American-Eurasian J. Agric. & Environ. Sci., 2 (Supple 1): 101-107, 2008
ISSN 1818-6769

Determination of the Optimal Pattern for Integrated Farms in Iran (A Case Study of Farzis Complex in Shiraz Province)

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Abstract: This study made an attempt to provide the optimal model of Meat and Milk in Farzis Complex in Shiraz and its comparison with the current model of the farms by using linear programming and Modeling to Generate Alternatives (MGA) models. The farm's activities can be divided into two parts of agricultural and animal husbandry. In agricultural section, plants such as wheat, maize, alfalfa and canola are cultivated and in animal husbandry section, cattle, male and female calves are kept. The required statistics and information of this study were collected through the questionnaire and interview with the manager of the farms for the farming year of 3003-2004. Results of the linear program model showed that the harvested area of wheat and canola were equal in the current and optimal model; the harvested area of maize had an increase of 16.6% in optimal model and alfalfa was omitted from the optimal model; thereby, in optimal model, there was an increase of 4.7% in the gross margin (in comparison with the current model). On the basis of the two models of MGA, it can be said that in MGA1, by the constant remaining the harvested area of wheat, reducing the harvested area of maize and canola and also reducing the number of cattle, alfalfa has been entered to the model by the amount of 14 Ha. While in MGA2, the number of cattle increased the harvested area of wheat and maize decreased and the harvested area of alfalfa and canola remained constant. Also, investigation of resource prices showed that the land factor is the major restricting factor toward the increasing of productions, which in turn would influence the earnings. Adopting the optimal model, the principle should exploit resources in an optimal way and increase farms income.

Key word: Optimal model · Linear programming · MGA model · Integrated farms

INTRODUCTION

Agriculture is one of the most important economic sectors which plays a crucial role in development in order to fulfill other sectors needs such as the industrial sector especially if agricultural sector is mixed with animal husbandry its role becomes more important. Although some plans have been made in order to develop these two sectors they are still having some problems. The significance of agricultural sector and its role in economic development of countries cause it to be one of the most important pivots in the development of developing countries. In order to gain agricultural development some policies and plans acceptable by farmers are necessary[1].

One of the basic elements in the production of agricultural products is proper planning. This plan can be most beneficial to the beneficiary according to constraints and conditions. Generally the knowledge and experience of beneficiaries can be most essential in making this plan. However agricultural planners can help farmers and planners in making plans by considering different factors such as the facilities and constraints of the farm, technical and economic conditions of production and input and products market and also the characteristics of the beneficiaries in mathematical models[2].

One of the most important factors in determining a proper model for farming is the fact that in considerable cases agricultural beneficiaries are engaged in other activities such as agricultural and animal husbandry at the same time. As a result these beneficiaries consider a set of activities with different natures when making plans. In these situations different production factors among these activities are allocated in such a way that it is impossible to separate them from each other and to make decisions for each of them independently and it is not logical to make independent plans for each of them [3].

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Bagheri *et al.* [1] adopted linear programming method in order to determine optimal model for farming herbs in Karaj. In order to determine relatively optimal models in making varied models, MGA was adopted. The results of comparing optimal model and the farm's current model showed that on the basis of optimal model gross margin increased for 13.7% as compared to current model.

Akbari *et al.* [2] adopted dynamic linear programming method in order to determine the optimal level of activities for one of the largest cow breeding farms in Iran, ie. Faka Branching Co. In Isfahan province. The time period for the study was 1998-2002.the results showed that during the first years there was a considerable difference between the model and reality but during final years these two were the same. Due to the consistency of market the farm in the best profitability conditions compared to 2002 had the possibility of %10 profit. Also it was maintained that the most sensitive constraint was the constraint of ration.

Jeffery *et al.* [3] adopted MGA method in order to determine the best type of cow feeding ration. Comparing MGA technique with linear programming method they stated the deficiencies of linear programming method. Also they maintained that the simplicity of MGA and lack of need to use software package related to this method and lack of need to specify objectives or weight preferences are the most important advantages of MGA method.

