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USING SENSITIVITY ANALYSIS IN DETERMINING OPTIMAL PRODUCTION PLANS IN Al-KADHIMIYA DISTRICT FARMS (SINAA FARM CASE STUDY 2016-2017)

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Abstract

Despite the interest of many farms in the country in directing the economic resources available to them towards maximizing their profits, but the use of these resources are not according to the concepts of the economics of production, which leads to discrepancies in the actual and possible production at the level of production unit. In order to try advance the reality of al-Kadhimiya district farms being of farms that do not apply the concepts of production economics and where their economic resources are not used optimally ,resulting in disparities in their actual and potential production, it became necessary to try the optimal allocation of economic resources available to them using the Linear programming LP) (method In order to increase the quantities of production and achieve the highest possible level of profits because of its positive impact in various economic, social and developmental aspects, which are the main objectives pursued by different sectors. The aim of the research is to optimize the allocation of resources available to farmers using the LP) (method for the agricultural season 2016-2017 to obtain the high levels of production and high levels of profits by maximizing the value of the objective function and increasing the profitability of farms based on the data obtained from questionnaires and conducting sensitivity analysis to determine the extent of changes in the optimal commodities, quantity, quality and profit level in a manner appropriate to the growth requirements of these farms. The research showed a number of results, the most important of which: Prove the hypothesis of achieving high levels of production and profit and optimal allocation of available resources The value of net income increased from 356232280D in the actual production plan to 98319580O D in the derived plan using the linear programming method, achieving an increase of 176%

Keywords: Economics of production, sensitivity analysis, optimal allocation, objective function

Introduction

Production studies have shown that the subject of production planning is integrated with the problem of determining the optimal production volume that meets the demand and at the same time optimizes resource utilization as production managers face several alternatives during the preparation of the production plan (Frederick, 1995) and the problem becomes more profound if the farm deals with a mix of products, which requires the use of scientific methods most able to express the treatment of this problems, and since these methods represent a practical tool which farms can make benefit from it in production planning so the production plans must be formulated according to scientific methods subject to change and response to developments arising from the scientific reality where the achievement of economic efficiency (which means access to production greater than the same resources available or to obtain the same amount of production but less resources) **(**Al-Samarai, 1974) To exploit the resources produced locally and imported, requires the adoption of methods of planning based on scientific grounds ,as the policy of optimal exploitation of available economic resources and re-distribution assure avoidance of waste and loss and this process must be in the forefront of the efforts of the planners and the economic problems need to be studied and attention to and as the Sinaa farm is one of the farms of the division of Agriculture Kadhimiya, which contribute to the nutrition and supply of crops to the surrounding areas in Baghdad, which did not use (LP) the as method in the production plans, so the study attempted to use this technique in the Sinaa farm in order to choose a mathematical model to determine the optimal production plan with a higher net income and to determine the sensitivity of the data, based on LP) (method that maximizes profit or reduces costs) (Al-Nassr, 2019). Which provide an advantage to the decision maker which is the possibility to select or determine a wide range of alternatives available and analyze the results of each alternative within certain assumptions and in a short time. The importance of the research comes from the importance of the crops that the farm cultivates as necessary crops which is related to the health of the citizens as well as the contribution of research in rationalizing economic activity through the process of allocating and exploiting the available resources in the optimal manner of the farm. This importance comes from the scarcity of different resources and helps in making decisions that lead to optimal use of resources to ensure the largest return or the lowest possible cost and then achieve the highest efficiency of the economic process. Therefore, the importance of the research highlight by addressing the topic of determining the optimal production mix using LP) (technique and sensitivity analysis as a technique of planning aimed at maximizing levels of production and profit and reducing waste and loss of economic resources available in the farms of division of agriculture of Kadhimiya, for what farms provide different crops for individuals, and for productive role which it plays as value and productions quantity. The problem of research is that most of the farms in the country suffer from the non-scientific method of using their available economic resources, which leads to a decrease in their ability to create value added and then decrease their contribution to the composition of GDP, which results in slower growth of this sector if we compare which can be achieved if the decision-maker in this sector use the appropriate methods to reallocate the available economic resources in a correct scientific technique to achieve their optimal utilization and the current reality of the farm indicates that farm does not follow the scientific plans of production by using correct scientific technique in optimal output mix setting which leads to not optimal exploitation of the economic resources available to them, which has led to a decrease in the quantity of actual production, so it is necessary to study this problem and try to find effective solutions which serve the central objective of the state which aims to provide products to members of society because of its importance, and the research will try to study the reality of crop composition in an important agricultural area suffering from multiple problems surrounding the city of Baghdad represented by the directorate of agriculture of Al-Kadhimiya We have been selected for the Sinaa farm as a case study as a farm Atypical contribute to cover part of the needs of the surrounding areas and follow Agriculture Division of Kadhimiya / Directorate of Agriculture Baghdad. The hypothesis of the research stems from the ability of the farms of the Kadhimiya Agriculture Division to utilize their available resources optimally through the implementation of the proposed plan according to the linear programming technique instead of the plan implemented by the Agricultural Division, which contributes to achieving the economic and technical efficiency of the production process and reducing waste in available resources To plan the production process and optimal allocation of resources and production efficiency, which leads to the achievement of high levels of production and profits The aim of the research was, through the optimal plan proposed according to LP) (technique achieving the following: Determine the optimal commodity mix using LP) (technique Agricultural season 2016- 2017 for (optimal allocation of available resources for farm Sinaa, high levels of production, high levels of profits) to maximize the value of the objective function and increase the profitability of the farm based on data derived from the questionnaire and personal interviews to farmers. Sensitivity analysis (post-optimization analysis) to determine the extent of changes in the optimal commodity composition (quantity and quality) and profit level in a manner appropriate to the growth requirements of the farm.

