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Some Models for Determining the Optimum Cropping System in A.R.E. Agriculture Under Certain Environmental and Organizational Conditions.

By

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Resource allocation is considered one of the major elements in reorganizing cropping systems. Resources should be allocated in such a way as to maximize economic welfare. Efficient resource allocation is attained when the values of the marginal products of a resource equalized in all alternative uses.

The objective of the current study is to reallocate available agricultural resources, viz. land, water. human - resources between the alternative uses to maximize net income.

The optimum combination of resources is defined as the combination that makes the rate of technical substitution of two resources equal to its price ratio. The optimum combination of products is determined when the price ratio of products is equal to the rate of product transformation. Linear programming as a tool of economic analysis can serve to solve such problem. In pursuit of this aim , an objective function with constant weights, alternative activities and input - output coefficients can be used.

The study investigates the optimum cropping system in A. R. E. agriculture under three specific conditions. The first is when physical constraints only are used. The second indicates the optimum cropping system when physical, institutional, economic and marketing constraints are taken into consideration. The third indicates

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the optimum cropping system when wheat self sufficiency is being the traget.

The objective function in the linear programming models is estimated according to the international prices of the agricultural crops.

Physical constraints used in the three models under examination include available land resources classified according to its various classes, available agricultural labour force and irrigation water resources.

The models consist of 59 alternative activities. Each activity represents the possible land utilization pattern over one year.

The linear programming model can be formulated as :

$$\text{Max.} \quad R = P_1 x_1 + P_2 x_2 + \ldots\ldots \quad P_{59} x_{59}$$

subject to :

$$a_{11} x_1 + a_{12} x_2 + \ldots\ldots a_{1n} x_n \leqslant C_1$$

$$a_{21} x_1 + a_{22} x_2 + \ldots\ldots a_{2n} x_n \leqslant C_2$$

$$a_{m1} x_1 + a_{m2} x_2 + \ldots\ldots a_{mn} x_n \leqslant C_n$$

$$X_j \geqslant 0 \qquad (j = 1 \ldots\ldots n)$$

where the notations used are as follows :

F(R) = the normative supply function or the objective function.
R = total net revenue
$a_n x_n$ = quantity of input n to produce output x
a = coefficient of inputs.
x, s = number of units produced.
P = price of the unit of output x

The objective function is to maximize net return of alternative activities as will be seen in the Appendix (Table I).

The constraints used in such models are indicated as follows :

A) Physical Constraints :

I. Land constraints : The cultivated area in Egypt is estimated at 5.83 million feddans which can be classified into four classes(1):

(i) Land resources used in all agricultural activities must not exceed total cultivated land area viz. 5.83 million feddans.

(ii) The cultivated area covered by all crops minus the area which are suitable for the third and fourth classes must not exceed the area of first and second classes viz. 2.7 million feddans.

(iii) The area covered by all crops minus that suitable for the fourth class (Cotton, Berseem and Rice) must not exceed the area of the first, second and third classes viz. 5.1 million feddans.

II. Constraints of labour force : The study of labour force in Egypt indicates that the available labour force in the months of winter, viz. January, February, March, April, May, October, November and December is estimated at 86.22 million man days.
The available labour force in the months of summer, viz. June, July, August and September is about 89.67 million man days.
The available labour force is greater in summer than in winter, due to the attendance of children at schools in winter(2).

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1) The first, second, third and fourth classes are estimated at 326, 2.356, 2398 and 747 thousands feddans respectively. The first, second and third classes of land are suitable for the cultivation of the various agricultural crops, viz. field; vegetable and orchard crops.
The fourth class is suitable for the cultivationof specific field crops, namely, cotton, Berseem and Rice.

2) Habashy, N.T. : An analytical study of agricultural resources allocation in Egypt, Ph.D. thesis, University of Ain Shams , 1972.

The constraint of labour force includes 12 constraints representing available agricultural labour force for the months of the year.

III. Irrigation constraints : Available water constraint is estimated according to the discharge of the River Nile at Aswan Dam excluding a percentage for water losses due to the evaporation, percolation, drinking water, ...etc.

