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PRIVATE LAND RECLAMATION IN EGYPT: DEVELOPMENT POLICY AND PROJECT DESIGN †

There is every reason to suppose that the question of additional "new lands" reclamation will be on Egypt's economic and political agenda for the foreseeable future.[1] Economic rates of return on such investments have been generally unfavorable, but it will be hard for planners and politicians to resist the pressures for space created by 45 million people living on six million feddans of land.[2] It will be particularly difficult to resist even questionable projects if they also promise some relief from the staggering acceleration of food imports that has occurred in recent years.

The public controversy that has held up a full-scale investment program has its origins in a series of studies during the past decade.[3] In

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1 The term "new lands" is somewhat fuzzy, but generally refers to areas reclaimed after the construction of the Aswan High Dam. By implication all other irrigated areas are "old lands."

2 One feddan equals 1.038 acres or 0.4203 hectares.

3 The most thorough evaluation of previous experience is Hunting Technical Services (1979). General issues of the feasibility of large-scale reclamation projects were also raised in Pacific Consultants (1980). Data from the latter were further

general, the studies show that productivity on the existing reclaimed area is low with only about half the lands recovering the variable costs of production. Technical deficiencies have been found in both the design of the projects, which ultimately has led to serious drainage problems, and in a lack of solid agricultural experimental data, which has led to uncertainty about the most appropriate reclamation practices. When these technical shortcomings are arrayed alongside a series of observed management deficiencies, the difficulties of new lands reclamation are obvious enough to raise doubts about the advisability of additional long-term investments.

One of the side effects of investigation into public sector projects was the finding that private reclamation was continuing in a variety of shapes and forms all over Egypt. The issues that these results raise are numerous and complex. How, in the presence of a wide range of documented difficulties in public sector reclamation, does the private sector manage to exploit domestic resources profitably? Is it because the distorted prices for inputs and outputs have created a situation in which financial returns are positive but economic returns negative?[4] Or have private entrepreneurs found a way to overcome the deficiences of the public sector system to the point where yields are higher, reclamation periods shorter, and the income stream sufficient to support substantial reclamation costs?

Answers to these questions are surely part of the story. But when questioned directly regarding their reasons for undertaking the arduous task of reclamation, farmers add a fine sense of relative costs and returns:

1. Government policies and crop restrictions that affect old lands do not necessarily apply to new lands. For example, the requirement that a certain amount of financially unprofitable cotton and wheat be planted is not enforced.

2. In certain parts of the old lands, waterlogging and salinity have led to significant declines in yields.

3. Population growth, fragmentation of holdings, and Egyptian tenure laws that limit the ability to rent land have combined to make the cultivation of traditional family holdings insufficient to cover family income requirements.

4. Soaring prices for old lands have made it difficult to assemble enough land to make a viable economic unit for the average farm family.[5] This has

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explored in a linear programming context by Carl Gotsch and Wayne Dyer (1982).

[4] In fairness to public sector enterprises, their "profitability" should correct for the low, government-determined prices they receive for their products. But then they must also take into account the subsidies on inputs. No systematic calculations of the actual social profitability of state farms have been published.

[5] Although no firm data are available, it is commonly thought that as much as one-third of the remittances from workers abroad has been spent on acquiring land in the traditional farming areas.

had two effects. For farmers with marginal units interested in acquiring more land, the possibility of doing so in the old lands has been put out of reach. At the same time, however, increasing land prices have made their marginal units valuable enough so that, if sold, the resulting capital is sufficient to permit the purchase and reclamation of new lands.

The present study reports fieldwork and economic analysis that shed light on the presence of private reclamation activities. The good news revealed by the detailed interviews with Egyptian farmers is that they are as resourceful in overcoming the difficulties of hostile environments as farmers anywhere in the world. They display an impressive combination of ingenuity and tenacity in making the desert bloom.

The bad news is that it is hard to imagine how the adaptive fine-tuning of the reclamation efforts reported here can be institutionalized on a large scale. In part it is a technical matter. For example, private individuals select land for reclamation on a plot-by-plot basis. If a particular field is especially saline, it is left for sustained leaching with surplus water rather than seeded and fertilized with costly inputs that yield little or no return.

It is also a matter of finding unusual marketing niches. Reclamation is costly and there seems little hope of recovering the expenditures needed to level the land, provide water, and improve the soils if ordinary field crops such as wheat, maize, and fodder are grown. High priced land demands high-value crops such as vegetables and fruits for the investment to pay off. This in turn means proximity to urban markets and climatic niches that permit delivery to these markets in periods of premium prices. The flexiblity of private individuals in seeking out such situations is an important component of their success.

Last, and most important, interview responses confirmed the importance of adaptation and learning for a successful reclamation activity. In many cases, farmers knew relatively little at the outset about the most appropriate way to handle lands much different from those to which they were accustomed. In interview after interview, it was apparent that the secret to their success was an experimental approach to their problems.[6] With the technology under individual control, they were free to try alternative methods of creating seedbeds, sheltering plants, timing irrigations, applying fertilizer, and harvesting crops. They also learned from their neighbors who were engaged in similar processes. No detailed knowledge of large-scale reclamation projects is required to suspect that this type of adaptive

[6] A definitive exploration of the literature of "adaptive management" is contained in Bruce Johnston and William Clark (1984). Material referenced in the book but worth pursing independently is contained in David Korten (1984). The latter reference is especially interesting because it contains examples taken from irrigation projects that emphasize issues of control over irrigation technology. On the significance of farmer control over technology, see also Thomas Tomich (1985).

behavior would be difficult to duplicate in the public sector.

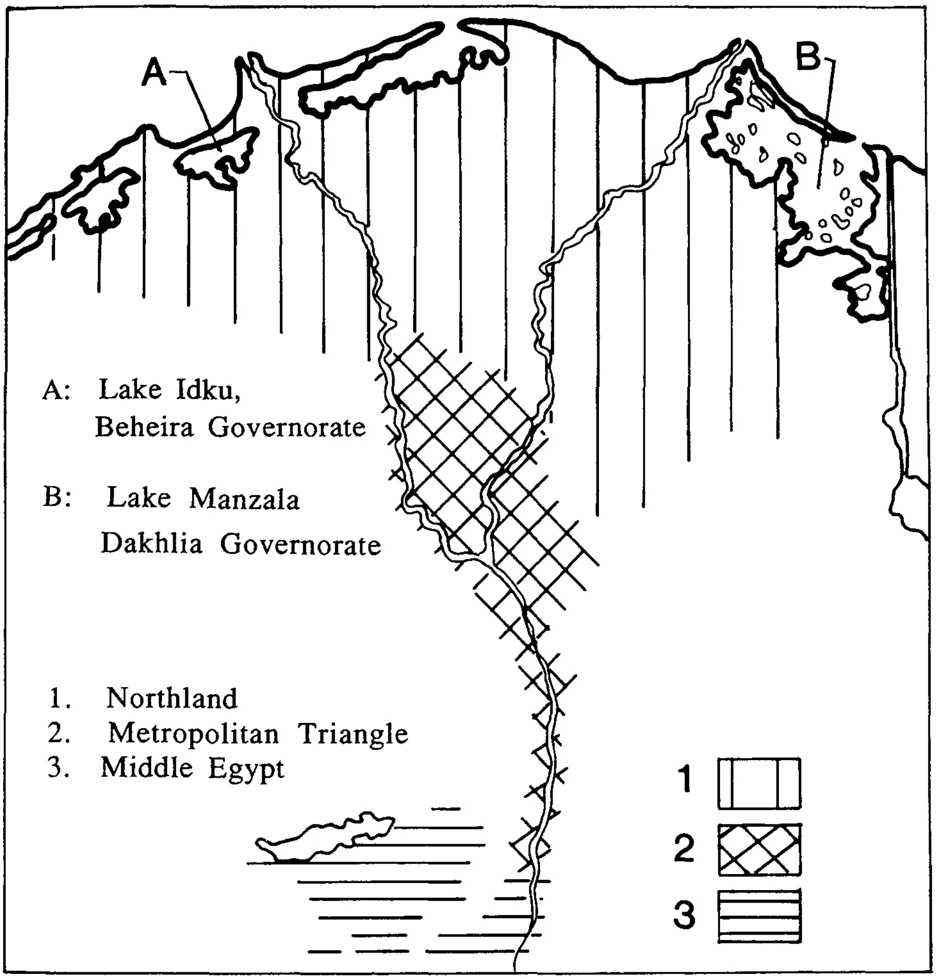
The present study focuses on the economics of reclamation. Rates of return on investment at both financial and economic prices were calculated with the aid of multiperiod programming models. Although these models are more demanding than simple budgeting methods, there are good reasons for expending the additional time and effort that optimization approaches require. Chief among these is the possiblity of making incremental reclamation, i.e., the production of new land, endogenous to the model. Land and agricultural outputs are modeled as joint products of a time-dependent investment process. As a consequence, labor and irrigation water above that required by the optimal cropping pattern continue to have positive scarcity values as they are used to create additional land resources.

