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DEVELOPMENT OF MIXED FARMING SYSTEM IN A NEWLY RECLAIMED AREA IN EGYPT

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SUMMER

A linear programming (LP) technique was adopted to determine the optimum combination of crops and livestock production on small mixed farms in a newly reclaimed area in Egypt. Technical coefficients estimated from a survey data collected from three locations in South Tahreer Province (120 km North-West of Cairo) during the agricultural year October 1995 to September 1996. Three locations reflected the different types of producers; traditional farmers (Location 1), early retirees, (location 2), and university graduates, (location 3). One LP model with two scenarios was proposed. The base run (simulate real-life situation) utilized farm available production resources of crop and livestock activities. While, the first scenario (LP1) was proposed to meet farmer's needs of basic food (wheat and maize) along with satisfying animal's requirements under the constraint of availability of LE 10000 as cash resources. The second scenario was the same as LP1 structure with modified the farm size in the three studied locations to 10 feddan. The main results of base run reveald that, the farmers have to cultivate 3.25, 2.32 and 2.22 feddan of berseem in winter. While, 2.32, 4.12 and 2.43 feddan maize in summer along with 1.61, 1.14 and 1.37 animal units in the three studied locations, respectively. Combing activities in these prescribed quantities are expected to improve farm income by 55%, 26% and 42% as compared to real situation in the three studies locations, respectively. In general, the return per animal unit under both real situation and the two scenarios was more profit than the return per feddan. Also, it could be recommended that, 10 feddan as farm size plus about 6 animal units with not less than 10000 LE as cash resources is reasonable structure for development the small mixed farm system in newly reclaimed areas in Egypt.

Key Words: *linear programming, farm income and crop/livestock.*

INTRODUCTION

In Egypt, about two million feddan (feddan = 4200 m^2) are classified as newly reclaimed area. This newly reclaimed area is sandy or saline soils recently recovered or rehabilitated for agricultural production (MOA, 2002).

The productivity (yield/feddan) of crops on newly reclaimed area is constrained by many limiting factors. These constraints represent serious threat to the sustainability of agricultural production in newly reclaimed areas. Many research projects and studies are on going in different institutions in Egypt to develop integrated technology packages for major crops grown on reclaimed areas.

Farmers usually looking for the best possible way for allocating their limited production resources among cropping and livestock activities. Moreover, farmers always seek on optimal mix of farming activities that maximizes their income. Farmers, often, follow their instinct and experience to handle this problem. Instinct and experience do not guarantee optimal results, however, farm planners can offer effective techniques, *e.g.* linear programming (LP), to address such problem and produce optimal solution.

This study adopted linear programming (LP) and simulation techniques to evaluate current small mixed farms system in the newly reclaimed area in Egypt and investigate the impact of different proposed scenarios on the overall efficiency of the current mixed farming system.

MATERIALS AND METHODS

The study area

This study was carried out at South Tahreer Province. It is located in the west of Nile Delta at 120 km north west of Cairo between; longitudes 30^o 57’ E and 30^o 41’ E and latitudes 29^o 55’ N and 29^o 25’ N. Three locations were identified, location (1) called Al-Ruwad, where the farmers were traditional farmers who own no more than 5 feddan (average farm size was 4.6). Location (2) called Al-Fath where farmers were mainly the early retirees who own 8-24 feddan (average farm size was 13.8) and location (3), called Al-Tahaddi, included university graduates who own 20-30 feddan (av. farm size was 15.4).

Data and data analysis

A random sample of 155 mixed farms was obtained. A questionnaire was designed to identify available production resources, animal and crop production performance, services, cost, and revenues. These data were collected during the agricultural year October 1995 to September 1996. Activities were wheat, berseem (*Trifolium alexantrinum*), groundnut, maize and livestock named X_1 , X_2, , X_3 , X_4 and X_5 , respectively. Livestock was measured in tropical animal unit (AU) according to Barnard and Nix (1993). The data were analyzed by least squares techniques using General Linear Model Procedure (SAS 1998). The fixed effects linear model was used to analyze production resources and to develop technical coefficients of crop and livestock activities and level of inputs needed for each activity. These estimates were used in building up the simulation models.

