AGRICULTURAL DEVELOPMENT SYSTEMS
EGYPT PROJECT

UNIVERSITY OF CALIFORNIA, DAVIS

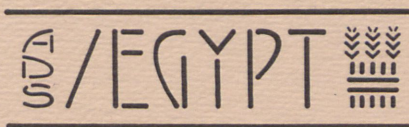## MECHANIZATION, LABOR SUPPLY AND FOOD PRODUCTION

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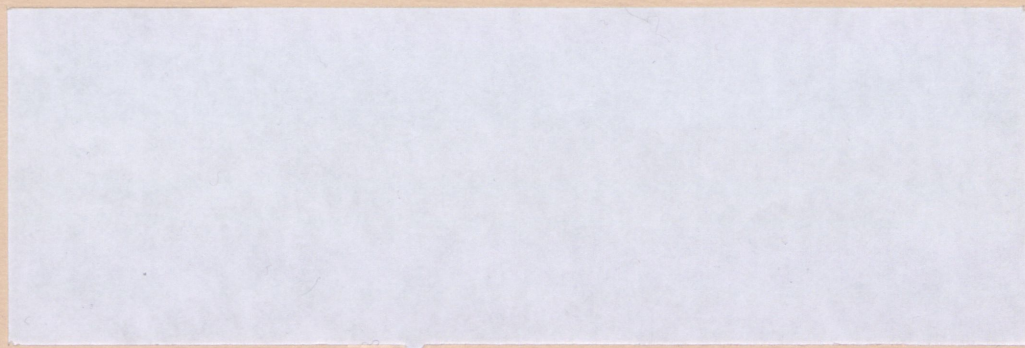
MECHANIZATION, LABOR SUPPLY AND FOOD PRODUCTION

A. Productivity, Growth and Underemployment

High rates of population growth under conditions of land scarcity are one of processes which generate and maintain high levels of absolute poverty in some developing countries. This is the case in rural Egypt. Population growth reinforces poverty in two major ways: one on the consumption side, ceteris paribus, it reduces the availability of food per capita; on the production side, it leads to a slower growth rate of urban employment and increases in rural underemployment. While the ultimate material condition for improving the welfare of both rural and urban populations is an increase in productivity, the question is how to induce production growth without social differentiation. The answer to this question lies in the solution of the problem of appropriate technologies. Genetically and chemically based technologies are considered to be appropriate because they save land (or they are yield increasing), and in many instances increase labor use. Thus, improved seed varities, soil conservation, fertilizer use, appropriate scheduling, etc., are sources of productivity growth, and given appropriate price relationships, of growth in food production. At the same time they do not save or displace labor. But the potential growth of food production by means of land saving technologies is limited under conditions of land scarcity. The welfare effects are still less significant if we consider that the majority of farmers operate very small plots of land. These limits to growth require the investigation of alternative sources of growth like land reclamation (expanding the supply of land) and creation of other employment opportunities in rural areas. Given the above scenario many economists are reluctant to consider mechanization as a source of productivity growth in rural economies. The rationale for including mechanization is that this

basically is a labor saving and labor displacing technology. While it may increase yields per feddan, it also reduces employment opportunities in rural areas.

Historical evidence shows that economic progress is associated with an increasing value of human time, i.e., growth of labor productivity. Agricultural mechanization is then a potential source of economic growth but, ceteris paribus, is also a source of underemployment. In order to break this underemployment "trap" it is necessary to investigate, more specifically, alternative paths of technological development. The quest then is how to save labor (a requirement for economic growth) without displacing labor (a requirement for social equity).

One answer is by creating employment opportunities in other farm and nonfarm related activities in the same rural area, e.g., by inducing a rural development. Under rural development the surplus created by productivity growth (both land and labor productivity) is recycled within a targeted region. This creation, appropriation and investment of surplus within a given region or village, requires the development and adoption of appropriate technologies and organizations.