Haouari and Azaiez [4] presented a mathematical programming method in order to determine the optimal model for farming under shortage of water conditions in dry lands. In this model the kind of products which were chosen increased the level of irrigation and also maximized the possible profit. The purpose of this study was to maximize the level of watering and profit. The mentioned model determines the optimal model for area's land in order to allocate water among water-distributors effectively.

Adesina and Quttara [5] adopted simple risk programming method in order to asses risk in Savanna, Africa and determined risky consequences of price and income of minor farmers. The results showed that by taking price and operation risk into consideration, the farmers' income increase was possible.

Degliotti *et al.* [6] used mixed integer linear programming method in order to determine the optimal model for farms in southern Uruguay. The results showed that compared to the current pattern, decreasing the farming area of the products and at the same time increasing the area of pastures and provender plants is a better strategy.

In their study, Acs *et al.* [7] adopted dynamic linear programming model in order to compare organic farming with conventional farming in the Netherlands. The results showed that the former is more profitable than the latter.

This is a case study of Farzis meat and dairy complex in Shiraz, Fars. Therefore the objectives of this study are:

- To determine optimal and relatively optimal models for integrated farms, Farzis.
- To compare model gross margin of the current model and the optimal model.

MATERIALS AND METHODS

Farzis meat and dairy complex is the largest integrated farms in Fars province and one of the largest ones in Iran. It is located in Akbarabad, Kavar, by the main Shiraz-Jahrom road. The main plan of this complex completed in 1973 and it was approved in 1974. It has been active since 1975. %49 of the property belongs to Sabz co., attached to Saderat Bank and %51 percent belongs to the farms manager. Data and statistics were gathered for agricultural year 2003-2004,visiting the complex and investigating the overall situation and conditions and anything necessary in order to conduct a the study and these were incorporated into a questionnaire. Then agricultural and animal husbandry experts along with the manager's information, accounting records and balance sheet helped gathering a considerable amount of data. Through re-investigation and re-consideration of the gathered data, the shortcomings were detected. Referring to the experts and comparing the recorded statistics with the experts views, the deficiencies were eliminated. Some of the necessary data were gathered by referring Agricultural Jihad Ministry, in order to meet the objectives, the linear programming model and MGA method were adopted. In order to assess the model, Lindo software package was used.

In order to determine the optimal model for farming usually deterministic optimization techniques such as linear planning model are used. Deterministic optimization techniques eliminate all non-optimal outputs so that the optimal output is obtained. However MGA makes it possible to get access to a wide range of plans which are in an acceptable range of optimal output. Therefore the planner will be able to choose among different models, those ones which are more adaptable to the farm objectives and features considering facilities, constraints and give and take relations of the farm. MGA is based on this logic that mathematical models are not able to reflect all aspects of a planning case [8]. Therefore by providing those responses which are on ignorable levels of optimal level it is possible to replace a special answer to the problem with the possible range of acceptable responses. This way a set of intelligible plans are provided for the planner.

Linear Programming Method: Linear programming method enjoys some advantages such as Investigating behavioral hypotheses, considering technological changes and risk realization [9] and considering marketing issues [10].

The linear programming method can be written as:

$$\text{Max } Z = \sum_{j=1}^{n} C_j X_j$$

$$\text{S.T: } \sum_{j=1}^{n} a_{ij} X_j \le b_i \qquad I=1, \ldots, m$$

$$x_j \ge 0 \qquad j=1, \ldots, n$$

In the first equation Z is total gross margin which are in fact is determined through subtracting variable costs from the gross income of proposed model.

Cj: Gross margin for each unit of activity.
J: He activities which are to be chosen.
b_i: Accessible input or resource.
a_{ij}: Necessary amount of resources for the production of each unit of activity (technical coefficient).

In the second case Xj is non-negative constraint or in other words the production of none of the activities is negative.

Xj: The activities which are to be chosen.