Farm budget

Table 1 shows the results of farm budget analysis of the three studied locations. Farm budget included gross output, variable costs, gross margin and available cash resources. Variable costs for crops included labor, mechanical power, fertilization and seeds. Also, variable costs for livestock activities included labor, green fodders, concentrates, veterinary care and mechanical power. The variable cost and gross margin were calculated per unit of production resources (land, animal), detailed calculations are presented in Ahmed, 1995.

Mathematical Linear Programming (LP) Model

The goal taken into account was to maximize farm income from the available production resources of the three studied locations.

One LP model structure with two scenarios was proposed. The set of estimates produced by least squares analysis and farm budgets were introduced to the model that based on Quantitative System Business (QSB, 1987) software.

Table 1. Gross output (GO), variable cost (VC), gross margin (GM) and available cash resources (ACR) in Egyptian pounds (LE) per feddan and per animal unit (AU) for the three studied locations.

Variables	GO	VC	GM	ACR
Location 1				
Winter crops:				606.3
Wheat	785.1	419.9	365.2	
Berseem	720.0	186.4	533.6	
Summer crops:				874.2
Groundnut	1164.9	496.6	668.3	
Maize	643.6	377.6	266.0	
Livestock	1077.7	668.7	409.0	500.0
Location 2				
Winter crops:				354.3
Wheat	423.5	202.0	221.5	
Berseem	720.0	152.3	567.7	
Summer crops:				535.9
Groundnut	477.5	405.7	71.80	
Maize	228.9	130.2	98.80	
Livestock	883.3	439.0	444.3	500.0
Location 3				
Winter crops:				604.1
Wheat	393.7	330.6	63.1	
Berseem	720.0	273.5	446.5	
Summer crops:				896.1
Groundnut	615.5	536.8	78.7	
Maize	292.1	359.3	67.2	
Livestock	1212.5	363.9	848.6	500.0

Base run sturacture

This run utilized farm available production resources and current crop and livestock activities of the three studied locations to maximize farm income (base run). The base run simulates the behavior of the current production system (real life situation) in the three studied location. The mathematical formula of the model structure in the three locations was as follows:

Objective function:

$$\text{Maximize (gross margin)} = \sum_{i=1}^{8} a_i X_i,$$

where,

a_i gross margin for each variable of X_i, X_i are no. of feddans cultivated with wheat (X_1), berseem (X_2), groundnut (X_3), maize (X_4), and no. of animal unit (X_5).

Subject to:

Land,

$X_1 + X_2$ = average farm size, (winter crops)

$X_3 + X_4$ = average farm size. (summer crops).

Labor,

where,

$$\sum_{i=j=1}^{8} c_j X_i \leq b,$$

c_j is labor (man–day) requirement & b is total labor; and X_i as mentioned before.

Available cash resources,

where,

$$\sum_{i=j=1}^{8} d_j X_i \leq m,$$

d_j is variable cost for each variable; m available cash resources; and X_i as mentioned before.

Non negativity $X_i \geq 0$, $i = 1,\ldots,5$.

Scenario 1 structure (LP1)

This scenario was proposed to fulfil family's consumption of essential food (wheat and maize) in addition to using on-farm feeding resources to satisfying animal's requirements. On-farm feeding resources were estimated as Total Digestible Nutrients (TDN) and crude protein (CP) per feddan. The amount of TDN and CP of berseem was 2160 kg TDN and 480 kg CP, wheat straw was 693 kg TDN and 37.5 kg CP and maize as green fodder was 160 kg TDN and 40 kg CP. Animal requirements were calculated according to the tropical animal unit requirements 1500 kg TDN and 180 kg CP per year (Alsheikh *et. at*., 2002). All of these under the constraint of availability of LE 10000 as cash resources. The mathematical formula of the LP1 structure in the three locations was as follows.

