity <sup>f</sup>	200	200	199	200	200	186	190	200	200	170	180	200
Net revenues, financial	737	(324)	(177)	761	955	919	1,526	1,845	1,514	1,301	2,011	2,531
Net revenues, economic	(558)	(1,826)	(1,664)	(281)	(1,407)	(608)	66	613	(600)	(342)	644	1,255

<sup>a</sup>PC = crop constraints set to those given in Pacific Consultants report (1979), "New Lands Productivity, Technical Feasibility Study," Cairo; IRR = -37.9 percent.

<sup>b</sup>M1 = crop constraints limit melons, lupines and tomatoes to 0.5 feddan each; IRR = -1.5 percent.

<sup>c</sup>M2 = crop constraints limit melons, lupines and tomatoes to 1.0 feddan each; IRR = 2.5 percent.

<sup>d</sup>N = crop constraints limit tomatoes on same ground to 1 out of 3 years; IRR = 8.9 percent.

<sup>e</sup>Citrus counted twice.

<sup>f</sup>200 percent intensity, double cropping.

degrees of optimization simulated by different marketing constraints were introduced to examine the impact of alternative behavioral assumptions on the internal rate of return.

## EVALUATION AND DESIGN OF RECLAMATION PROJECTS

The reclamation model was constructed in order to permit a variety of experiments in which project parameters were altered and the impact on the internal rate of return recorded. The results permitted the construction of a series of graphs and tables that, assuming the additivity of activities, would permit designers to gauge the likelihood that a given area could be the site of a project with an acceptable economic rate of return. For example, if the level of lift for a project was 50 meters, the cost of energy 0.5 piasters per kilowatt hour (kwh), the wage rate Egyptian pounds (£E) 1.1 per day, what would yields have to be in order to attain a 5 percent internal rate of return (£E1 equaled US\$1.40 in 1980.)? The following section provides the information for constructing such algorithms and shows, for a plausible set of parameters, that the additivity assumptions perform reasonably well.

### *Benefits of Optimization*

The first set of experiments is directed at the concerns of reclamation planners who argue that proposed cropping patterns are too conservative. Table 2 shows four different solutions beginning with the most conservative (PC), in which all crops are specified along traditional lines and forced into the model at these levels, and ending with a solution (N), in which only the so-called agronomic constraints have been introduced.

Examination of the cropping patterns quickly pinpoints the specific source of increased revenues that occur under liberal assumptions. When high-valued crops such as melons, tomatoes, and lupines are permitted to enter at high levels, the resulting economic returns—assumed in most cases to equal financial returns—are very high indeed. When market constraints that limit these crops to more reasonable levels are added, the internal rate of return drops accordingly. For example, when it is assumed that no more than one feddan of melons and tomatoes may be grown on a five-feddan holding, the internal rate of return is negative.

To a considerable extent the relationship between optimization and the internal rates of return is transparent. When acreage under high-valued crops is increased, both the financial and economic crop returns increase substantially, although not in the same proportion. The market constraints not only limit the crops that have a high financial value, but force into the solution crops like fodder that have reasonable financial returns but are of low economic value. The result of such distortions in domestic prices is to produce a disproportionate decline in the economic internal rates of return.

A second noteworthy effect of using optimal solutions to calculate internal rates of return is that, as Table 3 shows, there is a substantial decline in costs, specifically labor costs. When it was assumed that the 5-acre settler had two man-years at his disposal and that no more labor could be hired, the traditional cropping pattern produced an infeasible solution. Accordingly, labor-

TABLE 3. — IRRIGATED HOLDING AT FULL DEVELOPMENT:  
DISAGGREGATED BENEFITS AND COSTS UNDER ALTERNATIVE CONSTRAINTS  
(£E/feddan/year)

Items	Constraints			
	PC	M2	M1	N
Gross revenue	503	515	527	561
Production costs				
Labor	180	120	120	120
Energy	40	45	47	37
Water	41	47	48	38
Miscellaneous	38 <sup>a</sup>	26	26	26
Total	201	175	159	151
Value-added, full development	3	102	127	189
Average value added each year <sup>b</sup>	(15)	20	41	126

Source: Pacific Consultants, "New Lands Productivity Technical Feasibility Study," Cairo, 1979. Stabilized solutions, i.e., Period 6, used to represent linear-programming results. PC calculated from Table C.1 of the Main Report and Table 33, Working Paper 1; M2, M1, and N constraints calculated from transfer rows and activities in the linear-programming solution.