Modeling Generate Alternative (MGA): The first step in MGA is to solve the main problem in order to determine the optimal answer and the amount of the target function.for instance suppose this is the main problem of linear programming method:

$$MAX\text{: } Z = C'X \qquad (1)$$

$S.T\text{: } AX \le b$
$X \ge 0$

In which Z is the amount of the target function, c' is the vector of the target function coefficients, X is the vector of the activities, A is the constraints coefficient matrix and b is the vector of the current resources. When the main problem has been finished and the optimal answer has been determined, the target function (1) becomes a constraint. This yields the opportunity function:

$$C'X \ge (1-J)Z^{*} \qquad (2)$$

$S.T\text{: } AX \le b$
$X \ge 0$

In which Z* is the amount of the target function (1) and J is the standard deviation relatively appropriate to tolerance level from the optimal amount of the target function. For example if j=%1 the amount of the main function's deviation from the optimal amount is at most 1%. The answers which are in acceptable range from the optimal answer are assessed and investigated through defining and forming the new target function. The total of planning activities which are non-zero in the main problem are adopted in MGA conditioned to the defined constraints in (2). The new target function causes the activities which were not primary in the previous solving to become primary and this way the answers are different from the main answer in a meaningful manner.

Finally this method generates answers which respond to oriented amounts in the target function although they are totally different from the main answer. This method continues this way and each time the total of planning activities which were non-zero in the previous solving become the least. The method stops when the MGA answers are consistent (ie. the total of non-zero activities does not change) or a sufficient number of alternative answers has been generated.

RESULTS AND DISCUSSION

The activities of the farm can be divided into two types: agricultural and animal husbandry. In the agricultural part wheat, corn, canola and alfalfa are grown. The farming areas of wheat, corn, canola and alfalfa are 75, 60, 5 and 14 Ha, respectively. Wheat and corn are alternatively grown. About 50 Ha of the land is fallow which is considered in the growing model. Due to the weakness of the complex in expanding the agricultural farm and increasing the harvested area due to the shortage of water, cow breeding has gained importance. In animal husbandry part cows, heifers and male and female calves are kept. Each cow produces almost 24.8kg milk every day for 240 day of year. This farm has a total of 1117 cows with the average weight of 600 Kg (adult).

The Activities of the Linear Programming Method:

- Producing wheat, corn, canola and alfalfa in the agricultural part and producing milk, calves and fertilizer in cow breeding part.
- The needs related to self–sufficiency which involve corn, wheat and alfalfa for animal husbandry use.
- Selling product.
- The number of fallows which are taken into consideration in the alternation

Since the linear programming model is a prescriptive one based on the existing realities, in this part based on the facilities and constraints and the way inputs are utilized in the current model of the farm, the model for combining agricultural and animal husbandry products in an optimal way is:

Target function:

Maxz=30473X1+300000X2+323150X3+62500X4+181000X5

In this function the tendency of the farms for maximizing gross margin is shown. X1 to X4 coefficients show gross margin (10 Rials) of wheat, corn, canola and alfalfa per Ha. X5 coefficient shows gross margin of each cow.

Constraints:

1) X1+X3+X4+X13<150
2) X1+X2+X3+X4+X13<150
3) X2+X4+X13<150
4) X1<75
5) X2<75
6) X3<5
7) X4<14
8) 3050X1+3140X2+3050X3+4580X4<540080
9) 4050X2+5480X4<307899
10) 900X1+900X3+1640X4<405262
11) 2000X1+2100X3<540080
12) -X1+X2<0
13) 4500X1-X6-X11>0
14) 50000X2-X7-X10>0
15) 1500X3-X8>0
16) 7200X4-X9-X12>0
17) 1752X5<2100000
18) 657X5<780000
19) 657X5<780000
20) 306.6X5<405500
21) 2920X5<4061700
22) 438X5<509300
23) 219X5<401400
24) X1, X2, …, X13>=0

In this model:

X1 = growing one hectare of wheat
X2 =growing one hectare of corn
X3 =growing one hectare of canola
X4 =growing one hectare of alfalfa
X5 = the number of cows
X6 = the amount of sold wheat (Kg)
X7 = the amount of sold corn
X8 = the amount of sold canola
X9 = the amount of sold alfalfa
X10 = using corn for self-sufficiency
X11 = using wheat for self-sufficiency
X12 = using alfalfa for self sufficiency
X13 = the amount of fallow

The rows 1, 2, 3 are related to land constraints and show that the total farming area in each period can not exceed 150 Ha and this is the total of land which the beneficiaries can have. Taking land constraints into consideration in 3 different periods enables the model to take into consideration the competitive, complementary and helping relations among the products and also the possibility of farming for the second time. The length of each period is determined according to climatic conditions of the region so the first period starts from November and ends in January, the second one starts in February and ends in may and the second one starts in June and ends in October. The rows 4-7 show the maximum farming land of the products. The rows 8-11 show the constraints on using water in spring, summer, fall and winter. These constraints show the maximum amount of water which can be used in production. Row number 12 shows agricultural alternation. Rows 13-16 show that the total amount of products should not exceed the sold amount and the amounts necessary in meeting animal husbandry needs. In other words the amount of sale and self-consumption of the products (wheat, corn, canola and alfalfa) for providing the needs of the animal husbandry sector should not be more than the amount of their products. Rows 17-23 show the maximum amount of feed. These constraints are related to barley, pollard, cotton refuses, corn, alfalfa, soybeans and sugar beet refuses.

The current, optimal and relatively optimal models for 5% level of the farms are shown. According to the results, as shown in Table 1, the harvested area of wheat and canola were equal in the current and optimal model and the percentage of harvested area change is zero. But the harvested area of corn increased to 70 Ha in the optimal model while it is 60 Ha in the current model. Therefore the harvested area of corn in the optimal model increased for

Table 1: The comparison of the farms current model with the optimal and relatively optimal models level 5% (Ha, number,Rials)

The activities	The current model	The optimal model	The percentage of difference from the current model	MGA1	The percentage of difference from the current model	MGA2	The percentage of difference from the current model
X1	75	75	0	75	0	50.155	-13.13%
X2	60	70	16.6%	57.08	-4.87%	50.155	-16.41%
X3	5	5	0	3.688	-26.24%	5	0
X4	14	0	0	14	0	14	0
X5	117	1162	4.02%	1111	-0.54%	1162	4.03%

Source: Author's calculations.

Table 2: The Gross margin of agricultural and animal husbandry activities in the current and optimal models (Rials)

Gross margin	Agricultural farm	Animal Husbandry farm	The whole farms
current model	433637550	2010747320	2444384870
Optimal model	456308800	2103220000	2559528800

Source: Author's calculations

16.6% in the optimal plan alfalfa is eliminated from the agricultural model. Alfalfa which was used for the purpose of self-sufficiency is omitted in the optimal model and the number of cows is increased. This shows that if alfalfa is bought from outside the farm it will be more beneficial.

In animal husbandry farm the number of cows in the current model was 1117 and 1162 in the optimal one which had a 4.02% increase. This is due to the higher annual output than annual costs for each cow. Therefore the gross margin of animal husbandry farm increases from 2010747320Rls in the current model to 2103220000Rls in the optimal one. The gross margin of the animal husbandry farm increased for 4.6% in the optimal model. Since the gross margin of the agricultural farm in 433637550Rls in the current model and 456308800Rls in the optimal one, the gross margin of the agricultural farm increases for 22671250 and this is due to the increase of farming land of corn and the elimination of alfalfa from the optimal model (the amount of increase in gross margin is 5.2%). The gross margin of the whole farms in the optimal model increases to 2559528800 while it is 2444384870 in the current one. These results are shown in Table 2.