Although fieldwork was done on a number of sites in Egypt, the following report describes only one area, namely, the lake region of the northern Delta between Alexandria and Port Said (Map 1 and Appendix). The multiperiod linear programming models used to simulate the representative farms provide interesting evidence on the significance of government policies in determining the choice of area, choice of crops, and the extent to which distorted procurement and input prices determine the financial profitability of private investments. The essay closes with observations about the lessons learned from the private sector that might be incorporated in on-going efforts to make public sector investments more productive.

RECLAMATION IN THE LAKE AREAS

Two distinct types of reclamation—with several further subdivisions–can be found in the lake areas. Lake-bed reclamation follows the principles of reclamation that have been practiced along the coasts of Europe and other shallow bodies of water. It consists of a system of dikes that confine the water to certain parts of the lake while the remainder is drained and reclaimed. The water supply for the new land comes from the remainder of the lake or from a nearby surface water system.

Sand-fill reclamation approaches the problem of combining land and water for agricultural purposes by bringing the land to the water. Plots, often extending hundreds of yards onto the lake bed, are created with sand fill brought from nearby sand dunes. While the lake-bed farming system is characterized by efforts to manage adverse soil and water conditions, the sand-fill strategy is based on a complete transformation of the production environment. Rather than face the difficult agronomic problems associated with reclamining lake-bed soils, these soils are simply buried under layers of sand. The sand isolates the crop roots from the waterlogged and saline conditions of the original lake bottom.



Map 1.—Private Reclamation Study Sites

Source: G. Hamdan, 1961, "Evolution of Irrigation Agriculture in Egypt," in L. Dudley Stamp, ed., *A History of Land Use in Arid Regions*, UNESCO, Paris, p. 134.

Lake-Bed Reclamation

Traditional lake-bed reclamation can be broken into two types: small private diking efforts at the edges of the lake and large tracts drained by the government and settled under government auspices or claimed by squatters.

The crop rotation in the lake-bed farming system is a subset of the common cropping pattern associated with contemporary Egyptian agriculture. The major summer crops are cotton, maize, and rice. Summer vegetable crops include tomato, radish, leek, and *molokhia.*[7] The winter rotation is dominated by berseem (Egyptian clover), but other crops, such as broad beans, are grown as well.

The lake-bed farming system is unique among Egyptian private land reclamation strategies in two respects. First, it is the only case where animal husbandry has an important role in reclamation agriculture. It is also the only case where farmers choose to emphasize crops that are regulated heavily by the Egyptian agricultural price policy. The tree crops and perishable vegetables, which are central to profitable strategies in all other known private reclamation strategies, cannot survive in the saline, waterlogged environment of the former lake bottoms.

Assumptions regarding crop yields and labor requirements have long been central to the policy debate over the feasibility of land reclamation. Important yield figures used in the model of the lake-bed farming system and based on survey data, as well as estimates from other sources, are shown in Table 1. The yields used in the lake bed analysis are assumed to be attainable at full development. They are compared to data from government lake drainage projects at similar stages of development and to Egyptian national averages for the old lands. With the exception of broad beans, lake-bed model yields either exceed or are within 90 percent of average yields recorded for the government projects. Taken together, the lake-bed model and average of projects come within 75 percent of the national average in only two cases: cotton at 75 percent and rice at 77 percent. It is apparent from these estimates that, as a rule, drained lakes betray the hope that techniques and results are easily transferable from the old lands.[8]

Although survey yields are uniformly lower than national averages, observed lake-bed labor inputs are equal to or greater than those reported for comparable old land sites (Table 2). Labor requirements specified in the lake-bed model at full development (year 11 and after) are generally

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[7] Molokhia (*Corchorus olitorius*) is a leafy vegetable used to make glutinous sauces and soups.

[8] Many of the important divergences between observed yields at the farm-level and aggregate figures from the old lands (or from lake-bed projects) appear to be related to the adequacy of local irrigation systems.

Table 1.—Yields of Marketed Crops in Drained Lake Areas at Full Development
(Kilograms per feddan)

	Broad beans	Cotton	Maize	Rice	Tomato
Lake-bed model[a]	362	840	980	1,500–1,800	3,595
Average for government projects[b]	860	553	842	1,612	4,010
National average, 1981[c]	870	1,125	1,720	2,340	7,560
Government projects					
Idku (Lake Idku)	1,000	640	800	1,800	
Bahr El Bakar (near Manzala)	780	630	850	1,400	
El Hamoul (Lake Burullus)	1,400	390	990	1,350	4,000
Abis (Lake Mariut)	620		820	1,900	
El Nadha (Lake Mariut)	500		750		4,020

[a] The lake-bed model is based on survey data from private settlers at Lake Manzala and government project settlers at Lake Idku.

[b] All government project data are from Hunting Technical Services, *Suez Canal Region Integrated Agricultural Development Study*, Special Report No. 2, "Comparative Analysis of Reclamation Experience," Appendix C, Table C.1, Cairo, April 1979.

[c] National averages are from Youssef Wally et al., "Strategy for Agricultural Development in the Eighties for the Arab Republic of Egypt," International Development Series DSR-9, Iowa State University, 1983, p. 32.

above national figures and estimates used in studies of three governorates in the Nile Delta rice belt. Farmers in the lake-bed area uniformly reported that most crops on new land required more labor than those same crops on old land. Labor required for rice and berseem is increased by water shortages that are common in the land reclamation sites during the spring and summer when low water levels in drains and canals make it necessary to run pumps longer to irrigate a given area.[9]

Tables 3 and 4 contain partial budget calculations for gross margins on

[9] Due to low levels in water channels, the pump must be tended during the entire irrigation to prevent excessive uptake of mud. Typical pump sets have water-cooled engines. Pumping mud rather than water causes the motor to over-

Table 2.—Crop Labor Requirements:
Lake-Bed Model and Old Lands
(Adult-equivalent hours per feddan)

	Lake-bed model[a]	National data[b]	Beheira[c]	Sharqiya[d]	Kafr El Sheikh[e]
Broad beans	293	172		288	157
Cotton	638	684	672	717	377
Maize	295	240		296	207
Rice	833–865	440	648	417	236
Tomato	1,007			635	
Long-season berseem	341 + 797	160	240	228	159
Short-season berseem	75 + 199	94	144		54

[a] The lake-bed model is based on survey data. Berseem labor figures represent "all other labor" plus harvest labor.

[b] National data are from Amr Mohie-Eldin, "The Development of the Share of Agricultural Wage Labor in the National Income of Egypt," in Gouda Abdel-Khalek and Robert Tignor, eds., *The Political Economy of Income Distribution in Egypt*, Holmes and Meier, New York, 1982, p. 245. Data are converted by adding man-days to one-half nonman-days and multiplying by 8 hours.

[c] Beheira Governorate data are from Winrock International, "Potential for On-Farm Feed Production and Utilization by the Egyptian Small Farm Sector," Catholic Relief Services/USAID, Cairo, June 1980, p. 126. Man-days are multiplied by 8 hours.

[d] Sharqiya Governorate data are from Wayne M. Dyer and Carl H. Gotsch, "Public Policy and the Demand for Mechanization on Egyptian Farms," Economics Working Paper No. 133, ADS: Egypt Project, University of California, Davis, March 1983, pp. 41–44. Data are converted by adding man-days to one-half child days and multiplying by 8 hours.

[e] Kafr El Sheikh Governorate data are from the Egypt Water Use and Management Project, "Kafr El Sheikh Farm Management Survey, Crop Enterprise Budgets and Profitability Analysis," EWUP Technical Report No. 11, Cairo, November 1982, pp. 55–61.

crops included in the lake-bed farming system models. These budgets were a prelude to construction of the multiperiod linear programming models discussed in the following section. Cost and returns are evaluated for three sets of prices: (1) administered prices simulate the perfect realization of

heat, leading to severe damage.

government price policy; (2) parallel prices represent prevailing rates in the extensive unofficial market for agricultural inputs and outputs; and (3) "economic" prices reflect opportunity costs in world markets.

Table 3.—Partial Analysis of Returns for Marketed Crops in the Lake-Bed Farming System
(Standardized on one feddan; prices in Egyptian pounds)

	Yield (kg)	Yield (percent, national average)	Gross margin at Admin. prices	Gross margin at Parallel prices	Gross margin at Econ. prices	Transfer at admin. prices
Years 1–5						
Maize, year 1	686	40	−9	−14	1	−10
Broadcast rice						
Drainwater	500	21	−322	−317	−365	43
Canalwater	800	34	−317	−304	−336	18
Years 6–10						
Broad beans	362	42	30	23	30	0
Cotton	158	14	9	−2	30	−20
Transplanted rice	900 to 1,500	38 to 64	−239 to −244	−232 to −219	−267 to −223	28 to −21
Year 11 and more						
Broad bean	362	42	30	23	30	0
Cotton	840	75	165	153	424	−259
Maize	980	57	13	9	36	−23
Molokhia	6,668		131	116	65	66
Radish			−373	−397	−436	64
Transplanted rice						
Drainwater	1,500	64	−244	−219	−223	−21
Canalwater	1,850	79	−238	−213	−198	−40
Summer tomato	3,595	48	−201	−219	−228	27

The model shows low or negative gross returns during the first decade of reclamation, primarily because it was assumed that all labor was paid the prevailing wage rate in the area. In fact, most of the labor is provided by the family and low returns are accepted as part of the cost of establishing the new farm enterprise, a familiar phenomenon in pioneer settlements.