Materials and Methods

Linear programming (LP) technique and determination the optimal production components

First: Linear Programming Technique

The first to use linear programming (LP) in 1947 was Dantzig and Marshall **(**Kwak, 1987), which was used as a means to find the optimal solution to planning problems in the US Air Force and the use of LP) (was rapidly deployed in very broad areas of business management, It has become an effective and important tool to help the manager of the establishment to make the right decisions during the decision-making process and included its use from the governmental sector to the industrial, business and agriculture sectors. The importance of LP) (is to identify possible alternatives to achieve this through which it can reach the optimal solutions to many of the problems encountered (Al-Nassr, 2019). Experience and practical application have shown that this technique is economically effective and has a significant impact on the level of performance of companies and increase their production. This technique has been widely used in addressing many productive and economic problems (Barry, 2003). Linear programming is a set of mathematical methods for finding optimal solutions to multiple problems, including linear relationships of variables in the objective function and constraints (James, 1974). It is a mathematical technique used to solve economic problems with specific characteristics which represented by a linear objective function of maximization or minimization with several alternatives to achieve a objective function with a set of constraints which represented by the existence of specific production resources to achieve each alternative (Gibson, 2003) so LP represents a method for selecting the optimal alternative among these alternatives, and these determinants are in the form of smaller variations of or greater than or equal to. The process of determining the optimal level of a dependent variable involves a target function that is related to linear relationships with some of the variables (X `s) in the presence of a set of linear constraints that include these independent variables in the form of a variation. The dependent variable is called objective function, while the independent variables are called decision variables or choice variables and the optimal solution for LP) problems is to find set of optimal solution for decision variables and the value corresponding to the objective function (Al-Nassr, 2014).

Information Needed for Linear Programming Problem (Saltelli, 2001)

There are three types of information that the linear programming model needs:

A-Decision Variables. B - Objective Function, C – Constraints

Mathematical model for linear programming (Holder, 1997).