Objective function:

$$\text{Maximize(gross margin)} = \sum_{i=1}^{8} a_i X_i,$$

where,

a_i gross margin for each variable of X_i, X_i are no. of feddans cultivated with wheat (X_1), berseem (X_2), groundnut(X_3), maize(X_4), and no. of animal unit (X_5).

Subject to :

Land: Winter

$X_1 \geq 1$ feddan

$X_2 \geq 1$ feddan

$X_1 + X_2 \leq$ average farm size

Summer

$X_3 \geq 1$ feddan

$X_4 \geq 1$ feddan
$X_3 + X_4 \leq$ average farm size
Labor,

$$\sum_{i=j=1}^{8} c_j X_i \leq b,$$

where,
c_j is labor (man/day) requirement and
b is total labor available; and X_i as before.

Feeding
TDN

$$\sum_{i=j=1}^{8} t_j X_i = 0,$$

where,
t_j is amount of TDN for each variable; and X_i as before.
Crude Protein,
where,

$$\sum_{i=j=1}^{8} p_j X_i = 0,$$

p_j is amount of CP for each variable; and X_i as before.
i.e. the farmer is self sufficient in feed resources.

Available cash resources

$$\sum_{i=j=1}^{8} d_j X_i \leq m,$$

where,
d_j is variable cost for each variable; m available cash resources; and X_i as before.

Non negativity: $X_i \geq 0$, $i = 1,\ldots,5$.

Scenario 2 structure (LP2)

This scenario was similar to the first scenario in addition to adjust the farm size to 10 feddan for all studied locations.

RESULTS AND DISCUSSION

Results of real-life situation and the optimal solutions of the proposed scenarios for the three studied locations are shown in table 2.

Base run solution

In order to maximize farm income the base run solution revealed that, farmers have to change the current cropping pattern to 3.25, 2.32 and 2.22 feddan of berseem in winter, and 2.32, 4.12 and 2.43 feddan maize in summer along with 1.61, 1.14 and 1.37 animal units in the three studies locations, respectively, The obtained results are not comparable with the real-life situation, this may due to high variable cost of cultivating wheat. In case of farmers need to cultivate wheat in winter, they have to reduce the cost of wheat produced by 83.68, 53.15 and 47.7 LE per feddan in the three studied locations, respectively. While, if farmers need to cultivate groundnut in summer they have to reduce the cost of groundnut produced by 61.3, 124.93 and 50.38 LE per feddan in the three locations, respectively. The suggested areas cultivated with berseem in winter, represented about 71%, 17% and 14 % and those cultivated with maize in summer represented about 50%, 31% and 16 % of farm size, in the three locations, respectively. Livestock activity was found as a competitive activity with cropping. Herd size was small due to the limitation of cash resources.

Proposed scenarios solutions

The first scenario (LP1) was mainly proposed to reduce market risk due to cultivating one type of crops obtained from base run solution and to satisfy farmers basic needs, i.e. an attempt for farm self-sufficiency. Applying the LP1 scenario, in the three studied locations revealed that no feasible solution for the location 1. This result could be due to small farm size (4.6 feddan). Moreover, the optimal solutions in the locations 2 and 3 (average farm size was 13.8 and 15.4 feddan) were obtained.

The optimal LP1 solutions for locations 2 and 3 are shown in table 2. The optimal LP1 solutions suggested that, farmer should cultivate 12.32 feddan wheat and 1.48 feddan berseem in location 2 and 11.53 feddan wheat and 1.86 feddan berseem and leave 2.01 feddan fallow in location 3 in winter. While, in summer, farmer should cultivate 2.43 feddan groundnut and 11.37 feddan maize in location 2 and one feddan groundnut, 5.6 feddan maize and leave 8.8 feddan fallow in location 3, along with 9.03 and 8.6 animal unit in the locations 2 and 3, respectively. The total crop area suggested by LP1 in location 3 is smaller than total farm size due to the limiting cash resources which led to not cultivating all farm size and leaving some fallow.