Before investigating alternative programs of integrated development for rural Egypt it is necessary to investigate the present pattern of labor, land and capital in Egyptian agriculture. In this first paper we study the behavior of surplus labor supplied by fellahin households in a typical village of the Nile Delta: the response of surplus labor supplied to changes in wage rates and price of mechanization services. At the same time we investigate the response of crop production and patterns to changes in the same exogeneous variables.

B. Supply of Labor Under Part-Time Farming

1) Earnings generating activities within a _fellahin_ economy include both on-the-farm and off-farm activities. While "other source of income" is an important variable for explaining supply of labor in a labor market of a modern-urban economy, it is even more important in traditional-rural economies. Other sources of income in a fellahin economy--i.e., net farm income--are the result of an activity, farming, competing for family labor against wage earning activities. This phenomenon requires a more complete specification of the household economy so as to represent the alternative patterns of labor and land allocation.

2) One major employment opportunity for the surplus labor of small _fellahin_ economics is offered by the labor requirements of larger farms. Thus, it is necessary to specify the supply of surplus labor of small farms independently of the activities of larger farms. While adoption of mechanization within larger farms can induce labor saving and labor displacement among small farms, what effect the adoption of mechanization will have among small farms is not clear. While the adoption of mechanization results in labor saving but it does not necessarily have to result in labor displacement if other opportunities are made available for the household economies.

In this paper we only present the preliminary results of an empirical study of the response of labor supply (surplus) of small _fellahin_ households of the village Manshaat El-Gamal, in the Dakahlia Governorate. The Manshaat El-Gamal economy is representative of the agrarian economy of the Nile Delta. The crop patterns and prices are for the year 1976-77.

The supply of surplus labor--at the family level--was derived by means of comparative static methods based on an empirical model of a household

representative of small _fellahin_ farms. The behavorial pattern should be interpreted as indicating the long run relationships between quantity of labor supplied (to the market) and wage rates.

C. The _Fellahin_ Economy of Manshaat El-Gamal

Manshaat El-Gamal is located in the Dikirnis district in the governate of El Dakahlia in the Northern Nile Delta Rice Zone.

The northern Nile Delta Rice Zone which extends from Alexandria almost to Port Said includes about 1.7 million feddans (MF) of cropland. The dark brown soil in that part of the northern coastal belt contains over 60 percent clay. Some depressions in the area are below sea level. Salinity, alkalinity and a high water table characterizes the area around the village (USDA, 1976, p. 56).

Most of the soil in and around the village is rated III and IV, the two lowest productivity classes. Lack of drainage reduces crop productivity, but the soils are porous and respond well to reclamation. Since rice is fairly salt tolerant, this is a major reason for its concentration in this zone (USDA, 1976, p. 56).

The climate of Manshaat El-Gamal is semi-arid mediterraean with some marine influence. The most suitable crops under irrigation are: rice, sugar cane, soybeans, berseem and alfalfa. Wheat and barley are moderately suitable and among fruits, banana and citrus are suitable.

The population, village area, percentage of area in the various size classes of land holdings and the percentage of landholders in each of the size classes in the villages in the 1976-77 agricultural year (October through September) appear in Table 1 (Farm Management Survey, June 1980, Table 1, p. 3).

Table 1 presents the distribution of fellahin households by farm size. Fellahin with less than three feddans represent 69 percent of all households, and are the major suppliers of surplus labor for larger famrs or other nonfarm activities.

Table 2 describes village resources and cropping patterns.

D. A Model of the Fellahin Household

A typical fellahin household controlling a small plot of land has two major sources of income (in cash and kind): farming and off-farm employment.

Net farm income is generated from the production of food crops such as rice, wheat, maize and corn; and cash crops such as berseem and cotton. Crop patterns and yields are basically determined by nature (winter versus summer crops), price relationships, credit allotment and technology. Technology choice (i.e., rotation patterns; human power/animal power ratio; human power/mechanical power ratio; and yield increasing/traditional practices ratios) is in turn, also determined by price relationships.

All these choices correspond to a given informational structure of fellahin families. Risk is another element explaining crop pattern choice. These two explanatory factors have not been considered in this preliminary report, but will be introduced in the second stage of this research project.

