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Optimizing the Cropping Pattern in North Darfur State, Sudan A Study of Dar Elslam District

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Abstract: This study shed light on the constraints of increasing farm-income in the traditional rainfed sector of North Darfur State (NDS) through investigating the situation of crop production in Dar Elslam district. The study used linear programming (LP) technique in the data analysis. The results of data analysis showed that the basic models gave a cropping pattern different from the real farmers production plan. Groundnuts was the most profitable crop at the prevailing prices and productivity in season 2006/07. The basic models solution gave a profitable objective function while in reality the farmers gained a loss. Family labour and operating capital represented the main constraints of agricultural production in the study area. Application of recommended technologies, increasing output prices and lowering production costs gave high support to the farm income in the study area. In order to achieve agricultural development and farmers' food security in the study area, the study recommended supply of farmers with agricultural inputs especially seeds through repayment (in kind) after harvesting and support agricultural extension to be more efficient and effective in adoption of recommended improved technologies. Resolution of Darfur security problems in addition to solution and removal of all other problems facing agricultural production such as pests, marketing, desertification, drinking water, grazing …etc. are also essential.

Key words: Optimimization ,crop production, rain-fed agriculture.

INTRODUCTION

Dar Elslam district is located in North Darfur State (NDS). More specifically the study area lies, approximately between longitudes 29˚ 25´ and 30˚ 25´ east and latitudes 13˚ 2´ and 13˚ 3´ north. Dar Elslam district area is about 11 thousand squire kilometers[1]. The study area is one of the important agricultural regions in North Darfur State. It contributes to food production beside cash crops. The agricultural production in Dar Elslam district suffers from many problems (economical, technological, environmental and social) that hinder its development and success resulting in low yield and low income. These problems are (a) shortage of agricultural credit, agricultural inputs, low farm-income and limited chances of off-farm income[2], (b) limited use of technology as a result of lack of technology and absence of know-how[3], (c) variability of rain in amount and distribution within the same year and from year to year (the coefficient of variation (C.V) of rainfall for the years 1977-2006 in Alfashir recorded 34.12[4] and (d) Darfur conflict and its consequences of armed robbery and tribal conflicts that negatively affected agricultural production[2].

The objectives of the paper were to identify the constraints of increasing farm-income in Dar Elslam district, determine the optimum cropping pattern and assess the impact of some polices on farm income and resources use.

Background:

1. Rainfall: The geographical location of Dar Elslam, as a transitional zone between desert and semi desert in the north and savanna in the south has a direct impact on distribution and variability of annual rainfall[5]. The rainfall in Dar Elslam, is less than 400 mm (Table 1) and has a dry period ranging from 9 to 11 months. Rainfall in the agricultural season 2006/07

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Table 1: Rainfall (mm) in the years 2001 - 2003: Dar Elslam district.

Station / Year	2001	2002	2003	Average
Wadaa	146	146.3	264	185.4
Shengiltobai	-	116	121	118.5
Dar Elslam	-	81	243	162.3

Source: Hydromaster, 2005.[5]

in Dar Elslam, started almost at the beginning of July (10th July) with dry spell (sbna) about 12 days during July and August while stopped at the end of September (20th September).

2. Crops Grown: According to the survey conducted in Dar Elslam district, the main crops grown in the agricultural season2006/07 were millet, sorghum, groundnuts and okra. The cropping pattern of the above mentioned season was different from that in the previous seasons this, difference occurred due to insecurity conditions in the district and a drop in family labour participation (pupils) in the season 2006/07 due to change in the calendar of basic schools by the State Ministry of Education to start in autumn (14 June) instead of Summer. The farm size (feddans/farmer) was about 17.08 (13.86 feddan in sandy soils and 3.22 feddan in clay soils). Also, the farmer in Dar Elslam, possesses 4 parcels. Millet and groundnuts were grown in sandy soils while sorghum and okra were grown in clay soils. Most of the cropped area (67%) was allocated to millet to satisfy family consumption requirements of millet and the surplus goes to the market for selling. Sorghum comes in second order as food crop after millet; its allocated area was about 15% of the total cropped area. Groundnuts and okra were cultivated as cash crops occupying an area of about 14% and 4% from the total cultivated area, respectively. The area of watermelon grown in Winter (sival) in 2006/07season in Dar Elslam, was about 2.34 (feddan/farmer) and gum Arabic was about 3.92 (feddans/farmer). On the other hand, the total utilized land in Dar Elslam, by different agricultural systems was around 650 thousands feddan in addition to mall areas of home farming locally known as jubraca[5]. The productivity of the main crops (sacks/ feddan) in season2006/07 was 0.93, 1.42, 3.59, and 1.46 for millet, sorghum, groundnuts and okra, respectively.

On the other hand, the variations of cultivated area during the agricultural seasons 2000/01-2004/05 were due to late rainfall, variability of crops prices and security problems. The variability of the crops productivity returned to pests and diseases, shortage and variability of rainfall from year to year and within the same year and security problems.

Methodology: Cross sectional data on socioeconomic characteristics of farmers and inputs and outputs of crops grown in the study area (season 2006/07) were collected through personal interview survey of a random sample of 41farmers. The optimum cropping pattern, the constraints of increasing farm-income and the impacts of some policies on farm income and resources use were studied through linear programming model. Linear programming was applied in the agricultural sector of Sudan by some researchers among them [3,6,7,8,9].