It has also been shown previously that LP) (model consists of a linear objective function consisting of a set of decision variables to be maximized or minimized, which constitute production alternatives available to the decision maker and with a set of constraints that are in a different mathematical form, Greater than or equal to or smaller than or equal to. Assuming the existence of (n) of the decision variables of the objective function (Z) and the number of (m) of the determinants or constraints, the mathematical form of LP) (model takes the: following form (Hamdy, 1997)

$$\text{Min or Max } \sum_{j=1}^{n} CjXj$$

S.to

$$\Sigma^{n}_{j}\, a_{ij}X_j\ (\geq, =, \leq)\, b_i$$

$$X_j \geq 0$$

$$i = 1, 2 \ldots\ldots\ldots, m$$

$$j = 1, 2, \ldots\ldots\ldots\ldots, n$$

Where: Cj, bi, aij = constants, m = number of constraints, n = number of variables\

Second: Sensitivity Analysis or Post-optimality Analysis (Yildirim, 2001**)**

The great advantage of mathematical programming in general and LP) (in particular is that it allows the decision maker to choose a wide range of modifications in the available alternatives and analyze the effects of these modifications on the optimal solution for LP) (and for a short period of time especially after the availability of Parametric LP) (software and this is what expressed by Sensitivity analysis or post-optimality analysis). Decision-maker In order to obtain a full and broad interpretation of the plans obtained through the optimal solution of LP) (model, he wishes to test the stability and stability of this optimal solution the extent to which it remains stable and consistent from values of one or some factors involved in (LP) model, which are often not very well known or known and certain. in many case these values are often determined according to objective or partial expectations or future predictions (Zilberman, 2002) the sensitivity analysis to solve the optimization process can take the following forms (Al-Taei, 2009):

1- Change in the values of the variable coefficients of the target function. A-Non-Basic Variables, B. Basic Variables, 2-Changes in technical parameters of constraints (aij), 3-Changes in right-hand values of constrain, 4-add new variables, 5-add new constrains.

Result and Discussion

Identify optimal production plans for the Sinaa farm, analyze data and discuss model results

In this section the practical aspect of optimal allocation of resources using LP technique will be addressed through the formulation of a mathematical model for the Sinaa farm crops, and then analyzing the results. The most important stage in LP) (technique is a stage of model formulation which is based on the fact that the farm aims to maximize total net income by producing several products subject to specific constraints. After LP model had formulated, we used the ready program QSB (Quantitative System for Business) (Krajewiski, 1996), which maximizes profit using the Simplex Method, which is used to solve linear programming problems (Thomas, 2002). To reach the optimal production plan for 2016- 2017.

FIRST-Formulation of (LP) ELMOD and identification the optimal commodity combination.

To achieve the research objectives, we will formulate (LP) model of Sinaa Farm 2016- 2017 to optimize resource allocation that maximizes total net income of products. The target model is a mathematical model constrained to calculate the best income for the best plan and for the best combination of production that maximizes net income. The formulation of (LP) model requires defining the objective function and determining the constraints and determinants of the technical coefficients required by the production of the unit of each product. Depending on the data obtained from the questionnaires, it is possible to formulate an Objective Function and specify the technical parameters and constraints of (LP) model as follows:

1- Determining the data used in the LP P form (Al-Nassr, Redhab.2013):

A - Defining the objective function:

The objective function in the linear programming model represents maximizing the total net expected income as follows:

$$\text{Max} \sum_{j=1}^{6} C_jX_j = C_1X_1 + C_2X_2 + C_3X_3 \ldots\ldots\ldots\ldots C_6X_6$$

As:

Σ Cj Xj= represents the total value of the objective function to be maximized (total net income of the farm

Cj = Net income from product j

X = the output level of the product (j) where (j = 1, 2, ..., 6) the level of activity.

We aim from formulation the model to determine the optimal combination of products that achieve the greatest net income possible according to the available possibilities.

B) Identification of the technical transaction matrix data for the constraints that represent the product needs of the various production inputs per unit which representing left hand side (LHS).