The second reason that various crop activities show negative returns is that they have not been credited with their contribution to the reclamation process. In addition to providing immediate returns, benefits accrue to

Table 4.—Partial Analysis of Imputed Returns for Fodder Crops in the Lake-Bed Farming System
(Standardized on one feddan; in Egyptian pounds unless otherwise indicated)

	Maximum number of cuttings	Imputed value per cutting	Gross margin at Admin. prices	Gross margin at Parallel prices	Gross margin at Econ. prices	Transfer at admin. prices
Long-season berseem						
October planting						
Year 1	2	12	−66	−77	−119	53
Year 2	2	24	−42	−53	−95	53
Year 3 to 5	3	30	−4	−15	−62	59
Year 6 and 7	4	36	38	27	−36	75
Year 8 to 10	5	48	120	108	37	82
+ seed	4	48	172	161	84	88
Year 11	5	72	240	228	157	82
+ seed	4	72	268	257	180	88
Relayed with rice						
Year 6 and 7	4	36	57	45	−9	65
Year 8 to 10	5	36	70	59	−13	83
Year 11 +	5	72	250	239	167	83
Short-season berseem[a]						
Year 6 to 10	1	36	−36	−42	−56	19
Year 11 +	1	72	0	−6	−20	19
Sudan grass						
Any year	3	48	63	61	45	18

[a] Berseem cuttings include hay.

planting, tilling, and harvesting that are only reflected in future improvements in yields.

The implicit transfers indicated by a comparison of columns 3 (domestic prices) and 5 (world prices) is the net result of taxes and subsidies generated by the government's agricultural policy. In the early years of reclamation, subsidies to rice production through cheap fuel prices outweigh the implicit tax on the meager rice yield—arithmetic that is reversed by the time that full-development yields are achieved. For crops subject to price regulation, the implicit tax always outweighs the subsidy transfer. If farmers can obtain subsidized inputs for unregulated citrus and vegetable crops, on the other hand, the transfer effect is always positive. This effect holds even if they must resort to the black market to obtain inputs, as most do.

Fodder is an important crop in lake-bed reclamation. Its value is realized through livestock activities. Family members, especially women and children, are the primary source of labor. Although the only primary data collected during the survey of private land reclamation were inventories of animals kept by farmers, it was clear from farm visits that the methods of animal husbandry were very similar to those practiced on the old Delta lands, and these estimates were used in building the model.[10]

Sand-Fill Reclamation

The sand-fill cropping system severely restricts crop choice. Tomatoes are the sole annual crop grown during the winter. Watermelons are the only important summer annual. Occasionally, peppers or eggplant are grown in the summer, but cultivation is limited to a few plants raised for the farmers' own consumption. These annual crops are the first stage in a series of contingent investments and shifting crop mixtures. Guava trees and young date palms are planted in the next stage. Tomatoes are intercropped with the perennials for two to five years. By the time trees are five years old, shading and harvesting tree fruit interferes with tomatoes. The climax community in this pattern of ecological succession is a mature date grove interspersed with guava trees or date seedling propagation activities. Fifteen to twenty years elapse between initial reclamation investment and realization of a mature grove.

This limited range of crops is a manifestation of severe economic and agronomic constraints. Only high value annuals that are well-suited to sandy soil can generate sufficient revenue to finance sand-fill expenses during the period before tree crops begin production. Perennials must be able to issue adventitious roots to benefit from new layers of sand. Salt tolerance, for which date palms are noted, is also a requirement.

There are few sources of data that can be compared appropriately with the sand-fill system. In particular, no published data on yields or labor are available for the intercropping combinations that predominate. Yield and aggregate labor figures were obtained primarily from field investigations and checked against other sources for consistency (Table 5). The winter tomato figures are for tomatoes planted alone on open land. Tomato yields reported by farmers are more than twice national averages and more than four times the yield estimates in the feasibility study for an adjacent site.

[10] No data were available on weeds and other waste that are collected for fodder during seasonal feed deficits. *Deneiba*, a weed which grows on unsettled lake-bed land and in rice fields, probably is an important source of animal nutrients during the summer.

The 15 metric ton yield is used in feasibility calculations and represents a conservative interpretation of data obtained from interviews. Tomato yields in excess of 20 metric tons were reported for some farms. Date yields in the model are 24 percent above the low range and within 2 percent of the high range reported by University of California researchers for Zagloul dates, the dominant variety at Idku.

Table 5.—Sand-Fill Farming System at Full Development

	Winter tomato	Guava	Dates
Crop yields *(tons per feddan)*			
Sand-fill model[a]	15–18	7.2	6.1
Bouseili assessment[b]	3.5	8	
ADS–Egypt Project[c]			5–6
Crop labor requirements *(adult-equivalent hours per feddan)*			
Sand-fill model [a]	1,172	1,362–1,414	1,030–1,069
Bouseili assessment[b]	680	608	

[a] Sand-fill model figures are based on survey data.

[b] Ministry of Irrigation, Master Plan for Water Resources Development and Use, "Re-Use of Drainage Water for Irrigation in Buseili Area," Cairo, August 1982. Harvest costs are converted to man-days by dividing by £E2.50 per man-day. Labor requirements are converted to man-hours by multiplying by 8 hours per man-day.

[c] R.D. Blond, ed., *The Accomplishments of a California–Egypt Research Collaboration: Agricultural Development Systems–Egypt Project 1979–1983*, University of California, Davis, 1984. Date yields are from p. 95 for Zagloul variety at El-Kanater in 1982. Yield per palm is converted to yield per feddan assuming 45 palms per feddan, the planting density for the sand-fill model. Zagloul is the predominant variety in the survey data.

Guava never appear alone in the sand-fill model and mature plantings consisting exclusively of guava are observed rarely in the Idku region. The guava figures for the sand-fill model in Table 5 represent the hypothetical case in which data for intercropped guava are scaled to higher planting densities corresponding to guava alone. The guava yield figures are within 10 percent of the higher yield estimates for the Bouseili project assessment.

Labor estimates used in the model are roughly double the levels used by the Ministry of Irrigation. The high labor input documented for the sand-fill model is consistent with the management-intensive nature of the sand-fill cropping system.

Table 6 contains calculations of returns to crops and crop combinations based on input and output parameters in the sand-fill farming system model.[11] It is immediately apparent that profits and price policy transfers are much higher per unit area than activities in the lake-bed farming system. This is because the domestic prices used to calculate gross revenues of perishable fruits and vegetables are assumed to reflect their opportunity cost to the economy, i.e., their "world" prices, as well. Because, even at the parallel market price, many inputs are priced below world prices, sand-fill activities receive net subsidies at all stages of development.

Gross margins of Egyptian pounds[12] £E636 to £E621 per feddan for watermelons are based on what farmers characterized as a"good" year.[13] Successful melon production requires that they be planted in new sand. Consequently, melons are only observed on open land or with newly planted perennials. Gross margins of £E933 to £E955 for winter tomatoes on open land fit farmers' statements that they expect profits in the range of £E1,000 per feddan in a normal year. Most tomatoes grown in Idku are harvested during March, April, and May. (In the sand-fill model, about half of tomato output is marketed in May.) If the entire harvest occured in May, the gross margin for tomatoes planted alone would fall almost two-thirds to £E352 and £E330 for administered and parallel prices, respectively. Since average annual cost of new sand required to maintain productivity is about £E180 per year on vegetable land, market timing clearly is a crucial determinant of feasibility of the sand-fill reclamation strategy.

This marketing advantage is due to the special microclimatic characteristics of the Idku zone. Idku winter tomatoes are at much less risk of frost than other major producing areas, such as the Fayoum. Idku farmers also employ special techniques to augment their microclimatic advantage. Mulching and reed fences are common tactics used to give the plants extra protection. Some farmers and traders report that intercropping with young perennials also provides frost protection.

Farmers said they shift from annuals to perennials because dates have higher returns and require less labor than tomatoes. Figures in Table 6 are consistent with this explanation. Date palm seedlings are planted on sand-fill plots when they are one to five years old. The sand-fill model assumes seedlings transplanted at age five, which cost about £E30 each when purchased from nurseries in Rashid. Palms begin to produce a few dates when 10 years old (five years after transplantation), but do not approach

[11] These calculations do not include the cost of additional sand required to maintain productivity in the sand-fill system.

[12] In 1981, the parallel market exchange rate was about £E1 per U.S. dollar. The central bank exchange rate was £E0.70 per U.S. dollar.

[13] Fresh produce prices are as volatile in Egypt as elsewhere in the world, a fact that needs to be kept in mind when interpreting the gross revenue calculations.