Wage earnings are derived from work in farm and nonfarm related activities. The supply of surplus labor during the summer and winter seasons is also influenced by farming requirements and wage differentials.

The two major resources here considered were land and family labor. However, fellahin households are allowed to rent machinery and animal power and to hire labor.

Table 1. Percentage of Landholders, Percentage of Village Area by Size Class, According to Cooperative Membership Lists for Manshaat El-Gamal.

Village Code	District Code	Govern-orate Code	Popula-tion	Area of Village	Percent of area in size class						Percent of holders					
					0-1	1-3	3-5	5-10	10-25	over 25	0-1	1-3	3-5	5-10	10-25	over 25
49	17	5	6,446	4,239	4.81	28.54	19.86	16.93	21.13	8.73	22.43	46.52	16.91	8.61	4.58	0.95

Source: Arab Republic of Egypt Ministry of Agriculture, "Village Institutions, Socio-Economic Characteristics and Economic Indicators from the 1976-77 Egyptian Farm Management Survey." Project Technical Report No. 3, June 1980.

Table 2. Village Resources and Cropping Patterns

Variable	Manshaat El-Gamal
Population	6,446
Area of Village (feddans)	4,239
Agriculture Cooperative Availability	yes
Demonstration Plot Availability	yes
Experimental Station Distance (kilometers)	40
Veterinary Unit Distance (kilometers)	8
Special Bee Production Units	yes
Medical Unit Availability	yes
Village Club	yes
Primary Schools (number)	3
Privately Owned Tractors (number)	70
Cooperatively Owned Tractors (number)	800
Cooperatively Owned Irrigation Machines	180
Paved Road	yes
Covered Drainage	yes
Winter Crops (feddans)	
Wheat	977
Full	90
Berseem (catch-crop)	1,542
Berseem (long season)	1,522
Barley	2
Total Winter Crops	4,133

Table 2 (continued)

Variables	Manshaat El-Gamal
Summer Crops (feddans)	
Rice	2,388
Maize	67
Other Summer Crop	48
Total Summer Crop	2,503
Winter Vegetables	84
Summer Vegetables	230
Total Vegetables	314
Sugar Cane	2
Cotton	1,493
Fruit Trees	20
Cropped Area (feddans)	8,465
Crop Intensity Coefficient	199

Source: Arab Republic of Egypt Ministry of Agriculture, "Village Institutions, Socio-Economic Characteristics and Economic Indicators from the 1976-77 Egyptian Farm Management Survey." Project Technical Report No. 3, June 1980.

Farm operations are conditioned by access to modern inputs and credit. Fellahin receive seeds, fertilizers and pesticides from cooperatives paying low interest rates. Access to credit for other operations is assumed to be very costly; therefore financing depends on family savings.

It is assumed that the objective of the _fellahin_ family is to maximize net expected earnings under conditions of certainty equivalence.

E. Solution of the Model

The above structure was specified in a linear programming model. The optimal solution to this model simulates a crop pattern and a pattern of labor similar to the ones observed in Manshaat El-Gamal.

A comparative static analysis (by means of parametric programming) was used in order to estimate two kinds of responses: one, labor surplus response to wage rates, and secondly, labor surplus response to mechanization. Table 3 and 4 depict these two response patterns.

A positive relationship exists between surplus labor supplied to the market and wage rates. Although wage rates are higher during the summer season, it is more profitable for the family to supply labor during the winter season. This is due to the high opportunity cost of family labor on-the-farm during summer. Only for very high wage rates will the family prefer to sell part of its labor during the summer season. Figure 1 shows changes in crop patterns as a consequence of changes in wage rates.

Access to mechanization was simulated by change in the rent for mechanical power using values from zero to 2.50£E . As one would expect--if new working activitives within the household are not available--mechanization increases the supply of surplus family labor. At the same time the use of animal power on-the-farm also decreases.