C) Determining the available quantities of production inputs at the Sinaa farm, which represents right hand side RHS, and after determining the most important basic constraints as well as non-negative constraints, we will proceed to the formulation of LP models for farm crops for 2016-2017 at current prices as follow

2 - Formulation of the LP model for the Sinaa farm 2016-2017:

The research seeks to optimize the exploitation of inputs and production factors and to maximize profits in the programming formula Linearity of the crops cultivated by the farm which are: wheat X1, barley X2, cloves X3, tomato X4, cucumber X5, water melon x6 and based on data obtained from questionnaire and interviews with farmers of crop needs of different production requirements and quantities available for Sinaa farm, as well as the net income per unit of the various productive activities that the researcher had calculated by multiplying)the yield of one dunum of each crop (*) the price of one ton obtained from the questionnaires(, it is possible to formulate the objective function and determine the technical parameters and constraints for LP model and we will formulate this model as follows:

A) Objective function data

The objective of the model was to maximize total net income at current prices achieved by 6 various productive activities cultivated during the agricultural season 2016-2017, as shown in Table 1, which presents the total return, operational costs and net income per dunum. This farm had been cultivated other crops, but our selection of the crops under consideration as they constitute the largest proportion of the total production, while the remaining crops accounted for a small proportion of the total production(Thomas, S.2002).

B) Data of technical transaction matrix for constraints

Objective function of the model had restricted by 24 constraints, LHSrepresents the needs of dunum and RHS represented the quantities available as follows:

1-Determine the matrix of technical transactions and quantities resources conomics of available used in production

Technical transactions represent the requirements of dunum per crop, such as production material requirements, working hours, capital and others. These factors are determined in light of the needs of each dunum per crop. The amount which had been needed of each dunum and the quantities available to the farm from each of these resources were calculated according to the data obtained from' questionnaires and interviews with farmers, as well as the non-negative production constraints. Table 2 shows what needs to cultivate one dunum of agricultural production requirements and the quantities available from these materials during the agricultural season 2016-2017. These materials had represented by the constraints numbered from C1-C17 in model 1.

2 - Determine the needs one dunum of each working capital

This limitation represents needs of each dunum of capital to cultivate each crop. Cost of production represents the total operational cost to cultivate one dunum of each crop, as shown in Table 1. The total cost of the crops shown in the plan must not exceed the capital available to the Sinaa Farm for the agricultural season 2016-017 and the value of 78500000 dinars at current prices It is noted that this value is greater than the total cost. This can be written as the following formula, C18

$$C18 = 324500X1 + 324500X2 + 270600\ X3 + 538948X4 + 317350\ X5 + 288750\ X6 \le 78500000$$

5- Non Negativity Constraints

This means that all variables in the model must be positive, that is, larger or equal to zero, represented by the constraints of c19-c24 in Model 1. After defining the most important constraints and non-negative constraintnts. In light of the data prepared for the objective function, constraints and constrains of objective model, the final form of LP model for the Sinaa farm, which maximizes the net yield for the agricultural season 2016-2017, is illustrated in the following model. By finalizing the model form) 1 (we will move to the stage of identifying the optimal solution, analyzing the results and analyzing the sensitivity.

The first model matrix can be illustrated as follows:

The First model matrix 2016-2017

Quantities available		Water melon x6	Cucumbers x5	Tomatoes x4	Cloves x3	Barley x2	Wheat x1	Quantities required / Crops
6209	≥	8	10	25	100	40	70	Fertilizer Urea / kg
22982	≥	100	66	200	100	50	70	Compound fertilizer / kg
13186	≥	50	66	66	0	0	0	Animal fertilizer / m^3
2000	≥	4	5	6	2	3	5	Pesticides / L
13000	≥	8	13	18	14	3	6	Workman January-March/hour
13500	≥	31	102	50	23	1	2	Workman April –Jun /hour
15024	≥	58	0	80	0	1	0	Workman July-September/hour
12700	≥	0	0	52	7	4	7	Workman October-December/hour
390	≥	1.5	1.5	1.5	1.5	1.5	1.5	Automatic work tillage / hour
390	≥	1	1	1	1	1	1	Automatic work machining and adjustment / hour
390	≥	0.5	0.5	0.5	0.5	0.5	0.5	Mechanical work waving and milling / hour
631	≥	0	0	0	0	0.5	0.5	Work for a harvester / hour
129000	≥	100	133	100	370	450	390	Irrigation water* January-March/m^3
177500	≥	1215	955	101 5	470	520	275	Irrigation water* April-Jun/m^3
122000	≥	1095	0	1683	150	230	0	Irrigation water* July –September/m^3
19000	≥	0	0	0	305	460	300	Irrigation water* October-December/m^3
78500000	≥	288750	317350	538948	270600	324500	324500	Capital