Table 6.—Partial Analysis of Returns for Sand-Fill Crops*
(Standardized on one feddan; prices in Egyptian pounds)

	Yield *(kg)*	Gross margin at Admin. prices	Gross margin at Parallel prices	Gross margin at Econ. prices	Transfer at admin. prices
Annual crops alone					
Winter tomato	15,000	955	933	906	49
Summer watermelon	n.a.	636	621	603	32
Intercropping combinations					
Newly planted					
Date + guava[a]		−1,503	−1,511	−1,539	36
+ tomato	15,000	−657	−686	−737	80
+ melon	n.a.	−400	−442	−505	105
Age one					
Date + guava[a]	0	−69	−77	−102	33
+ tomato	7,500	180	157	93	86
Age two					
Date + guava[a]	0	−69	−77	−102	33
+ tomato	5,025	42	19	−44	85
Age three					
Date + guava	450 + 360	66	54	15	51
+ tomato	3,367	156	134	68	87
Age four					
Date + guava	1,800 + 4,500	928	910	857	71
+ tomato	2,256	893	866	792	101
Ages six to ten					
Date + guava	2,925 + 6,751	1,166	1,122	1,019	147
Mature groves					
Dates + guava	6,075 + 5,400	1,746	1,702	1,594	152
Dates alone	6,075	1,454	1,443	1,392	62
Guava alone[a]	7,200	397	353	245	152

*Figures are based on survey data.
[a]Marks hypothetical figures.

full production until the fifteenth year. Thereafter, yields increase gradually for several decades; the productive lifetime of the tree may be between 50 and 100 years depending upon the care with which the surrounding sand fill is maintained.

Gross margins of intercropping combinations in Table 6 demonstrate the role of tomatoes and guavas in financing date grove development. Typically, farmers grow tomatoes alone on new plots for two to five years to pay the high costs incurred to build sand to the depth required by trees. After trees are planted, tomatoes make a positive contribution to gross margins in intercropping combinations through four years of tree growth (from planting through age three) in calculations based on the parameters in the model.

The maximum palm density of 45 palms per feddan for most date varieties is determined by agronomic considerations, principally rodent control. This pattern leaves space between palms for guava trees. Significant complementarities result from growing date and guava on the same plot, but guavas have no known negative effect on productivity of mature date palms. At full development, cultivation and irrigation account for more than 40 percent of labor inputs to joint production; similar inputs would be required for each crop separately.

Complementarity also exists for manure and chemical fertilizer inputs and application activities. The most significant economy of joint production of dates and guavas, however, is due to expenses for ongoing addition of sand. Although additional compaction probably results from performing crop-specific activites (such as harvesting) in tandem, there is no evidence that less sand is added to groves of dates alone than to groves of dates intercropped with guavas. Conversely, the cost of maintaining productivity by adding sand explains why few groves are composed exclusively of guava trees. If £E300, the average annual cost of adding sand for perennial plots, is subtracted from the gross margins for mature guavas alone in Table 6, returns to fixed factors are less than £E100 per feddan. It makes no economic sense to grow guava alone in the sand-fill model because returns to date palms alone or date palms plus guavas are at least ten times as high after land maintenance costs are counted. However, the cash-generating role of guava trees in the intermediate stage of date grove development parallels the role of winter tomatoes in the initial stage.

Cropping must be intensive because initial and ongoing costs of sand-fill are high. These high costs and the scarcity of winter tomatoes have also led to a special financial role for produce traders. Linked credit and marketing arrangements between farmers and wholesalers are common in Egypt. For certain crops, wholesalers advance cash to farmers at the beginning of a growing season to cover production costs. These advances generally are repaid at harvest from revenue generated by sale of produce. Unlike bank loans, no fixed interest charges are levied. Instead, farmers agree to market their entire crop through the wholesaler, who is entitled to charge an ad valorem commission. Wholesalers eager to obtain supplies of tomatoes and watermelons are willing to advance about half of crop production costs to farmers investing in reclamation and to wait up to three years for the amount to be be repaid. Total maximum outstandings do not exceed

£E1,500 to £E3,000 per farmer, based on area planted. Loans of £E1,000 per feddan of winter tomatoes and £E500 per feddan of watermelons are typical. Like the working capital advances, the intermediate term loans bear no interest charges and are subject to the same commission rates: 6 percent for tomatoes and 8 percent for watermelons.

MODELING LAKE AREA RECLAMATION

The diversity of opportunities and constraints faced by farmers in reclamation agriculture mean that even a simplified model with a minimum horizon is quite large. The lake-bed model consists of 10 one-year periods. It has 798 rows, 888 activities, and 6,398 nonzero elements in the coefficient matrix. The sand-fill model consists of 13 one-year periods with a total of 465 rows, 628 activities, and 4,423 nonzero structural elements. Consequently, only a general outline of the model's structure can be presented here.

Objective Function

The models contain two objective functions. One, in which inputs and outputs are measured at market prices, serves as the maximand when financial feasibility is being examined. (If the model was used to maximize economic returns, it serves as the accounting row that evaluates the financial implications of economic optimization.) In the second, alternative, objective function, inputs, and outputs are valued at "economic" prices. These prices are derived from the usual reference to the prices of similar commodities in world markets adjusted for differences between the border and the farm gate. (When not used as the objective function, this row evaluates economic returns under the assumption that private returns are being maximized.)

The most numerous elements in the objective function are the conventional net revenues of crop and livestock enterprises. Variable costs that have been subtracted directly from gross enterprise revenues include purchased inputs and hired tractor or animal power used in field preparation, threshing, and other contract services. Labor and water pumping costs are isolated as separate activities in the objective function. Labor hiring is limited by profitability or the availability of capital.

Reclamation and land maintenance activities are also included in the objective function. In lake-bed reclamation, leaching and tractor hiring for cultivation are specified. In sand-fill reclamation, a range of sand-adding activities allow the creation of an initial depth of one meter (minimum for annuals), 1.25 meters, and 1.5 meters (minimum for perennials). Depth may be built up through increments of 0.25 meters, thereby allowing for conversion from land initially limited to annuals to land suited for perennials. Settling and capillary action require addition of 0.20 meters of sand for every five years for annuals and every three years for perennials to maintain productivity.

Constraints

The bulk of the constraints in the model are transfer rows that serve to link time periods together. In the first period, the capital constraint in each model is bounded by a net worth parameter. Capital rows in each period serve to make capital acquired in the foregoing period available for current period production. In the sand-fill reclamation model, working capital advances contingent on production of specific annual crops (watermelon and winter tomatoes) and subsequent repayment of these advances, increase and decrease capital availability. A constraint on credit, empirically based on conversations with produce traders, limits cumulative outstanding capital advances, which may be carried over up to three years.

A second set of constraints serves to tranfer the increased productivity resulting from agricultural activities from one period to the next. These transfers may be thought of as shifts in land quality resulting from initiation and maturation of perennial crops in the sand-fill model and increases in land productivity in the lake-bed model. Both are considered to be measures that reflect the progress of the reclamation process.

Constraints representing the technical requirements of various crop enterprises also place limitations on crop and livestock output. In each model, the range of optional crop activities expands over time and hence the number of such constraints increases over the simulated time horizon.