The River Nile water constitutes about 99% of irrigation water in Egypt. Twelve constraints represent available irrigation water.

B) Institutional, Marketing and Self Sufficiency Crops Constraints :

Institutional constraints must be taken into consideration when constructing a model to determine the optimum cropping system. Cotton and wheat areas[1] represent the essential institutional constraints in Egyptian agriculture. Marketing and economic constraints result from the limited foreign marketing capacity and the shortage of marketing potentialities. The marketing constraints for export crops are represented by the maximum area cultivated by these crops during the last ten years of 1958 - 1968.

C) Self Sufficiency Crops Constraints :

These imply the average cultivated area in the last four years of 1965 - 1968 for certain crops such as Maize, Barley, Wheat, Cabbage, Eggplant .... etc.

Some Characteristic Features of the Optimum Cropping System in Agriculture under Prevailing Egyptian Farming Conditions.

The models indicated certain recommendations to improve the

1) Cotton and wheat areas should not be less than 1/3 the total cultivated area for each crop.

efficiency of the utilization of agricultural resources.

The First Model :

The first model indicates the effect of the physical constraints on the cropping system when only used. These are physical land classification, irrigation water and available agricultural labour force(1). The model indicates that an extensive area of agricultural land should be devoted to the cultivation of garlic, onion and watermellon. This area is estimated at about 2.682 million feddans. About 710.4 thousand feddans should be devoted to winter onion and sesame, 1.55 million feddans should be devoted to winter onion and sorghum, 747 thousand feddans to temporary berseem and cotton and about 132.8 thousand feddans should be devoted to sugar-cane. The area of winter onion that should be cultivated is estimated at about 2.26 million feddans.

Labour force is not considered a constraint in this model, there is a surplus of this resource throughout the year. The present area of cotton in Egyptian agriculture should be decreased by about 797 thousand feddans as indicated by such model.

It should be mentioned that the international prices for the traditional agricultural exports are not profitable in contrast with non traditional ones with the exception of onion.

The total labour requirements for this pattern are estimated at about 514.7 million man-days annually. These exceed the requirements of the present cropping system with about 68 million man-days annually(2) representing 210 thousand men monthly. The disguised unemployment in this pattern is estimated at 10.24, 13.68 million man-days annually in winter and summer respectively, representing 0.45, 0.6 million men monthly. The disguised unemployment accrued by this cropping pattern

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(1) Three constraints represent physical land classification, twelve constraints represent available agricultural labour force, twelve constraints represent irrigation water.

(2) A farm labourer works 270 days per year under Egyptian farming conditions.

tends to decrease with about 56 % , 49 % as compared with the disguised unemployment in the present pattern in winter and summer, respectively.

The model indicates that irrigation water is considered a real constraint on agricultural production. There is no surplus of irrigation water in the months of April and October. The water requirements for this cropping pattern increase with about two million cubic meters as compared with that of the present cropping pattern.

The net agricultural income realized according to this pattern is about L.E. 1287 millions. It exceeds the present net farm income with about L.E. 808 millions representing 167 % of the present income (Table 2 of the appendix).

The Second Model :

It is obvious from the first model that an extensive area is deveted to garlic, onion and watermellon. There are other constraints that make the application of this model more difficult such as marketing and export constraints. Such constraints are included in this model to limit the area cultivated. Self sufficiency constraints(1) and physical constraints(2) are also taken into account.

Table (3) of the appendix indicates the optimum cropping system under physical production, institutional and marketing constraints.

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(1) This implies the area of Wheat, Berseem, Beans, Barley, squash and eggplant.

(2) Irrigation water constraints during the months of April, May, June and November, while labour constraints are added in March, April, October and November.
These represent physical constraints.