Form 1 The final form of the matrix of the LP model of the Sinaa Farm 2016-2017

$Max\ (Z) = 515500X1 + 5675500X2 + 2729400X3 + 5461052X4 + 4182650X5 + 2211250X6$

Subject to

$C1 = 1X1 + 1\ X2 + 1X3 + 1\ X4 + 1\ X5 + 1\ X6 \le 200$

$C2 = 70X1 + 40X2 + 100\ X3 + 25X4 + 10X5 + 8X6 \le 6209$

$C3 = 70X1 + 50X2 + 100\ X3 + 200\ X4 + 66\ X5 + 66\ X6 \le 22982$

$C4 = 0X1 + 0X2 + 0X3 + 66X4 + 66X5 + 50X6 \le 13189$

$C5 = 5\ X1 + 3\ X2 + 2X3 + 6X4 + 5X5 + 4X6 \le 2000$

$C6 = 6X1 + 3X2 + 14X3 + 18\ X4 + 13\ X5 + 8\ X6 \le 13000$

$C7 = 2\ X1 + 1\ X2 + 23\ X3 + 50X4 + 102X5 + 31X6 \le 13500$

$C8 = 0X1 + 1X2 + 0\ X3 + 80\ X4 + 0X5 + 58X6 \le 15024$

$C9 = 7X1 + 4X2 + 7X3 + 52X4 + 0\ X5 + 0\ X6 \le 12700$

$C10 = 1.5\ X1 + 1.5\ X2 + 1.5\ X3 + 1.5\ X4 + 1.5\ X5 + 1.5\ X6 \le 390$

$C11 = 1\ X1 + 1X2 + 1X3 + 1X4 + 1X5 + 1X6 \le 390$

$C12 = 0.5X1 + 0.5X2 + 0.5X3 + 0.5X4 + 0.5X5 + 0.5X6 \le 390$

$C13 = 0.5X1 + 0.5\ X2 + 0X3 + 0X4 + 0X5 + 0X6 \le 631$

$C14 = 390\ X1 + 450\ X2 + 370\ X3 + 100\ X4 + 133\ X5 + 100\ X6 \le 129000$

$C15 = 275\ X1 + 520\ X2 + 470X3 + 1015\ X4 + 955\ X5 + 1215X6 \le 177500$

$C16 = 0X1 + 230X2 + 150\ X3 + 1683\ X4 + 0X5 + 1095\ X6 \le 122000$

C17 = 300 X1 + 460 X2 + 305X3 + 0X4 + 0X5 ≤ 19000
C18 = 324500X1 + 324500X2 +270600 X3 + 538948X4 +317350 X5 + 288750 X6 ≤ 78500000
C19 = X1 + 0X2 + 0X3 + 0X4 + 0X5 + 0X6 ≥ 0
C20 =0 X1 + 1X2 + 0X3 + 0X4 + 0X5 + 0X6 ≥ 0
C21 = 0X1 + 0X2 + 1X3 + 0X4 + 0X5 + 0X6 ≥ 0
C22 = 0X1 + 0X2 + 0X3 + 1X4 + 0X5 + 0X6 ≥ 0
C23 = 0X1 + 0X2 + 0X3 + 0X4 + 1X5 + 0X6 ≥ 0
C24 = 0X1 + 0X2 + 0X3 + 0X4 + 0X5 + 1X6 ≥ 0

Second: Determining the optimal combination of commodities in Sinaa farm, analyzing the data and discussing the results