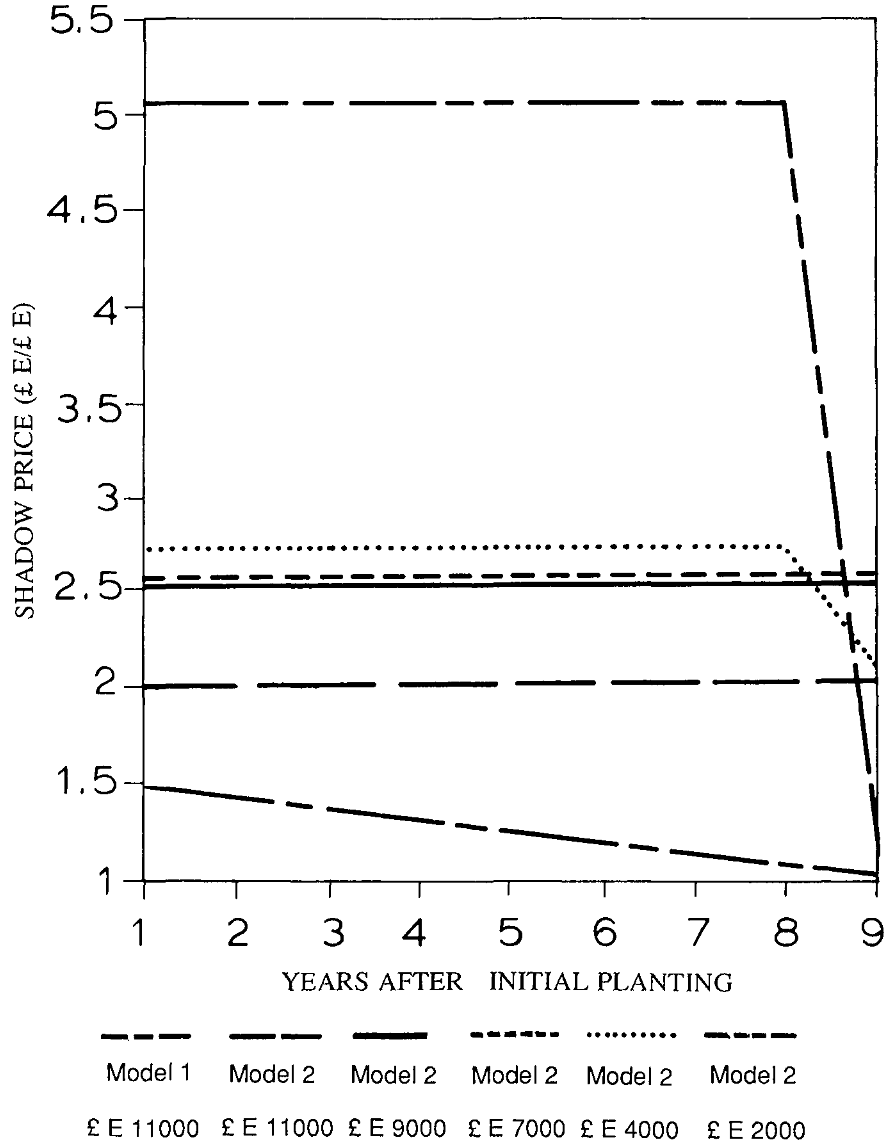
Modeling Results

Mathematical optimization undoubtedly overstates the ability of decision makers to make intemporal capital allocation decisions in uncertain and risky environments. Hence the results of the model exercise represent an upper bound on the profitability of reclamation in the lake areas.

The models were run under two basic assumptions, namely, the presence or absence of perfect capital markets. In the former, it was assumed that borrowing and lending were determined only by profitability. In the latter, a range of alternative restrictions that limit production investments to the generation of capital in previous periods was explored. The result was a series of period-specific shadow prices for capital that provide evidence about the interaction of capital availability and time for each farming system.

Period-specific shadow prices of capital are plotted in Charts 1 and 2. The difference between the patterns in the two charts highlights the fundamental difference between the economics of lake-bed and sand-fill reclama-

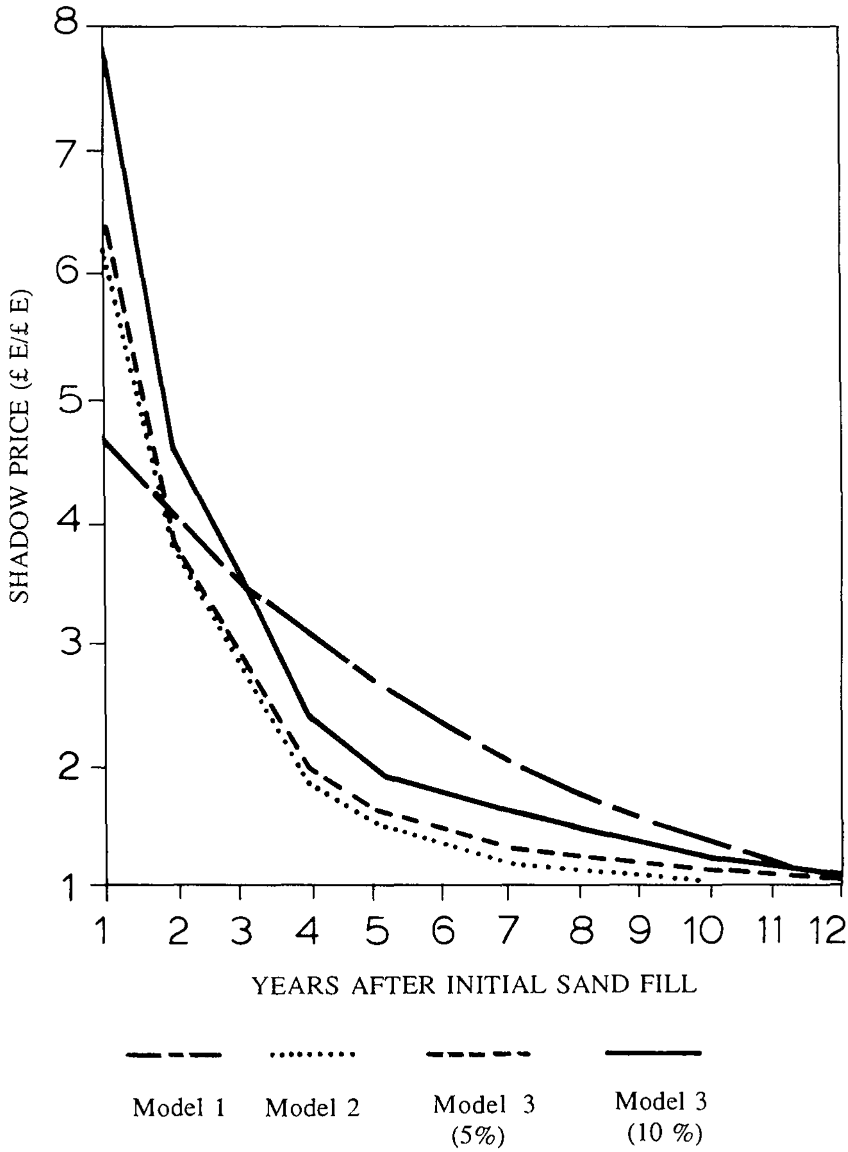
Chart 1.—Shadow Price of Capital
in Lake-Bed Models*



*Figures are initial capital endowments in the models.

tion. As with most private land reclamation strategies, capital constraints are alleviated with time in the sand-fill farming system because high value crops contribute cash from the outset. In constrast, persistence of low yields and high costs in the lake-bed system lead to chronic capital scarcity. The constant shadow prices in the lake-bed model reflect the necessity for the farm family to retain a share of the initial capital endowment throughout

Chart 2.—Shadow Price of Capital
in Sand-Fill Models



the nine-year period of land development to meet consumption requirements. Thus, reclamation investments in early years are constrained by consumption requirments in the terminal period. Households with limited capital (£E2,000 to £E4,000) subsist by reclaiming very little land, minimizing cash outlays for pumping and labor hiring, and concentrating available family labor on livestock production activities.

Charts 3 and 4 demonstrate the familiar finding that the path of time-dependent models is a function of both the rate of change and the initial conditions. In Chart 3, farm size increases with increasing capital endowments until irrigation constraints impose an upper bound beyond which initial capital availability does not have an effect (£E12,000). An inverse relationship with herd size is shown in Chart 4. Under the assumption that investment is determined by retained earnings, the relaxation of initial capital constraints permits the redirection of labor from the production of livestock to the reclamation of land.[14]

Farm size in various runs of the sand-fill model increases to 1.25 to 1.5 feddans over the first three years of investment reflecting the credit limits imposed by the produce traders. Depending upon assumptions regarding alternative investment opportunities, farm size ranges from roughly 2.5 feddans to 3.75 feddans after ten years of investment. This growth trajectory fits the pattern observed on farms at Lake Idku. The onset and rate of investment in perennial crops also is sensitive to assumptions regarding captial markets. For various models, the first date palms and guava trees were planted in the fifth, sixth, or seventh year of investment.

Financial and Economic Feasibility of Lake Area Reclamation

The financial and economic feasiblity of reclamation rest on a wide range of detailed assumptions; only some of the more important are indicated below.[15]