The areas devoted to wheat, barley, beans, soft beans and Egyptian clover are about 1273, 1117, 351.7, 29 and 1346 thousand feddans for these crops respectively. The areas devoted to these crops do not differ from the present average area. The area devoted to Garlic, Onion and Watermellon are estimated at 18.8, 57.7, 103 thousand feddans respectively. The area devoted to these crops represent the maximum area cultivated by these crops during the period 1958-1968. Hence the area of these crops must not be less than the maximum area in this period. This area however exceeds that of the present cropping with about 4.2, 14.6, 11.0 thousand feddans for garlic, onion and watermellon respectively. Area devoted to rice is about 3.12 million feddans. It exceeds the area of the present cropping pattern with about 1927thousand feddans. The area of potatoes in this model is estimated at 103 thousand feddans. It exceeds the area of the presentcropping pattern with about 73 thousand feddans. Grapes area is estimated at 543 thousand feddans, which is a very extensive area by contrast to its area under the present cropping pattern.The expansion of rice and tomatoes areas can be realized from the annual increase in the exports of these two crops.

The model indicates clearly that labour force is not considered a constraint on agricultural production. There is a surplus of labour throughout the months of the year. The application of such cropping system results in an excess of labour force which amounts to about 130 thousand men monthly. The disguised unemployment decreases to a great extent as against the disguised unemployment in the existing cropping system, amounting to 100 and 250 thousand men in winter and summer respectively and representing a decrease of 90% and 79% of the present disguised unemployment in the same order. Irrigation water is considered a real constrant. There is no surplus of water resource in the month of June.

The net income realized from this model is about L.E. 600 millions. It exceeds the present net farm income with about L.E. 120 millions representing 25%.

The Third Model :

This model aims at indicating the optimum cropping system when wheat self sufficiency is put into action. All the previous constraints, viz. physical production, marketing potentialities are considered. The cotton constraint is abandoned(1).

The model concerned indicates that wheat must be included in two activities : wheat - summer maize and wheat - cabbage. The area devoted is about 3.19 million feddans for the first activity and 9.3 thousand feddans for the second activity. The area devoted to wheat and summer maize is about 3.2 and 3.3 million feddans respectively. The area devoted to summer sorghum is about 658 thousand feddans. 307, 1199 thousand feddans are devoted to tomatoes and rice respectively. The areas devoted to wheat, summer maize , sorghum, rice and tomatoes increase with about 2000, 2100, 287, 100 and 97.4 thousand feddans respectively. The areas devoted to Barley, Beans, Soft beans, Egyptian clover, other winter crops, cabbage, squash, garlic, watermellon, onions do not differ from the area of the second model. The area of potatoes decreases with about 36.6 thousand feddans by contrast to the second model. This model does not include cotton. Areas of 138.8, 121.4, 23.1, 9.4 thousand feddans are devoted to sugar cane, citrus, mangoes and bananas respectively. Such areas are similar to the areas of the crops comprising the existing cropping system. The cropping system proved to be inefficient in the utilization of agricultural land resources.

The model also indicates that no increase in agricultural labour force is likely to exist. However the disguised unemployment might decrease with about 83%, 72% in winter and summer respectively by contrast to the disguised unemployment resulting from the present cropping system.

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(1) Since wheat self sufficiency constraint is added in the presence of minimum cotton area constraint, there would be no feasible solution as emphasized by the computer.

The irrigation water requirements exceeds the present requirements with about 3.5 million cubic meters which are far below the available irrigation water in Egypt.

The agricultural net income realized from this cropping system is about L.E. 405 millions. This revenue is below that of the present cropping system by about L.E. 75 millions, representing 16% of total agricultural net income (Table 4).

Conclusions :

(1) Vegetables area should be increased due to its high profitability if compared with field and orchard crops. The vegetables area indicated in the first model is considered unrealistically high due to the limited domestic and foreign marketing capacity and to the shortage of marketing potentialities, although vegetable area should be expanded for exporting purposes.

(2) The current study shows that the present cropping system lacks specialization in terms of agricultural activities which is responsible for the high inefficiency in Egyptian agriculture. The second model indicates that the net farm income realized from the optimum cropping system exceeds the present one with about L.E. 120 millions, representing about 25% of the existing net farm income.

(3) Agricultural labour force is not considered a real constraint on agricultural production under prevailing Egyptian farming conditions.

(4) Water resources are considered a real constraint on agricultural production in Egypt.