PC—Crop constraints as in Pacific Consultants report.

M1—Limit of 0.5 feddans each on melons, lupines, and tomatoes.

M2—Limit of 1 feddan each on melons, lupines, and tomatoes.

N—Tomatoes limited to once in three years on same soil.

<sup>a</sup>Includes animal replacement handled endogenously in the linear-programming model.

<sup>b</sup>Approximate except under PC crop constraints.

hiring activities were introduced for the traditional situation. The cost of production declined by 20 percent, but the value added per feddan at full development fell by £E 60. The attendant decline in the internal rate of return reflects the lack of a mechanism in a partial approach for a labor adjustment process to affect the optimal crop mix.

#### *Alternative Yield Assumptions*

Yield assumptions are among the most critical parameters in agricultural project analysis, and reclamation projects are no exception. Chart 1 shows the sharply rising internal rate of return that results when yields are assumed to be greater than target yields.<sup>8</sup> Every 5 percent increase in the assumed level of target yields increases the internal rate of return 1 percent.

#### *Levels of Lift*

One of the most disconcerting findings of the study is the adverse effects that rising water costs have on the economics of reclamation. Chart 2 shows the impact of increased lift. Assuming the standard conditions of modest market

<sup>8</sup> Higher yields are not assumed to require additional inputs.