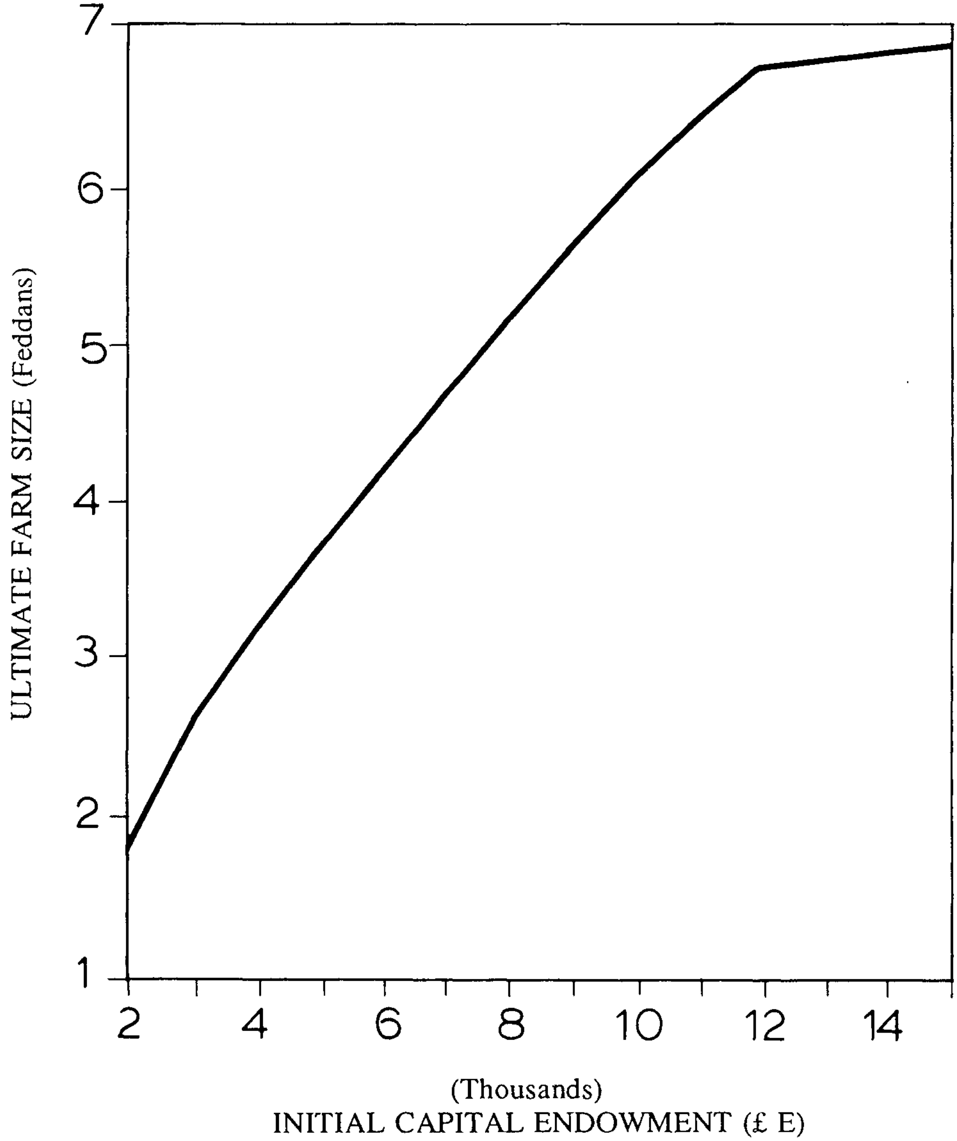
Model 2 (Table 7) refers to models of self-financing reclamation enterprises with neither opportunities for borrowing from financial institutions nor opportunities for alternative uses of cash, such as consumption beyond the minimum subsistence level specified in the model or lending.[16] These restrictions reflect capital market imperfections impinging on reclamation investment. The only borrowing possible in models of type 2 occurs in sand-fill reclamation and represents cash advances from produce traders that are contingent on specific commodity flows.

[14] The disappearance of livestock from the lake-bed model does not reflect the reality of many lake-bed farms. This discrepancy is probably the result of setting the labor constraint at seven hours per day. While this is a typical work day for casual labor, it does not reflect the time available from family members for livestock enterprises. Increasing the labor constraint (a "hardworking" scenario), improves the performance of the model vis-à-vis the field survey results.

[15] For a comprehensive interpretation of the results of the modeling exercises, see Thomas Tomich (1984). John Page (1982) provides a detailed methodology for the estimation of the opportunity cost of the factors of production.

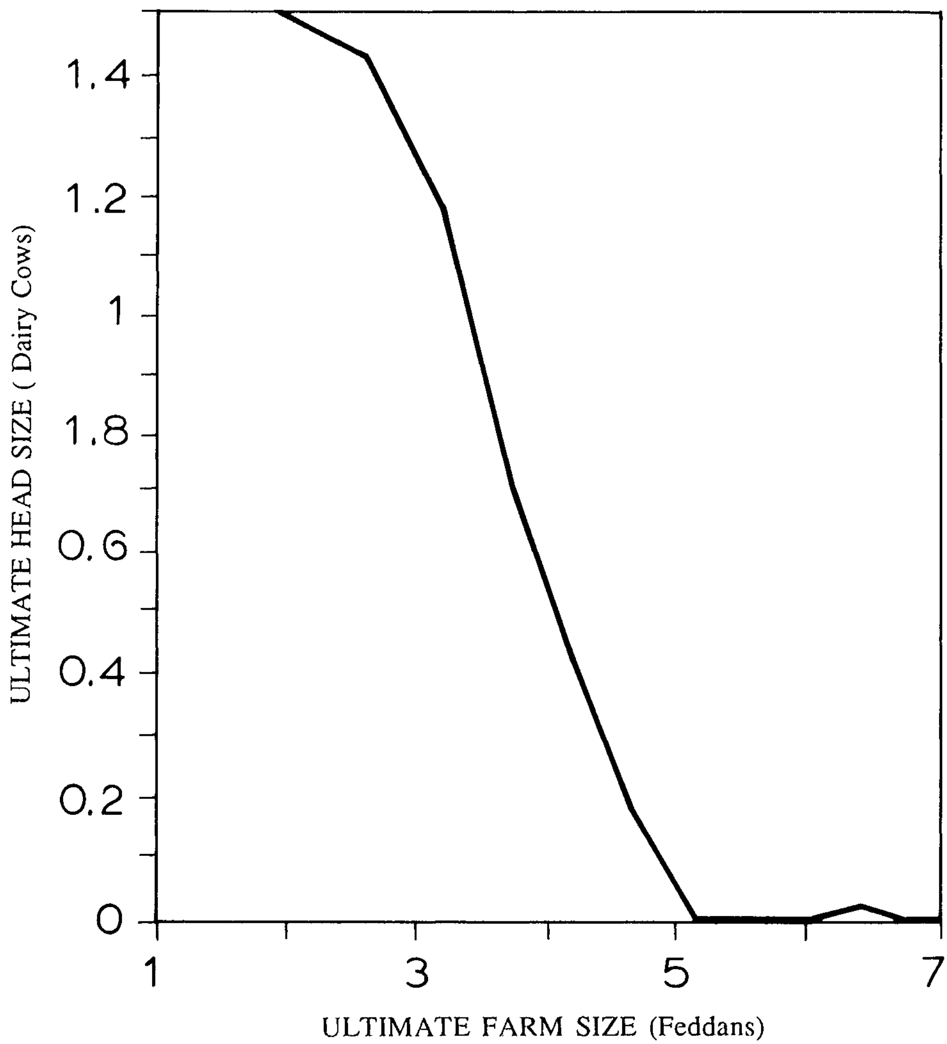
[16] Model 1 corresponds to models employed for theoretical validation with perfect borrowing and lending opportunities. Results from these simulations conducted under the assumption of perfect capital markets are not reported because they have little relevance to the circumstances faced by Egyptian farmers investing in land reclamation.

Chart 3.—Effect of Capital Constraint on Lake-Bed Farm Size



Model 3 refers to models of the sand-fill system that resemble model 2 described above, except that models of type 3 incorporate "lending" activities to allow alternative uses of cash with a return of 5 percent in some cases and 10 percent in others. These lending activities can be interpreted as simulations of alternative investment opportunities or as approximations

Chart 4.—Effect of Lake-Bed Farm Size
on Livestock Activities



of time preference for cash withdrawals for consumption. Model 3 is irrelevant in the lake-bed models because these models generate no cash surpluses during the development period.

Lake-bed reclamation—financial feasibility: Based on the programming analysis, there is a significant divergence between financial and economic

Table 7.—Comparison of Financial and Economic Feasibility for Sand-Fill and Lake-Bed Reclamation Models*
(Values in Egyptian pounds)

	Financial internal rate of return *(percent)*	Economic present value discounted at *(percent)*		
		4	10	12
Sand-fill model 2[a] with family labor valued at £E550	14.7	51,510	4,109	734
Sand-fill models with family labor valued at £E780				
Model 2	12.8	45,846	1,831	—
Model 3 (with option of lending cash at 5 percent)	n.a.	40,256	1,960	—
Model 3 (with option of lending cash at 10 percent)	n.a.	32,930	1,719	—
Lake-bed model 2[b] with 10-hour work days and land preparation costs of				
£E2,000 per feddan	4.5–6.3	—	—	—
£E1,200 per feddan	7.2–9.1	—	—	—
£E400 per feddan	11.0–12.9	—	—	—
Lake-bed model 2 with 12-hour work days and land preparation costs of				
£E2,000 per feddan	5.1–6.8	—	—	—
£E1,200 per feddan	7.8–9.5	—	—	—
£E400 per feddan	11.6–13.4	367	—	—
Lake-bed model 2 with 12-hour work days, high-value livestock and land preparation costs of				
£E400 per feddan	12.2–13.9	6,569	—	—

*Dashes indicate negative present values.
[a]Sand-fill models are based on 7-hour work days.
[b]Lake-bed models value total family labor at £E550 per year.

returns for all time periods. In the early years, there is a substantial subsidy to the lake-bed reclamation program because of Egyptian subsidies on diesel fuel used in pumps. In the latter part of the development period, the net subsidies become implicit taxes as the tax implemented through official crop prices outweighs the effects of the fuel subsidy. For example, at full development, total annual financial returns are £E874, while economic returns are £E1,521. The optimal cropping pattern at full development follows a two-year cotton rotation. The limited range of profitable crops in the adverse lake-bed environment means that cotton is financially attractive in the models, despite low prices from the government.