(5) Available irrigation water in May and November is lower than what is needed.

(6) The policy of self sufficiency in wheat production should not

be recommended in Egypt since self sufficiency in wheat production would lead to a great loss in farm income. Moreover, wheat cultivation is not recommended except when introducing a constraint indicating the lower limit of wheat area.

APPENDIX

Table I - The Alternative Activites

Activity	Content	Net Return (L.E.)
X_1	Wheat + summer maize	47.14
X_2	Wheat + summer rice	80.69
X_3	Wheat + summer squash	159.87
X_4	Wheat + Nili squash	112.27
X_5	Barley + summer maize	45.17
X_6	Barley + summer rice	78.72
X_7	Barley + summer sorghum	50.00
X_8	Barley + summer squash	158.00
X_9	Bean + summer maize	54.99
X_{10}	Bean + summer sorghum	59.00
X_{11}	Bean + summer rice	88.54
X_{12}	Bean + summer squash	167.80
X_{13}	Soft bean + sesame	59.00
X_{14}	Soft bean + peanut	98.35
X_{15}	Soft bean + water mellon	191.15
X_{16}	Soft bean + summer tomatoes	130.15
X_{17}	Soft bean + summer sorghum	169.00
X_{18}	Flax + sesame	51.37

Table I : cont'd.

Activity	Content	Net Return (L.E.)
X_{19}	Flax + summer rice	82.90
X_{20}	Flax + summer sorghum	54.20
X_{21}	Flax + summer maize	49.35
X_{22}	Flax + water mellon	183.48
X_{23}	Permanentclover + summer rice	82.72
X_{24}	Permanentclover + summer maize	49.17
X_{25}	Permanentclover + summer squash	162.00
X_{26}	Garlic + summer maize	175.87
X_{27}	Garlic + peanut	217.20
X_{28}	Garlic + water-mellon	310.00
X_{29}	Garlic + summer tomatoes	259.00
X_{30}	Winter onion + sesame	154.89
X_{31}	Winter onion + summer rice	69.42
X_{32}	Winter onion + summer sorghum	157.69
X_{33}	Winter onion + summer maize	152.87
X_{34}	Winter onion + summer tomatoes	226.00
X_{35}	Winter onion + summer squash	265.60
X_{36}	Winter tomatoes + summer rice	152.42
X_{37}	Winter tomatoes + summer sorghum	123.69
X_{38}	Winter tomatoes + summer maize	118.80
X_{39}	Winter tomatoes + summer squash	231.60
X_{40}	Winter squash + summer potatoes	123.90
X_{41}	Winter squash + summer tomatoes	157.70

Table I : cont'd.

Activity	Content	Net Return (L.E.)
X_{42}	Winter vegetables + summer vegetables	134.00
X_{43}	Temporar y clover + cotton	115.00
X_{44}	Sugar cane	104.00
X_{45}	Temporar y clover + summer potatoes	69.20
X_{46}	Winter vegetables + sesame	84.39
X_{47}	Winter vegetables + summer maize	82.37
X_{48}	Winter vegetables + peanut	123.70
X_{49}	Winter vegetables + summer eggplant	182.50
X_{50}	Winter vegetables + summer tomatoes	155.50
X_{51}	Other winter farm crops + summer rice	101.75
X_{52}	Other winter farm crops + summer maize	63.20
X_{53}	Other winter farm crops + water mellon	202.30
X_{54}	Other winter farm crops + summer tomatoes	141.30
X_{55}	Citrus	113.00
X_{56}	Mangoes	48.40
X_{57}	Bananas	127.50
X_{58}	Grapes	109.90
X_{59}	Water mellon + Nili potatoes	219.20

Source : Habashy, N.T. Op. Cit. pp. 491, 492.

Table 2 - The First Model :
The Optimum Cropping System Under
Physical Constraints .