CHART 1.—IMPACT OF ALTERNATIVE YIELD ASSUMPTIONS ON INTERNAL RATES OF RETURN

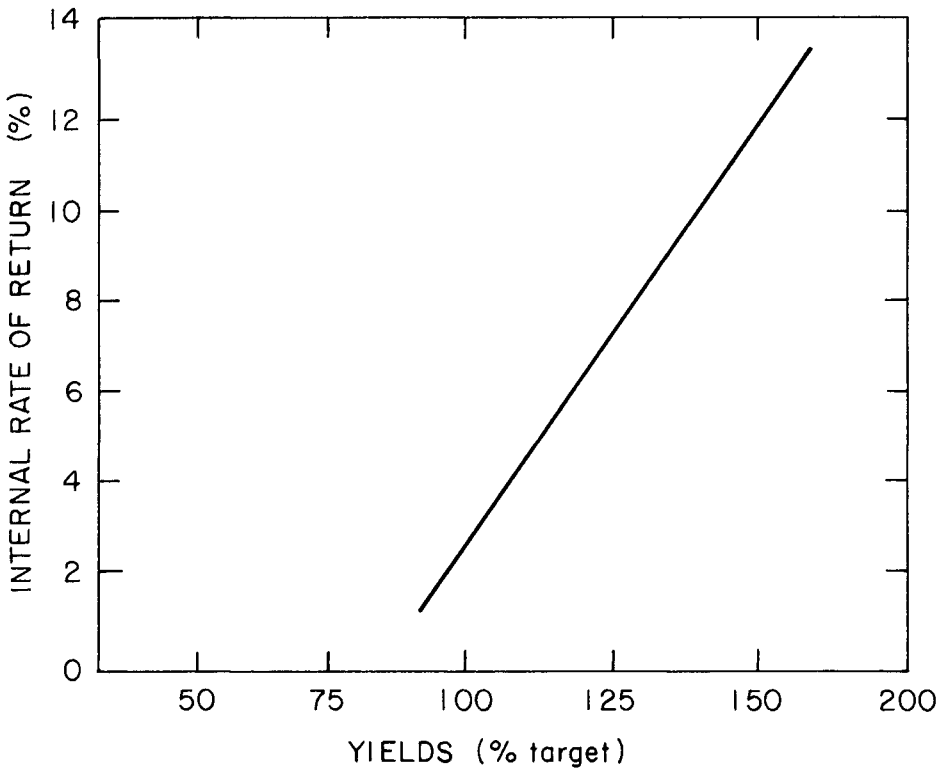


CHART 2.—IMPACT OF LEVELS OF LIFT ON INTERNAL RATES OF RETURN

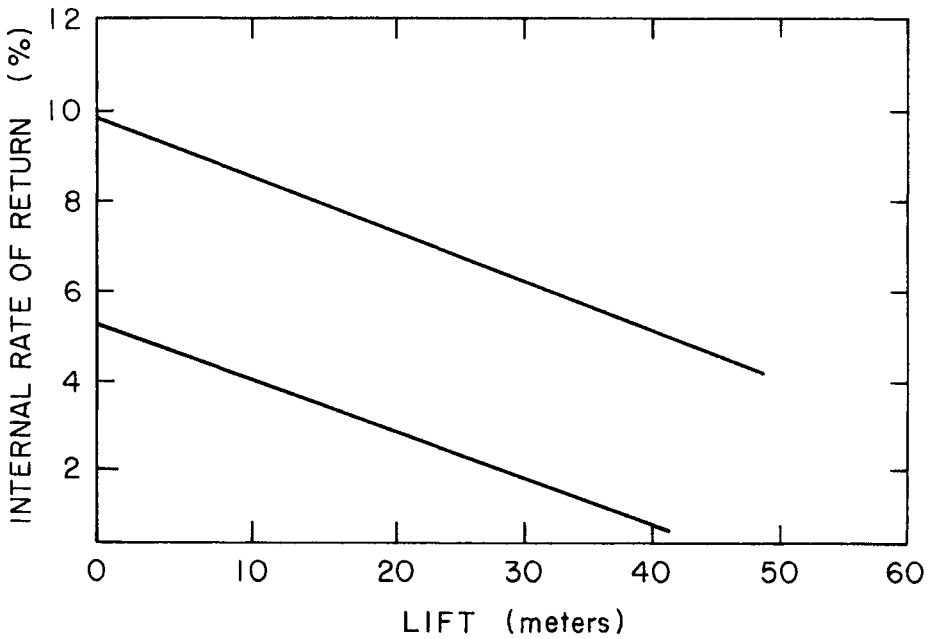


TABLE 4.—INTERNAL RATES OF RETURN  
UNDER VARIOUS COSTS OF ENERGY AND WATER

Water (piasters/m <sup>3</sup> )	Energy (£E per kwh)				
	0	.025	.050	.075	.100
0	13.6	11.2	9.2	8.3	7.3
.25	11.2	10.2	8.3	7.3	6.3
.50	9.2	8.3	7.4	6.4	5.4
.75	8.3	7.3	6.4	4.4	3.4
1.00	7.3	6.3	5.4	3.4	2.4

constraints, calculations show that a project internal rate of return of 5.5 percent could be expected at 100 percent of target yields and no lift. This modest return would quickly be driven to zero, however, if lifts were to exceed 40 meters. The average lift on already reclaimed land is 20 meters, but a number of projects scheduled for implementation are clearly in excess of that amount. Indeed, in some of the proposed Sinai developments lifts are said to approach 75 meters; this would drive the return to zero at yields 25 percent above target levels.