The highest profit scenario in the lake-bed models is achieved by increasing prices for livestock products produced in the model under the assumption that in peak periods farmers can work 10–12 hours per day. Under the hardworking scenario, farms in the low range of land preparation costs (£E400 per feddan) produce internal rates of return ranging from 11 to 14 percent. At the intermediate land preparation cost (£E1,200 per feddan), the range of rates declines to 7 to 10 percent. Finally, for the high-range fixed cost of land preparation (£E2,000 per feddan), internal rates of return are 4 to 7 percent. These computations suggest that a hardworking farm family probably can obtain a reasonable income from lake-bed reclamation—if they have a bit of good fortune plus enough capital to provide for interim consumption. In a country with large extended families willing to share resources and a scarcity of arable land, there appear to be a substantial number of farm families who are willing to risk lake-bed reclamation.

Lake-bed reclamation—economic feasiblity: The economic feasibility of several lake-bed scenarios were calculated with family labor valued at £E550 per year. Even under this low-value assumption for the opportunity cost of family labor, only the two most favorable scenarios were economically feasible at a discount rate of 4 percent. None of the models were feasible at 6 percent.[17] If these models accurately portray the lake-bed farming system, it is difficult to justify public investment in lake-bed reclamation because economic returns are well below the 10 percent scarcity value of capital estimated in the study by John Page (1982). (The 6 per-

[17] The lake-bed models represent optimistic agronomic assumptions. In particular, the two-year cotton rotation is generally considered appropriate only for fertile Delta soils. Furthermore, a rice crop may be necessary every third year to insure sufficient leaching of generally saline soils. Imposing these constraints on the model results in drastic reductions in financial income, but they are consistent with complaints by farmers regarding inadequate income in the government scheme at Lake Idku. Incomes obtained under more pessimistic assumptions are also consistent with farmers' efforts to convert their lake-bed plots to the sand-fill farming system.

cent social return in the best-case scenario is roughly consistent with Page's estimate of 5.5 percent for the consumption rate of interest, meaning that policy makers ought to be indifferent between investments in lake-bed reclamation and food subsidy expenditures for low income consumers.)

Financial and Economic Feasiblity of Sand-Fill Reclamation

The feasibility tests performed on the results from the sand-fill model are robust under a variety of assumptions regarding the structure of the capital market and the opportunity cost of labor. In the model of a self-financing sand-fill enterprise, the financial internal rate of return is calculated to be 15 percent per annum. (Family labor is assumed to have an opportunity cost of £E550 per year.) If the models are reasonable representations of real investment opportunities, these results demonstrate that sand-fill reclamation can be attractive to private investors under the prices currently prevailing in Egypt.

The results of the economic feasiblity analysis of investment in sand-fill reclamation projects are also robust in the face of reasonable alternative assumptions about the availability of an institutional lending mechanism. For land with relatively unproductive alternative uses, such as salt flats, low-yielding fisheries, and waterlogged reclamation sites, sand-fill reclamation seems to present a socially productive use of resources.[18]

PRIVATE SECTOR RECLAMATION AND PUBLIC POLICY

It will by now be clear that the lessons of private reclamation in Egypt are not especially encouraging for further government investment in large-scale, public sector development. It is indeed true that a significant number of individuals are involved in such undertakings and that their contribution to the country's agricultural output, particularly in the off-season, is quite substantial. However, the very characteristics that have permitted this achievement will be difficult to replicate on large projects. Nevertheless, public sector planners would do well to examine carefully the series of ideas and concepts that emerge from studying individual farmers.

Lessons from Models of Private Land Reclamation

The preceding analyses show there is no simple formula for economic feasibility of land reclamation because characteristics of specific sites are the main determining factors. Obviously, opportunities characterized by low costs and immediate high returns are good investments, but these are

[18] Care needs to be taken, of course, not to permit indiscriminate sand-fill reclamation in lakes that currently have high yielding fisheries.

hard to identify and impossible to generalize because they depend on comparative advantage linked to unique conditions. If returns are low and delayed by a long development period (as in lake-bed reclamation), feasibility is doubtful even if reclamation costs are low.

On the other hand, analysis of sand-fill reclamation demonstrates that high cost techniques can be feasible if returns are prompt and high. This is significant because the sand-fill farming system has much in common with reclamation of the sandy desert soils that are Egypt's most abundant and least costly land resource. Sandy soils can benefit from technical innovations in water management that increase technical feasibility. The sand-fill capital outlays of £E6,000 to £E8,000 per feddan are comparable to or exceed cost estimates for installation of sophisticated irrigation technology on desert soils.

Behavior of the models highlights the importance of capital budgeting and family labor supply in allocative decisions at the farm level. These interactions often are overlooked in feasibility analyses because they require more sophisticated methods than are commonly employed in project assessment. While many activities are not profitable when undertaken with hired labor, the returns to labor by family members are attractive and the attainment of wealth embodied in land ownership is sufficient to induce investment. Large-scale operating units have financial problems because wage bills cut too deeply into profit margins for high value crops. Chronic labor shortages on government projects are symptomatic of these problems: project managers cannot afford to pay competitive wages. Conversely, because farm families face capital constraints, individual farmers are receptive to techniques that allow substitution of family labor for capital expenditure. This leads to investment patterns that economize on scarce capital and employ abundant family labor. However, since hired labor represents a cash drain to the farm household, small-scale investors in land reclamation may be severely constrained in their ability to hire labor.

Credit programs for reclamation can be financially attractive to people with labor power and access to open space. The models suggest that in some circumstances rates of return are sufficient for reclamation agriculture to pay off long-term loans. In addition to benefiting those whose only assets are agricultural skills, institutional financing could encourage farmers who are now reclaiming tiny parcels to undertake more ambitious projects. The financing issue is a critical one because of the need for funds for consumption in the initial project years. Not all families have sufficient means to enable them to live off previously accumulated capital while they struggle to develop a surplus in their new environment.

Nevertheless, there are significant barriers to design of workable credit programs due to the special nature of land reclamation. In private reclamation, intra-family transfers and credit from produce traders typically substitute for transactions with financial institutions. However, these alternatives are limited to circumstances of specific individuals or to seasonal marketing links confined to special environmental circumstances. Because ultimate land productivity (and hence land value) is uncertain when financing requirements are highest, newly settled land is not effective collateral to secure loans for reclamation. Furthermore, where private financial arrangements are possible, enforcement of financial contracts depends on personal relationships which are difficult to duplicate and easy to subvert in public lending institutions. (The financing necessary for sand-fill reclamation is provided by private traders who devote considerable attention to the circumstances of their debtors.) Some familiar credit programs, such as self-liquidating working capital loans for specific crops or livestock loans secured by animals, may be workable, but do little to alleviate long-term credit needs.

As an alternative to long-term credit schemes, reclamation projects could be designed to promote self-financing, small-farm units, but this means financial surpluses must be available soon after settlement. Under different reclamation farming systems, the period before agricultural activities cover their variable costs can be as long as a decade or as short as a cropping season. Given the costs of fuel, hired labor, and other inputs to reclamation activities, profitable land development will almost certainly require production of high value annual crops in early years. The traditional crop rotation emphasizing grains, cotton, and fodder cannot provide adequate cash flow. As the field survey demonstrated, the identification of micro climates that permit the production of off-season vegetables and fruits is a key element in profitable private operations. But large-scale public sector development of schemes to produce tomatoes, watermelons, guavas, or dates are likely to run into marketing and distribution problems. Thus a commitment to high value crops carries a commitment to infrastructure for marketing and processing or exporting perishable commodities. At present, this capacity exists only in embryonic form.[19]

A Development Perspective on Private Land Reclamation

Farmers' decisions to substitute the sand-fill farming system for lakebed agriculture at Lake Idku demonstrate that technical choices matter and emphasizes that technical options exist. Rehabilitation of failing farms by a

[19] The experience of several private firms attemping to export fruits and vegetables suggests that developing the physical infrastructure may not be all that difficult. What is less clear is how the small farmers currently selling off-season crops domestically can gain access to the international market. An evaluation of Egypt's export potential, including reference to the recent successful development of cooperatives in Turkey is contained in IADS (1984).

radical transformation of the farming system and institution of an effective soil and water management strategy had to be paired with an effective—and exotic—agronomic system to attain adequate revenues.

Similar challenges inevitably will be encountered in desert reclamation projects based on new irrigation technology. The technical and economic significance of private land reclamation stems from apparent success in adverse agronomic environments where public sector projects failed. But the feasibility of private reclamation under specific circumstances does not mean it can be a blueprint for success in land reclamation. Instead, the technologies underlying the models described in this article should be viewed as outcomes of ongoing learning, conjecture, experimentation, and internalization of lessons gleaned by farmers from their experience and the experience of their neighbors. Successful investment in land reclamation requires receptiveness to useful lessons and ability to incorporate information if feasible, but currently unspecified, systems are to evolve. Thus, the central problem is not replication of one technological solution in other environments, but replication of the conditions that enabled identification of techniques and organizations that work.