After completing the mathematical formulation of objective function and constraints of LP model, the data was entered into the computer for the purpose of analysis and after the implementation of QSB (LP problem solving) The value of net income at current prices amounted to 983195800 dinars, an increase of 176% from the net income actually realized at current prices of 356232280 dinars for 2016-2017(Where it was calculated by the researcher by multiplying (the value of net income at the current prices of each crops shown in Table 1 (*) cultivated areas of each crop, (and then calculated had the multiplication values) in spite of wheat ,cloves and water melon had been disappear in the optimal plan, From the above we note that this plan derived using the linear programming model is different from the actual plan for the agricultural season 2016-2017 in terms of crop structure and agricultural area and net farm income and the available agricultural land area 200 dunum which had been exploited , an increase of 95 dunum for the area of agricultural land planted with total of 105 dunum. The optimal solution using LP technique has shown that the resource-use, which represents (LHS) of the model is less than the available resources, representing (RHS) of the model which means that optimal plans have used fewer resources and gave largest income, and the optimal solution for the optimal crop combination for optimal plan which represented by barley X2, tomato X4 and cucumber X5, shows that the production combination remains the same if the X2 yield is changed from a minimum of 4223899 D per unit and a maximum of (M) D, as well as for X4 where the production combination remains the same unchanged if its return changed from a minimum of 4182650 D per unit and a higher limit of 71032296 D as well as for the X5 crop, the production combination will remain unchanged if the X5 yield changes from a minimum of 3215644 D per unit and a higher limit of 5461052D. Also, the fully exploited production resources, which represent limited resources of agricultural land C1, capital C18, and water quantities (October-December) C17, the addition of one unit of C1 will add to the objective function value of 2351853 D and up to 200.5 units maximum, One unit of the C17 will add to the objective function value of from 3100.7 D and up to 20551.5 units as maximum, while adding one unit of C18 will add 5.8 D to the objective function value and up to 78578020 D as maximum, which reflected by the shadow prices of these resources. Given the importance of the current production structure and the availability of surplus resources to production, we have made a number of alternatives for the costs of production inputs and product prices through sensitivity analysis to show their impact on the proposed model to reach optimal plans that can be adopted by the farm management and choose what suits them in light of the possibilities available to them.

Third: Sensitivity Analysis

To illustrate sensitivity analyzes on the basis of which the extent of possible changes in the components of the model are identified, we analyzed the sensitivity of the optimal production plan and the sensitivity analysis included the following forms (T.H.F. 2017**)** as shown in Table (3) as follows :

A- Analysis of the sensitivity of the optimal solution (the basic solution) for the changes in the coefficients of the objective function: column (2), sensitivity analysis includes the possibility of a decline in the prices of one unit of products by 10% from the prices of the products of the first plan and this plan had achieved objective function of 884876200 D, with a decrease of 98319600D than the achievement of the objective function of the first plan with the same production structure and the same quantities .

B -Analysis of the sensitivity of the optimal solution to changes in the coefficients of constraints and its includes the following probabilities:

- The possibility of a decrease in available capital by 10% than in the first plan (column 3). This plan achieved objective function of 923079600 D, a decrease of 60116200 D for the first plan and with the same production structure.
- The probability of increasing the operational costs of production by 10% (column 4) this plan achieved objective function of 929428400 D and a decrease of 53767400 D, than achieved by the objective function of the first plan with the same production structure
- The possibility of a decrease in the prices of one unit of products by 10% from the prices of the first plan and the increase in the operational costs of production by 10% (column 5). This plan achieved objective function of 836,485,600 D and a decrease of 146710200 D, than achieved by the first plan goal with the same production structure achieved in the optimal plan.