#### *Water and Energy Costs*

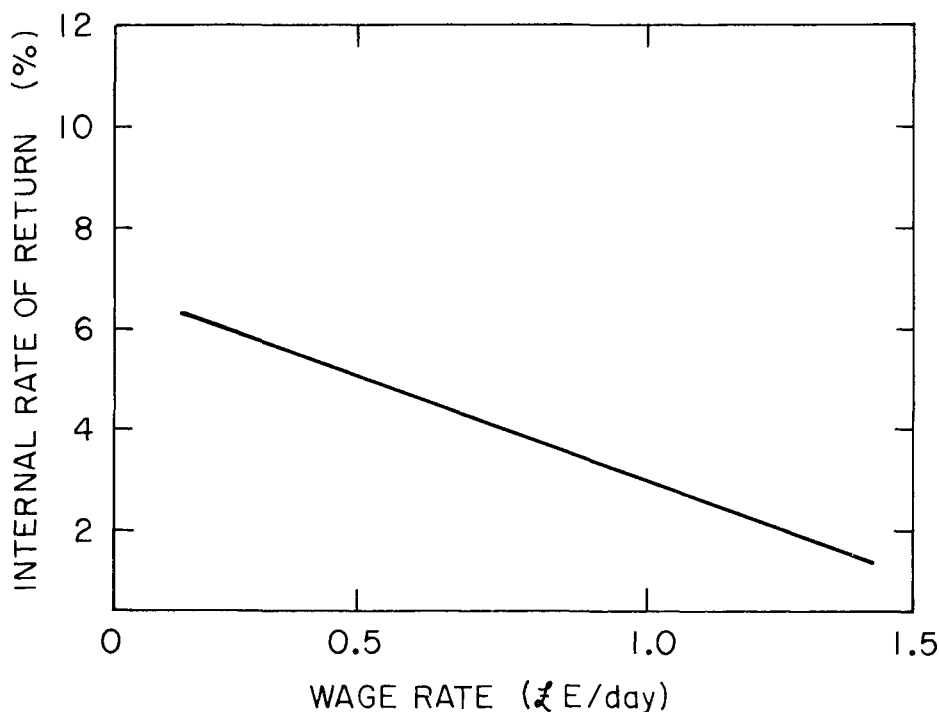
It is obvious from Table 4, calculated at 125 percent of target yields, that assumptions about these water and energy costs make an important difference in project internal rates of return. If, for example, water had no economic cost, i.e., a particular project did not require the construction of additional works or the extension of additional canals, the table suggests that the internal rate of return would increase by 25 percent from 7.3 percent in the standard solution to 9.2 percent.

A combination of lower water costs and lower energy costs could increase the internal rate of return still further until at zero economic costs for water and energy costs of, say, 0.25 piasters per kwh, the model produces an internal rate of roughly 10 percent.

#### *Labor Market Assumptions*

One of the most widely discussed parameters in benefit-cost analysis for developing countries has been the appropriate wage rate for agricultural projects. Earlier comments noted that one of the difficulties of utilizing the strength of the linear-programming approach to this problem, i.e., letting the model generate shadow prices endogenously, is the wide variance in scarcity values obtained when seasonality is introduced. It was also noted that, at least for relatively small projects, the assumption of a fixed supply of labor probably distorts the market cost of labor somewhat even when the project is made up of smallholders farming their own land. So long as it is possible for people to move rather easily from the Old Lands to the New, it is important to explore the implications of a reasonably well functioning labor market before attempting to apply quantity constraints.

CHART 3.—INTERNAL RATES OF RETURN WITH VARIOUS WAGE RATES



The wage rate used in the basic solution was £E 1.10 per day. This estimate assumes that the labor situation is now tightening in the rural areas as a result of migration to urban areas and the large exodus of Egyptian laborers to the oil-rich states of the Persian Gulf. Remittances from the emigrants have also increased labor's reservation price in Egypt.

The effect of the wage rate on internal rates of return is shown in Chart 3. Based on the standard solution of a five-feddan, furrow-irrigated farm operating under modest (M1) market constraints, the graph shows a 0.5 per cent increase in the return for every £E 0.10 reduction in the shadow price of labor.

#### *Sensitivity Analysis and Project Identification*

It is evident from the foregoing analysis that projects are sensitive to yields, technology, levels of lift, energy costs, and water costs. How can this information be used to identify those projects that are likely to be worthy of financing? Alternatively, what should one look for—or what sort of arguments might be required—to design projects that would have acceptable internal rates of return and also be consistent with the structure of financial incentives currently existing in Egypt? Some rules of thumb are suggested below.