Activity number	Agric. Activity	Cultivated area	Cropped area crops	area
X_{28}	Garlic + water mellon	2682100	Garlic	2682100
			Water mellon	2682100
X_{30}	Onion + sesame	710387	Onion	2265842
			Sesame	710387
X_{32}	Onion + summer sorghum	1555455	Summer sorghum	1555455
X_{43}	Temporar y clover+cotton	746967	Temporar y clover	746967
			Cotton	746967
X_{44}	Sugar cane	132552	Sugar cane	132552

Net income L.E. 1287 millions with an increase above the present net farm income of L.E. 808 millions representing 167 %

Source : Habashy, N.T. Op. Cit. p. 569.

Table 3 - The Second Model :

The optimum cropping system under physical institutional, marketing and economic constraints.

Activity Number	Agric. Activity	Cultivated area	Cropped area crops	Cropped area area
X_2	Wheat + summer rice	1264026	wheat	1273303
			Rice	3126090
X_4	Wheat + cabbage	9275	Cabbage	9275
X_6	Barley + rice	111769	Barley	111769
X_{11}	Beans + Rice	351729	Beans	351729
X_{16}	Soft beans + tomatoes	29000	Soft beans	29000
			Tomatoes	363792
X_{23}	Egyptian clover + summer rice	1346771	Egyptian clover	1346771
X_{29}	Garlic + tomatoes	18887	Garlic	18887
X_{34}	Winter onion + tomatoes	57694	Onion	57694
X_{36}	Winter tomatoes + summer rice	51796		
X_{39}	Winter tomatoes + summer squash	39703	Squash	39703
X_{43}	Temporarily clover + cotton	1712357		1712357
X_{49}	Other winter vegetables + summer eggplant	20755	Eggplant	20755
X_{50}	Other winter vegetables + summer tomatoes	25692	Other winter vegetables	46447
X_{54}	Other winter field crops + summer tomatoes	141020	Other winter field crops	141020
X_{58}	Grapes	543957	Grapes	543957
X_{59}	Water mellon + Nili potatoes	103030	Watermellon	103030
			Nili-potatoes	103030

Net income L.E. 600 millions with an increase of L.E. 120 millions above present net income representing 25%.

Source: Habashy, N.T. Op.Cit. p. 576.

Table 4 - The Third Model :

The optimum cropping system under self-sufficiency wheat constraints and other constraints.

Activity number	Agric. Activity	Cultivated area	cropped crops	area
X_1	Wheat + summer maize	3490720	Wheat	3200000
			Summer maize	3298613
X_4	Wheat + Nili cabbage	9275	Cabbage	9275
X_7	Barley + summer sorghum	111769	Barley	111769
			Summer sorghum	658217
X_{10}	Beans + summer sorghum	351729	Beans	351729
X_{16}	Soft beans + summer tomatoes	29000	Soft beans	29000
			Summer tomatoes	307105
X_{23}	Egyptian clover + summer rice	199180	Egyptian clover	1346771
			summer rice	199180
X_{24}	Egyptian clover + summer maize	107888		
X_{25}	Egyptian clover + squash	39702	squash	39702
X_{28}	Garlic + water mellon	18887	Garlic	18887
			watermellon	103030
X_{34}	Onion + tomatoes	57694	Onion	57694
X_{37}	Winter tomatoes + summer sorghum	194719		
X_{44}	Sugar cane	133822	Sugar cane	138822
X_{49}	Other winter vegetables + eggplant	20755	Other winter vegetables	46448
			Eggplant	20755
X_{50}	Other winter vegetables + summer tomatoes	25692		
X_{52}	Other winter field crops + water mellon	47534	Other winter field crops	141020
X_{54}	Other winter field crops + tomatoes	93486		
X_{55}	Citrus	121462	Citrus	121462
X_{56}	Mangoes	23102	Mangoes	23102

Table 4 - cont'd.

Activity number	Agric. Activity	Cultivated area	cropped crops	cropped area
X_{57}	Bananas	9431	Bananas	9431
X_{59}	Water mellon + Nili potatoes	36609	Nili potatoes	36609

Net income L.E. 405 millions with a decrease below the net income gained by present cropping system totalling L.E. 75 millions, representing a minus of 16%.

Source : Habashy, N.T. : Op. Cit. p. 582