Table 1 : Items of Net income for each crop at current prices 2016-2017
Th. D /Dunum

Water Melon X1	cucumber X5	tomato X4	cloves X3	barley X2	Wheat X1	Crops Items
2500	4500	6000	3000	6000	840	Total Income
288.8	317.4	583.9	370.6	324.5	324.5	*Operational costs
2211.3	4182.6	5461.1	2729.4	5675.5	515.5	Net income **

Source: The data were calculated by the researcher based on the questionnaire
* Operational costs = variable costs + maintenance costs. (4)
** Net income = total income - operating costs. (4)

Table 2 : Required quantities and available from the requirements of agricultural production for each crop 2016-2017 **Dunum**

Quantities available	Water melon x6	Cucumbers x5	Tomatoes x4	Cloves x3	Barley x2	Wheat x1	Quantities required / Crops
6209	8	10	25	100	40	70	Fertilizer Urea / kg
22982	100	66	200	100	50	70	Compound fertilizer / kg
13186	50	66	66	0	0	0	Animal fertilizer / m^3
2000	4	5	6	2	3	5	Pesticides / L
13000	8	13	18	14	3	6	Workman January-March/hour
13500	31	102	50	23	1	2	Workman April –Jun /hour
15024	58	0	80	0	1	0	Workman July-September/hour
12700	0	0	52	7	4	7	Workman October-December/hour
390	1.5	1.5	1.5	1.5	1.5	1.5	Automatic work tillage / hour
390	1	1	1	1	1	1	Automatic work machining and adjustment / hour
390	0.5	0.5	0.5	0.5	0.5	0.5	Mechanical work waving and milling / hour
631	0	0	0	0	0.5	0.5	Work for a harvester / hour
129000	100	133	100	370	450	390	Irrigation water* January-March / m^3
177500	1215	955	101 5	470	520	275	Irrigation water* April-Jun / m^3
122000	1095	0	1683	150	230	0	Irrigation water* July –September/m^3
19000	0	0	0	305	460	300	Irrigation water* October-December / m^3

Source: 1- Questionnaire form, 2- Division of Al-Kadhimiya Agriculture 2018

Table 3 : Optimal production plans of the Sinaa 2016-2017

Plan number crop	**1) Optimum Solution**	**2) Net income decrease 10%**	**3) Capital decrease 10%**	**4) Operational costs increase 10%**	**5) Net income and operating costs decreased 10%**
1-Wheat	0	0	0	0	0
2-Barley	41.3043	41.3043	41.3043	41.3043	41.3043
3-Cloves	0	0	0	0	0
4-Tomato	66.4928	66.4928	40.0983	41.9597	41.9597
5-Cucumber	92.2028	92.2028	112.2920	111.3795	111.3795
6-Water melon	0	0	0	0	0
7- Total crop area (Dunum)	200	193.6946	200	194.6436	194.6436
8-Income (D) (Objective Function)	983195800	923079600	884876200	929428400	836485600

Source: Table based on the results of the plans described in the table above

Conclusions and Recommendations

The research reached a number of conclusions, perhaps the most important:

1. Prove the validity of the hypothesis to achieve high levels of production and profits and the optimal allocation of available resources as the value of net income from 356232280D in the actual production plan to 983195800D in the plan derived using the linear programming method, an increase of 176% D for the season. 2016-2017
2. The plan derived from the LP model is different from the actual production plan for the agricultural season 2016-2017 in terms of the value of net income and in terms of crop structure, where the wheat, cloves and water melon did not appear, and the results of this plan showed that all resources available are optimally exploited.
3. The optimal solution using LP method shows that the resource exploiter LHS is less than the available resources RHS which means that optimal plans have used less resources and gave greater net income and the optimal solution for the production structure of the first plan d explain:
   - The productive resources that have been fully exploited and which represent limited resources of agricultural land; C1, C18 capital and water quantities (October-December) C17, adding one unit of C1 will add to the value of objective function 2351853 D and up to 200.5 units as maximum, and add One unit of C17 will add to the value of objective function from 3100.7 D and up to 20551.5 units as maximum, while adding one unit of C18 will add to the value of objective function 5.8 D up to 78578020D maximum, as reflected by the shadow prices of these resources.
   - The results of LP model showed efficiency in the optimal allocation of resources and the decision-maker's ability to make decisions by increasing profits in accordance with the possibilities available to him.
4. The results of the sensitivity analysis in the LP model for the objective function parameters, the constraints used and the technical parameters showed the following:
   - The results of the sensitivity analysis of the objective function parameters showed that the upper and lower limits of the gross margin of net income for each crop ensured that these products remained within the optimal production volume and that it was possible to make a decision to change crop prices in line with competitive market conditions.
   - The results of the sensitivity analysis of the alternative plans showed a decrease in the value of the objective function, the same production structure