VILLAGE: Manshaat El-Gamal
GOVERNORATE: Dakahlia

Table 3. Farm Size: Less Than Three Feddans Labor Supply Response

Wage Rate Per Day			Supply of Surplus Labor			Family Farm Labor			Hired in Labor		
Summer	Winter	Average	Summer	Winter	Total	Summer	Winter	Total	Summer	Winter	Total
0	0	0	0	0	0	102	135	237	55	0	55
.50	.30	.30	0	32	32	102	135	237	55	0	55
1.00	.60	.60	0	48	48	104	120	224	53	0	53
1.50	.90	.90	0	141	131	106	38	144	48	0	48
2.00	1.20	1.20	0	131	131	106	38	144	48	0	48
2.50	1.50	1.76	48	139	187	66	38	104	43	0	43
3.00	1.80	2.10	48	139	187	66	38	104	43	0	43
3.50	2.10	2.71	125	161	286	10	38	48	28	0	28
4.00	2.40	3.10	125	161	286	10	38	48	28	0	28
4.50	2.70	3.49	125	161	286	10	38	48	28	0	28
5.00	3.00	3.82	130	187	317	17	23	39	22	0	22

Table continued

Animal Power	Machinery Power	Rice		Wheat		Berseem		Cotton	
		Feddan	Yield	Feddan	Yield	Feddan	Yield	Feddan	Yield
414	90	.44	1,4700	–	–	1.40	197	.65	810
414	90	.44	1,4700	–	–	1.40	197	.65	810
452	90	.56	1,4700	–	–	1.40	173	.76	700
452	90	.54	1,4700	.64	2,750	.76	24	.76	700
452	90	.54	1,4700	.64	2,750	.76	24	.76	700
281	90	.38	1,4700	.64	2,750	.76	24	.76	700
281	90	.38	1,4700	.64	2,750	.76	24	.76	700
81	20	–	–	.64	2,750	.76	24	.76	700
81	20	–	–	.64	2,750	.76	24	.76	700
81	20	–	–	.64	2,750	.76	24	.76	700
70	9	–	–	–	–	.76	24	.76	700

VILLAGE: Manshaat El-Gamal
GOVERNORATE: Dakahlia

Table 4. Mechanization and Labor Use

Cost Mechanization Per Hour	Supply of Surplus Labor			Family Farm Labor			Hired in Labor		
	Summer	Winter	Total	Summer	Winter	Total	Summer	Winter	Total
0	0	124	124	98	38	136	59	0	59
.50	0	124	124	98	38	136	59	0	59
1.00	0	124	124	98	38	137	59	0	59
1.25	0	124	124	99	38	137	59	0	59
1.50	0	133	133	108	39	147	55	0	55
2.00	0	50	50	108	122	230	53	0	53
2.50	2	53	56	107	120	227	54	0	54

Table 4 continued

Animal Power	Machinery Power	Rice		Wheat		Berseem		Cotton	
		Feddan	Yield	Feddan	Yield	Feddan	Yield	Feddan	Yield
422	140	.65	1,4700	.65	2,750	.75	24	.75	703
422	140	.65	1,4700	.65	2,750	.75	24	.75	703
422	140	.65	1,4700	.65	2,750	.75	24	.75	703
427	138	.65	1,4700	.65	2,750	.75	24	.75	700
500	56	.49	1,4700	.68	2,750	.72	24	.71	744
500	48	.49	1,4700	–	–	1.40	177	.74	719
500	48	.49	1,4700	–	–	1.40	173	.76	700