1. Permitting the cropping pattern to reflect comparative advantage, instead of imposing the historical cropping patterns of adjacent areas, could bring the internal rate of return from very negative to roughly zero. This



TABLE 5.—ILLUSTRATIVE APPLICATION OF SENSITIVITY ANALYSIS TO PROJECT DESIGN

	Assumptions	Internal rate of return
Basic solution	Standard	2.5
Yields	25% above target	5.0
Labor	Decrease by 50%	2.5
Lift	Lower by 10 meters	1.0
Water cost	Zero	2.0
Energy cost	Decrease by 20%	.4
Total		13.4

does not mean that farmers are only breaking even. Quite the contrary, financial returns under these conditions may be more than adequate to entice a substantial amount of private investment into the New Lands sector.

2. Legitimized higher yields would be extremely effective in raising the project internal rate of return. For every 5 percent increase in yields, one could expect a 1 percent increase in the internal rate of return from the indicated base.

3. Halving the wage rate to reflect substantial disguised unemployment in the rural areas would increase the project internal rate of return by 2.5 percent.

4. The lower the lift, the higher the internal rate of return. Projects that require only 10 meters of lift would yield an internal rate of return that is 1 percent higher than the standard 20-meter solution.

5. Lower energy and water costs would both increase internal rate of return. For example, if water could be brought to the project site at zero cost, there would be a 2 percent increase in the standard internal rate of return. If energy costs could be reduced by 20 percent, from £E 0.05 per kwh to £E 0.04, the internal rate of return would increase by 0.5 percent.

What would be the effect of introducing the entire package of optimistic assumptions? What would be the internal rate of return if one assumed: (1) a less conservative cropping pattern, (2) a 25 percent increase in yields, (3) an opportunity cost for labor of half the market price, (4) a lift of 10 meters, (5) zero economic cost for water, and (6) an energy cost of £E 0.04 per kwh.

Adding up the benefits according to the rules of thumb suggested above produces a rather handsome internal rate of return of 13.4 percent, only slightly below the 15 percent frequently used in Egypt as the cut-off point for project selection (Table 5).

In order to check these results, the parameters in the model were set at the values indicated and the internal rate of return calculated. The result was 12.58 percent indicating that, while there are some effects of the multiplicative relationships between levels of lift and energy costs, the rules of thumb derived from the sensitivity analysis appear to perform quite well.

Choice of technology was not included explicitly in the project design analysis because its implications are relatively clear-cut and largely involve

straightforward trade-offs between energy costs, water costs, construction and maintenance costs, and yields. Yields are assumed to increase substantially with sprinklers, for example, largely offsetting the increased energy costs. However, even if sprinkler yields are 25 percent higher than those associated with furrow irrigation, the internal rate of return will be 4.64 percent as compared to 7.36 percent for furrow irrigation.

The interesting question at this point, and it can only be answered for the specific case, is how much yield improvement with sprinkler irrigation should be assumed. Consultations with irrigation experts suggest that, almost without exception, the improved water-management practices that can be implemented with sprinklers would produce 10 to 15 percent higher yields. In porous soils, the improvement would be even greater. If this is so, it would obviously improve the case for sprinklers relative to furrow irrigation. Unfortunately, the major issue has been that neither delivery system has shown a rate of return that makes it an attractive investment from a social point of view.

### IMPLICATIONS FOR RECLAMATION RESEARCH

The model results suggest that the internal rate of return is sensitive to all of the parameters included in the analysis. It might therefore be concluded that the appropriate research prescription would be a rather comprehensive program to obtain new information across a broad range of issues. However, the costs of obtaining various kinds of information and their value should also play a part in determining the nature of the research efforts that should be undertaken.

#### *Value of Additional Information*

The demand and supply situations with respect to information about the parameters examined in the model fall into several categories.

Many parameters are determined by the physical characteristics of the project and hence are site-specific. The most obvious of these is the level of lift. It is an important determinant of the economic profitability of a project, but one about which generalizations are not helpful. It is what it is, so to speak.