and the quantities of resources available for the initial plan. However, there is a difference in the areas allocated for cultivation between the increase and the decrease.

From the previous conclusions we can propose a number of recommendations perhaps the most important, using LP technique to determine the extent of exploit of available resources efficiently, which helps to increase production. The need to generalize this method and apply it in other farms with similar conditions to determine the optimal use of different productive resources available. Increase the resources who's Shadow Prices is positive for the purpose of benefiting from the other surplus resources which shadow prices are zero so as to increase production and the farms directors should take the scientific approach to address waste and loss of productive resources available.

References

Al-Nassr, R. (2013). The Optimum Commodities Combination in Factory of Medical Cotton Production in Baghdad by using the Linear Programming Technique. The Iraqi Journal of Agricultural Sciences. 44(1): 114-129.

Al-Nassr, R. (2014). Efficient Production Plans in the Association of Hamorabi Farms Under conditions of Risk and Uncertainty Using MOTAD. The Iraqi Journal of Agricultural Sciences. 45(1): 77-91.

Al-Nassr, R. (2019). The Optimal Crop Rotation of Al-Rashed District Farms Using Linear Programming Technique. The Iraqi Journal of Agricultural Sciences. 50(Special Issue): 113-127.

Al-Samarai, H.A. (1974). Economics and Methods of Farm Management. 1st Edn. Coll. of Agric., Univ. of Baghdad. p. 103.

Al-Taei, Kh.D. *et al*. (2009). Applications and Analysis of Quantitative Business System Win QSB. Al-Thakira Library. 150.

Barry, R. and Ralph, M. (2003). Quantitative Analysis for Management, 8th edition. Prentice Hall, New Jersey, P234-235.

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Frederick, H. and Gerald, L. (1995). Introduction to Operations Research, Stand Ford University, McGraw-Hill, International Editions, Industrial Engineering Series, and P203.

Gibson, J. and Ivancevic, M. (2003). Organization Behavior Structure Process. McGraw-Hill Company, Inc, New York.P 265-268.

Hamdy, A. (1997). The Introduction of Operation Research,6th edition, Prentice-Hall International, Inc, P67-68.

Holder, A.G. and Zhang, S. (1997). Sensitivity Analysis and Parametric Linear Programming, P20.

James, E.S. and Stevens, G.T. (1974). Operations Research, a Fundamental Approach, McGraw- Hill. New York, 243-303.

Krajewiski, L.J. and Ritzman, L. (1996). Operations Management, 3ed edition. 2003. Addison Wesley Publishing Company, New York, P628.

Kwak, N.K. (1987). Mathematical Programming with Business Application, McGraw-Hill Book Company, New York 15.

Saltelli, A. and Chan, K.S. (2001). Sensitivity Analysis, Wiley Series in Probability and Statistics, England. 13-15.

T.H.F and Ali, I.H. (2017). An analysis of Economic Efficiency and Optimal Allocation of Economic Resources in Abu Ghraib Dairy Factory using Linear Programming in 2015. The Iraqi Journal of Agricultural Sciences 48(1): 382-396.

Thomas, S. and Bateman, S.A. (2002). Management "5th edition, MeGraw-Hill Irwin, New York, p4.

Yildirim, E.A and Todd, M. (2001). Sensitivity analysis in linear Programming and semi definite Programming using interior-point methods, Journal Mathematical Programming, ISSN 00255610, 90(2): 229-261.

Zilberman, D. (2002). Agriculture and Environment Policies, U.S.A. 94-100.