Figure 1

Crop Pattern and Wage Rates
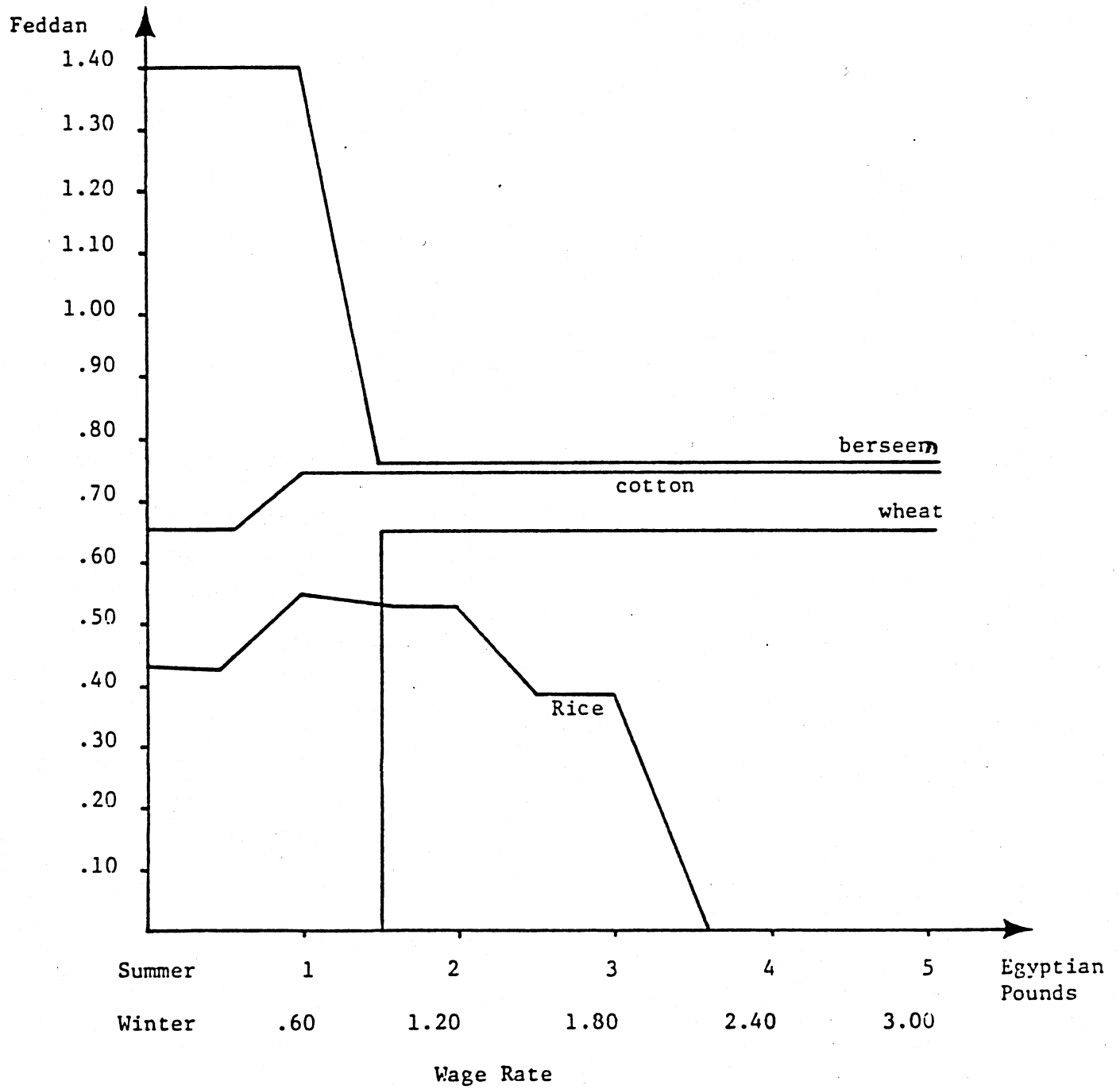
The likely impact of mechanization on crop patterns is most interesting. Ceteris paribus, higher rates of mechanization will likely induce increases in food crops at the expense of cash crops. Indeed, for low mechanization loads, wheat is not a profitable crop and berseem tends to be substituted for it.

Some Limitations

1. The above results should be interpreted as long run adjustments. In the short run one would expect some lags, which need to be investigated.

2. The explanatory power of this empirical model needs to be improved. First the model should be extended to include consumption and nutritional activities. This will allow a more interesting and realistic representation of the reproduction of family labor. Second, the model should be extended so as to consider risk choices and alternate information structures.

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