It is impossible to anticipate the diversity that exists within the various reclamation sites and work out a centralized response to each. In most reclamation sites, plot-by-plot variation requires plot-specific production decisions. Farmers' ability to discern the best prospects among various subplots before making major commitments of cash and labor is an extremely important aspect of their financial success. In areas where soils are patchy, farmers leave undesirable plots fallow and concentrate resources on plots showing the greatest promise. Diversity also makes initial assessment of production alternatives difficult. Whether public or private, investments to develop large operating units have poor prospects simply because of difficulty in coping with micro-level diversity in the environment. In typical cases, precise assessment will be costly and comprehensive planning will be impossible. Reclamation planners need to give serious thought to ways of making technologies more flexible within public schemes.

Recognition of intrinsic uncertainty in land reclamation processes reveals the crucial adaptive role of farm-level decision-making. Small units operated by farm families are of a scale that enables people to seek out and employ information gained directly from the environment. Experienced farmers have a two-fold advantage in dealing with the environmental diversity characteristic of new lands and the complex environmental managememt tasks characteristic of land reclamation. First, although there is not a perfect fit between skills gained from past agricultural experience and agronomic conditions faced in the new environment, Egyptian farmers do bring usable knowledge to new lands. This body of detailed, practical expertise obtained through a career of interaction with Egyptian farming systems provides a starting point for identification of feasible technical solutions to problems as they emerge on new lands. Second, although farmers suffer from the same initial uncertainty regarding productive potential of plots, they act quickly to accumulate intimate knowledge about characteristics specific to their farm. This environmental interaction is a key ingredient in the process of active learning and tinkering necessary for adaptation and innovation to achieve fit between techniques and environments.

Despite their substantial skill, farmers cannot always solve the technical and economic problems of land reclamation by themselves. Although adaptation of well known methods can be rapid because farmers simply screen for positive results, accumulation of innovative solutions typically is slow when it depends on chance observations. The array of variables often swamps the empirical problem-solving techniques farmers employ and confounding factors obscure results of their trials. Moreover, farmers' casual empiricism must always contend with compelling needs to secure minimum subsistence.

If agricultural researchers know enough about farm-level conditions to ask useful questions, they can make important contributions to resolution of the technical problems of land reclamation. But the systematic complexity that can confuse farmers prevents researchers from fully anticipating the range of interactions between the environment and their recommendations. Here, farmers' opportunities for learning by doing, this time by using the products of scientific research, can provide important information to guide scientists' research efforts.[20]

Reform in Public Reclamation Programs and Policies

The broadest lesson that can be drawn from the study is the necessity of developing a more eclectic approach to the entire reclamation problem than the goverment has heretofore exhibited. For example, it is now generally recognized that much of the research that has gone into Delta agriculture will not be directly useful in the desert areas. (The exception is the selection and development of improved genetic materials for both cereals and horticultural crops.) However, the regional diversity of the problems

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[20] Because lessons are tied to specific environmental niches, returns to applied research and opportunities for farmers to share and receive relevant information are limited by the extent of the common domain. Clearly, devoting institutional resources to a niche that spans only a few feddans is a misappropriation of research capacity. If other things are equal, devoting reclamation effort to a larger agroenvironment should be favored over a smaller one. Furthermore, allocation of research effort to land reclamation, which has extensive problem-solving requirements, must be weighed against foregone opportunities for increased production by farmers in the old lands.

suggests that efforts at a centralized desert research facility which has been advocated in some quarters could only address a fraction of the problems that farmers face.

If the above diagnosis is correct, it would argue for the strengthening of the Faculties of Agriculture in various regions to cope more effectively with the reclamation problems in their areas. For example, the Department of Agronomy in Alexandria University might undertake a study of the problems of salinity and drainage encountered in the sand-fill system that exists around the city. Zagazig University could study the techniques being employed in Solhiya that permit farmers to get their crops to market several months early. Initial micro investigations would lead naturally to broader efforts to identify constraints that limit participation in both domestic and international markets.

The implication of such suggestions, of course, would be a less monolithic approach to the funding of research than is normally encountered in the Egyptian system. Admittedly, developing an effective institution to deliver such flexible funding in the Egyptian environment would present major difficulties. However, the reality of past performance would appear to make it a necessary if not sufficient condition for addressing the variability of problems that have surfaced in the course of this investigation.

A similar argument might be made with respect to the direct financing of reclamation activities. The Principal Bank for Development and Agricultural Credit (PBDAC) has shown some progress in developing a program of medium term credit for the purchase of capital goods. These revisions of long established collateral requirements have not, however, come easily. Loans of the type needed for reclamation, i.e., loans like those provided by the Federal Land Bank in the United States, would probably pose even more difficulties for PBDAC authorities. Again, like the facility for research funding, establishing guidelines and controls over such a fund would be difficult and require a more flexible approach to small farmer credit than has thus far been discernible on the Egyptian scene.

At a deeper level, the findings of the survey and the results of the economic analysis point to use of properly conceived small farmer reclamation projects as one of the few ways of mobilizing labor from the rural areas. Admittedly, in recent years there has been a substantial migration of rural labor to the cities and to the Persian Gulf States, and real rural wages rates have risen. But most observers would argue that labor markets are far from perfect and, especially within families, labor is less than fully utilized. (Concerns have also been expressed about the impact that the slow-down of economic activity throughout the region is likely to have on migration possibilities.)

Under normal circumstances, it has proved to be difficult to counteract the effects of factor price distortions resulting from capital market imperfections. Proposed wage subsidies, for example, simply lack operational credibility. However, when given the opportunity to reclaim land for themselves and their heirs, Egyptian farmers have shown themselves willing to accept less than the normal market wage for their labor. To acquire land is a powerful force in the Egyptian psyche and is something that could be used to mobilize resources now lying idle.

CONCLUSION

Shifts in land reclamation policy over the past 30 years were driven by a variety of objectives, including national security, food security, absorption of college graduates, and alleviation of land scarcity. Over time, the policy debate about land reclamation was detached from general strategies regarding Egypt's economic development. While there are advocates of the broader view of land reclamation as part of a participatory development process, the various arguments based on a pragmatic approach seeking to bypass participation by farmers had a major influence on reclamation policy decisions. This latter view was symptomatic of the state-farm stage of reclamation policy through the 1960s and has carried over to the current joint-venture phase. The historical record contradicts the assumption that these enclaves are feasible. Moreover, the enormous energy and ingenuity displayed by homesteading settlers in all parts of the country is missing from the current public program. In what is often an exceedingly hostile environment, they have created a livelihood where none existed. Until public sector planners develop schemes that tap this deep rooted desire for land, future efforts to develop new lands in Egypt are likely to show little improvement over the past.

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APPENDIX

Data collection for the sand-fill and lake-bed studies was part of a larger farm level survey conducted at a number of sites in Egypt. Preliminary interviews were conducted in August and September of 1981. The bulk of the work was carried out between August and December in 1982.

Site selection was organized around the source of irrigation water. The 1981 fieldwork was confined to the Solhiya region of Sharqiya Governorate at the eastern fringe of the Nile Delta. The Solhiya zone consists of a variety of sandy soils and comprises two irrigation water sources: canals and tubewells. The 1982 research activity expanded to include areas representative of other reclamation farming systems as well as further interviews in Solhiya. In the north, private reclamation on the saline clay soils adjacent to Lake Idku in Beheria Governorate and Lake Manzala in Dakhlia Governorate draws water from drains and directly from the lakes. In middle Egypt, the farms visited were at the edge of the Nile Valley and around the fringe of the Fayoum Oasis. They draw water from the exisiting irrigation system. In the Nile Valley at al-Saf in Giza Governorate, water is obtained from tubewells and applied through drip irrigation systems. Soils at al-Saf are sandy or calcareous. Farms at the two Fayoum study sites, Kom Aushim and Khawagaat, depend on canals for irrigation water. Soil types on the periphery of the Fayoum range from yellow clay to white sand. A total of 40 farms were studied in 1981. A different batch of 40 farms were studied in 1982.

Due to uncertainty regarding reasonable ranges in the data, analysis of the 1981 surveys was hampered by the extreme variance in observations and inability to distinguish extraordinary (but real) observations from spurious outliers caused by errors in reporting or recording data. Since an important research goal was to establish an impression of the production-possibilities frontier for private land reclamation, authentic, but extraordinary, observations were of particular interest. For this reason, the survey procedure was modified in 1982. Relatively fewer farms were visited and interviews were pursued in greater detail. The wide ranges observed in 1981 persisted in the 1982 data, but the intensive documentation of the latter observations enhanced their crediblity and analytical value.

Farm-level collection of the standard input-output coefficients also put the investigator in a position to observe important and often unanticipated aspects of private land reclamation. The unusual environments and unfamiliar farming systems encountered at various reclamation study sites required a flexible approach to assemble information. By 1982, the structured questionnaire used earlier as the sole research tool was relegated to providing a framework for unstructured conversations with farmers. This allowed a detailed investigation of the processes of adaptation and technological innovation that were not considered previously.