The cost of water for a specific project is similar. Once a specific project is being examined, then the extent to which additional, basin-wide facilities are required to provide water to the project will rapidly become evident. Specific barrages, canal enlargements, bridges and overpasses might be part of the incremental investment package. But the draining of the Sud in the Sudan, on the other hand, would involve a broad array of activities that goes well beyond any individual reclamation effort. At some future date, the assumption that there is "marginal" water in the present system will obviously become untenable; but for the moment, this issue does not appear to be a key one in holding up project designs.

The argument about the cost of energy is more general and could well be the subject of additional research. Substantial investments are now implemented in the power sector and hence marginal calculations, not only of fuel but of capital investment, can be made. Moreover, the economic cost of energy to

Egypt is likely to be a sensitive parameter for a wide variety of project calculations, thus providing further justification for additional research.<sup>9</sup>

The recent rise in real wage rates in the rural areas gives some grounds for arguing that the rapid emigration to the Gulf States and to the cities has produced a situation in which the market rate is a reasonable approximation of the economic wage. Other possible assumptions have no stronger empirical basis, and consequently it would be difficult to recommend that further efforts be made to determine some other figure for use in valuing labor.

Knowledge about yields is the single most important parameter as far as project analysis per se is concerned. Fortunately, unlike some of the other parameters indicated above, it is also information that can be obtained at reasonable cost. Admittedly, facilities will have to be constructed, land prepared and people trained, but these are all within the realm of what both Egyptians and foreign aid donors know how to do. Because of the lags involved, work along these lines should be begun immediately. Indeed, if no new lands were ever reclaimed, the need for an effective research program would be dictated by the needs of the lands already reclaimed.

#### *Action Experiments and Adaptive Management*

Some of the most critical determinants of successful projects in the New Lands are closely linked to institutional and organizational considerations. Consequently, research that concentrated on determining the cost of energy or the yields that were attainable under experimental conditions would leave largely untouched the differences in management and administrative capacity that have given rise to skepticism about the Egyptian program. Unless the historical experience is to be swept under the rug, some means must be found to provide new and persuasive knowledge of how the organizational aspects of reclamation projects can be made to function more effectively. How might this formidable requirement be met? Two approaches suggest themselves:

1. First, a substantial amount of information about the impact of alternative institutional approaches might be derived from observing the activities of farmers who have been reclaiming land on an individual basis. These "homesteaders" exist in a number of places: on the edges of current projects, in areas where groundwater has made desert reclamation possible, and in areas where drainage of freshwater lakes has provided access to non-saline soils. Little is known about these farmers and the scope of their activities. It is clear, however, that they offer a potential alternative to the model of massive investments in which the entire infrastructure of reclamation projects is provided by the government.<sup>10</sup>

2. A second and obviously much more ambitious approach to the design of improved new lands projects would be to experiment with an action project of sufficient size to identify the interaction of alternative technologies and modes of social organization. Under such a program, a project would

<sup>9</sup> As far as reclamation projects are concerned, however, the present study establishes clearly that the order of magnitude is sufficient to place severe limitations on certain projects. Hence fine-tuning estimates of cost per kwh, while interesting, would probably not be worth the cost if the only use was to evaluate the economic viability of reclaiming new lands.

<sup>10</sup> For a more detailed discussion of the "homesteader" phenomenon, see Gotsch (1980).

be initiated whose size was sufficient to capture both the economies of scale inherent in construction, and to test alternative management schemes. A project on the scale of 5,000 to 10,000 feddans, while not of the size favored by local reclamation engineers, would nevertheless provide the opportunity to test both technical and institutional hypotheses.

The suggestion that a complicated action project be a requirement for undertaking new projects or rehabilitating old ones poses difficult choices for foreign aid donors. For it is not sufficient that the implementation of such a project simply be permitted by the Egyptian government. While important information on cropping systems could be obtained from a model developed largely under outside guidance, if the historical difficulties lie in substantial measure in the management and institutional area, then to proceed without the full cooperation and interest of the agencies ultimately responsible for the new lands program would be self-defeating.

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