The optimal LP2 solutions for the three studied locations are shown in table 2. The optimal LP2 solutions suggested that, farmer should cultivate 8.99, 8.5 and 9 feddan wheat and 1.01,1.5 and 1 feddan berseem in the three locations, respectively, in winter. While, in summer, he should cultivate 1, 7and 1 feddan groundnut and 9, 3 and 8 feddan maize in locations 1,2 and 3, respectively. Moreover, the solution suggested that farmers in location 3 could leave one feddan fallow.

The result of LP2 solution for livestock activity was 6.6, 6.4 and 6.5 animal unit in the three studied locations, respectively. These results show that the limitation of small farm size in location 1 in the LP1 constrained the farmers for using the high amount of the available cash resources to improve their farm income. While, in location 3, the cropping pattern was changing but as in the same trend as LP1 and the 8.8 feddan of fallow area obtained in LP1 in summer was decreased to 1 feddan in LP2. The number of animal units in this scenario was nearly the same in the three studied locations. This result indicted that, livestock activity was not competitive with cropping activity. Because, decreasing the farm size from 13.5 and 15.4 feddan in location 2 and 3, respectively to 10 feddan not led to increase the livestock activity. Moreover, the cultivated area in location 3 was increased from 6.6 feddan in LP2 to 9 feddan in LP2.

Table 2. Real-life situation and proposed scenarios solution of the three studied locations.

Item	Real- life situation	Base run	LP1	LP2
Location 1:				
Cropping pattern (feddan):				
Winter				
Wheat	1.95	---	**No feasible Solution**	8.99
Berseem	1.65	3.25		1.01
Summer				
Groundnut	3.05	---		1.00
Maize	1.39	2.32		9.00
Livestock production (Animal unit)	2.32	1.61		6.60
Location 2:				
Cropping pattern (feddan):				
Winter				
Wheat	4.10	---	12.32	8.50
Berseem	2.67	2.32	1.48	1.50
Summer				
Groundnut	4.85	---	2.43	7.00
Maize	2.33	4.10	11.37	3.00
Livestock production (Animal unit)	2.40	1.14	9.03	6.40
Location 3				
Cropping pattern (feddan):				
Winter				
Wheat	3.32	---	11.53	9.00
Berseem	2.35	2.22	1.86	1.00
Summer				
Groundnut	4.41	---	1.00	1.00
Maize	1.65	2.43	5.60	8.00
Livestock production (Animal unit)	2.84	1.37	8.60	6.50

Economic indicators

The farm income and return per unit of production resources were used as economic indicator for the system efficiency. The farm income in base run (Table 3) can be improved 55%, 26% and 42 % more than real life situation in the three locations, respectively. Farm income in location 1 was the highest among of the three locations. This could be due to type of farmers who have more experience than the other farmers in the two other locations, smaller farm size made farmers use most available resources in their farms.

These results in agree with other findings in previous studies as those conducted by, Siam, et. al. (1994); Ahmed (1995); Ahmed et. al. (1996); Mahmoud (1997) and Alsheikh et. at. (2002). This result supported the concept suggested by Bhatia and Gangwar (1981) that, farmers have different type of thinking other than just maximizing their farm income. Also, Abdulkadri and Ajibefun (1998) suggested that farmers could have objective(s) other than profit maximization like family satisfaction and diversification of crops to avoid market risk. To deal with market risk problem many researchers (e.g. Charnes and Cooper, 1958; Madansky, 1962; Charnes and Cooper, 1963; Bawa 1973; El-Shishiny and Attia 1985; El-Shishiny, 1988; Rodriguez and Anderson, 1988) introduced various stochastic or multi-objective modeling techniques farm planning to avoid uncertainty problem.