According to the optimal answers in Table 1 which are the results of solving linear programming model and considering the %5 tolerance of the optimal answer the first step of MGA is generated as fallows:

Min C=304973X1+300000X2+323150X3+181000X5

Subject to:
304973X1+300000X2+323150X3+62500X4+181000X5 >243155236

Other constraints of MGA are those of the linear programming model. In the above model those answers which are in an acceptable range from the optimal answer are determined through forming the target function in which X1, X2, X3 and X5 (the activities whose amount in the optimal answer are non-zero) are minimized. In the target function activities coefficients are their gross margin and the target function becomes a constraint. The right side of this constraint is (1-J)z* in which z*is the amount of the target function and J is tolerance level. The results are shown in Table 1. The amount of gross margin of optimal answer in this case is 2422802240Rls. As it is shown in this alternative, X4 enters the optimal answers. In the same manner X2, X3 and X5 decrease and X1 does not change.

In order to determine the other alternative the target function is altered in a way that X1, X2, X3, X4 and X5 are minimized.

The below model shows this alternation:

Min C = 304973X1+ 300000X2+ 323150X3+ 62500X4 + 181000X5

Subject to:
304973X1+300000X2+323150X3+62500X4+181000X5 >243155236

Other constraints of MGA are those of the linear programming model. The results which are the second alternative are shown in Table 1. As it is determined by studying Table 2 X5 has increased and X2 and X1 have decreases and X3 and X4 have not changed. The total gross margin of these activities in the optimal answer (the second alternative) is 2431552320Rls in this case.

Table 3: The shadow price of the model's constraints

Constraint	Shadow price	The amount of excess or shortage
1	0	70
2	300000	0
3	0	80
4	4973	0
5	0	5
6	2315	0
7	0	14
8	0	1120
9	0	770
10	0	710
11	0	630
12	0	22500
13	0	37500
14	0	3750
15	0	76280
16	0	24399
17	0	333262
18	0	379580
19	0	5
20	0	337500
21	0	3500000
22	0	7500
23	0	0
24	0	64176
25	0	16566
26	0	16566
27	0	49230
28	0	668660
29	0	344
30	0	146922

Source: Author's calculations

In order to determine the third alternative, the target function and limitations will be the same as those of the second alternative since the variables of non-zero will not change. This shows that MGA answers are stabilized and in other words the problem has only two answers in the determined range.

The shadow price of a constraint shows the alternations of he amount of the target function per unit extension toward the right side of that constraint. According to the results the constraints 2, 4 and 6 have shadow price which means altering in right side of these constraints for one unit causes the alternation of the target function as much as the shadow price. Also if the harvested area in the second period increases for one unit (one Ha) the total gross margin will increase for 3000000Rls. If the harvested area of canola and wheat increases for one unit (one Ha) the amount of the target function will increase for 49730Rls and 23150Rls, respectively. The other constraints have zero shadow price and in the optimal model they are used less frequently then the others. The details are shown in Table 3. The results show that the factor land is the main limiting factor in boosting production and therefore income

Finally since one of the most important issues in optimal resource exploitation is adopting optimal model in production farms, therefore it is proposed that the farms manager act on the basis of optimal model in order to have optimal exploitation of resources on the one hand and to increase farms gross income and productivity on the other [9-11].

CONCLUSIONS

The significance and role of Agricultural sector from the viewpoint of increasing agricultural products and farmers' earning in Iran has always been considered by the politicians and administrators. This is especially important if this sector is integrated with animal husbandry sector. One of the basic elements in the production of agricultural products is proper planning. One of the most important factors in determining a proper model for farming is the fact that in considerable cases agricultural beneficiaries are engaged in other activities such as agricultural and animal husbandry at the same time. As a result these beneficiaries consider a set of activities with different natures when making plans. In these situations different production factors among these activities are allocated in such a way that it is impossible to separate them from each other and to make decisions for each of them independently and it is not logical to make independent plans for each of them. By providing proper model, the utmost income out of consuming a certain amount of input or the least amount of expense from the creation of a composition of products can be determined. As it is shown by the findings of this study, the manager of farzis dairy and meet complex can increase the gross margin for 4.7% using an optimal model. In fact if the manager acts on the basis of the optimal model the resources are used optimally and the gross income increases.

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