Table 3. Economic indicators of the Real situation and the different proposed scenarios solutions of the three studied locations (LE).

Item	Real - life situation	Base run	LP1	LP2
Location 1:				
Farm income	2919.00	4524.00		12132.00
Return / feddan	635.00	983.00		1213.00
Return / animal unit	1258.00	2810.00		1838.00
Location 2:				
Farm income	1730.00	2179.00	8638.00	6476.00
Return / feddan	128.00	161.00	640.00	648.00
Return / animal unit	720.0	1911.00	957.00	1012.00
Location 3				
Farm income	1654.00	2347.00	9361.00	7299.00
Return / feddan	107.00	151.00	608.00	730.00
Return / animal unit	582.00	1713.00	1088.00	1123.00

Under the LP1 solution when apply the first scenario, the resulted that the farm income (Table 3) can be improved by 296% and 299 % mare than base run in the locations 2 and 3, respectively. These high percentages could occur due to different available cash resources between base run and LP1. While, the difference between the two percentages indicated that farmers in location 3 were lately more efficient than that in location 2.This difference could obtained due to lately different of farm size between the two location (13.8 vs. 15.4).

The farm income in LP2 was improved from 4524, 2179 and 2347 LE in LP1 to 12132, 6476 and 7299 LE in the three studied locations, respectively. This result was conferment that the farmers in location 1 were more efficient than the other two farmer types. Because, they used there own resources economically and not due to small farm size only.

The return feddan was improved about 55%, 26 and 41% in base run compared to the actual situation in the three locations, respectively. While, the return feddan in LP1 was improved about 297% and 303 % compared to base run in the locations 2 and 3, respectively. This result could be supported the same result obtained in the first economic indicator. While, in the LP2, the return per feddan was improved 1% and 20% in Location 2 and 3 respectively. This result indicated that, decreasing the farm size to 10 feddan was not affected strongly on the return per feddan.

The return per animal unit was improved by about 123%, 165 % and 194% in base run compared to the real life situation in the three locations, respectively. These high percentages could occur due to theoretical assumption, which the farmers in the three locations already have the animal. Anyhow, these percentages indicated that there was obsessed result against that obtained in the first and secand economic indicators, which suggested the farmers in location 1 was the more efficiency than those in the two other locations. It could be explained this result due to the farmers in the last two locations prefer livestock activities than cropping activities. While, the return per animal unit in LP1 was decreased about 100% and 57 % in the locations 2 and 3, respectively. This result could occur due to the farmers in location 2 cultivated 13.8 feddan in both winter and summer seasons in LP1 vs. 2.32 feddan in winter and 4.1 feddan in summer in the base run solution. Also, this result could occur due to small number of the animal units suggested from base run solution (1.14 animal unit in location 2). The same trended was happened in location 3. This result, also supported that farmers in the last two location could prefer livestock activities than cropping activities, because they kept high number of animal units (9.03 and 8.6 animal units in location 2 and 3, respectively) and leave some fallow.

In the LP2, the return per animal unit was decreased from 2810, 1911 and 1713 LE to 1838, 1012 and 1088 LE, in the three studied locations, respectively. While, this indictor was improved 6% and 3% than LP1 in location 2 and 3, respectively. This result appeared that decreasing the number of animal unit, which suggested by LP2 solution, improved the return per animal unit. This result could happen due to constrain of on feeding farm resources that limited the number of kept animal units. In general, the return per animal unit under both real situation and the two scenarios was more profit than the return per feddan.

It could be recommended that, 10 feddan as farm size plus about 6 animal units with not lees than 10000 LE as cash resources is reasonable structure for development the small mixed farm system in newly reclaimed areas in Egypt.

It could conclude that, modeling with the aid of linear programming is potentially useful as a tool for preliminary evaluation of technologies. The proposed model is a valuable planning tool formulated to assist decision-makers in evaluating alternative plans for the integrated development of newly reclaimed areas.

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