The algebraic expression of the linear programming model is given below[10].

$$\text{Max } \pi = C_1 X_1 + C_2 X_2 + \ldots\ldots\ldots + C_n X_n$$

objective function

Subject to $a_{11}x_1 + a_{12}x_2 + \ldots\ldots\ldots + a_{1n}x_n \le b_1$

constraints

$$a_{21}x_1 + a_{22}x_2 + \ldots\ldots\ldots + a_{2n}x_n \le b_2$$

$$\vdots \qquad \vdots \qquad \vdots \qquad \vdots$$

$$a_{m1}x_1 + a_{m2}x_2 + \ldots\ldots\ldots + a_{mn}x_n \le b_m$$

And $x_1, x_2, \ldots\ldots\ldots\ldots\ldots, x_n \ge 0$ non negativity constraints و Where:

π = the objective function value.

c_j = the coefficients of decision variables (j = 1, 2, ….., n) .

x_j = decision variables (j = 1, 2, ….., n) .

a_{ij} = technological coefficients (i=1, 2 , …, m and j = 1, 2, .., n).

b_j = available units of productive capacity in the production line i for production of n products (i=1, 2 , …, m and j = 1, 2, , n).

Empirical Specification Of Linear Programming Model:

a. The Objective Function: The objective of farming practice in the study area is profit maximization after household food security of millet and sorghum. Below, are the variables that constitute the objective function values in the district as revealed from the survey.

Table 2: Cultivated area (feddan/ household) and crops productivity (sacks/feddan) in the agricultural seasons 2000/01- 2004/05.

Agricultural Season	Millet		Groundnuts		Sorghum		Melon seed		Sesame		Karkdai	
	CA	CP	CA	CP	CA	CP	CA	CP	CA	CP	CA	CP
2000/01	14.8	0.36	0.34	2.27	1.9	0.66	1.75	1.16	1.01	0.94	-	-
2001/02	12.02	0.43	0.87	1.71	0.6	3.56	0.96	0	0.93	0.38	-	-
2002/03	14.53	0.39	0.65	1.1	0.93	1.23	0.01	3.81	0.49	0.36	0.05	0.33
2003/04	13.29	0.35	0.47	4.15	0.16	9.14	-	-	0.44	1.56	0.05	1.33
2004/05	16.9	0.21	0.28	4.29	0.08	0	-	-	0.12	1.67	-	-
Average	14.31	0.35	0.52	2.7	0.73	2.92	0.91	1.66	0.6	1.02	0.05	0.83

Source: State Ministry of Agriculture ,Animal Wealth and Irrigation, North Darfur State,2001/02-2004/05.[11]
CA: Cultivated area. CP: Crop productivity.
One sack of millet =106 kg One sack of sorghum =100 kg One sack of groundnuts = 47 kg
One sack of melon seed =76 kg One sack of sesame =80 kg One sack of karkdai =27 kg

Table 3: Costs (SDG/ feddan) breakdown of main crops in agricultural season 2006/ 07 in Dar Elslam

Operation	Millet	sorghum	G/ nuts	Okra	Total
Land clearance	4.87	8.12	4.58	5.73	23.3
Planting	10.9	5.88	19.69	7.53	44
Weeding	3.17	3.72	4.34	3.26	14.49
Harvesting	8.3	8.11	13.85	10.61	40.87
Total	27.24	25.83	42.46	27.13	122.66

Source: field survey, 2007.
State Ministry of Agriculture, Animal Wealth and Irrigation, North Darfur State. Annual Reports {2001/02-2004/05}

1. Production Cost: The total production cost (SDG/ feddan) represents the total production cost that is expended in specific crop (Table 3) excluding the hired labour cost which was dealt with separately.

2. Labour Hiring Activity: The average wage rates during the agricultural season 2006/07 was SDG 9.25 in Dar Elslam. The wage rates were constant throughout the agricultural season.

3. Capital Transfer Activity: Capital transfer from one period to another did not affect the objective function values since it doesn't involve money transactions.

4. Crops Sales Activity: The average prices per sack of the crops during the harvest in Dar Elslam, were SDG 50, 31.1, 23.13 and 47.53 for millet, sorghum, groundnuts and Okra, respectively.

5. Millet And Sorghum Consumption: Millet and sorghum produced for consumption take zero value in the objective function while the values of these crops purchased from the market affected negatively the objective function by the price per sack. The prices of consumed millet and sorghum in Dar Elslam were SDG 54 and 35.58, respectively, (SDG/ Sack) in Dar Elslam.

b.Constraints:

1. Land: The average holding size in Dar Elslam region was 26.81 in sandy soils and 8.75 in clay soils.

2. Family Labour (FL): Family labour represented by the available mandays per family that can be employed in crop production during the agricultural season 2006/07. The available mandays per family in the district were 156, 169.89, 134.25 and 107.04 for land clearance, planting, weeding and harvesting, respectively. Table (4) shows the main crops labour requirements (mandays/feddan) in Dar Elslam district in the agricultural season 2006/07.

3. Capital: The available cash (SDG) during the agricultural season 2006/07 was 407.32, 0, 474.39 and 0 in periods of land clearance, planting, weeding and harvesting, respectively. The farmers of the study area obtained the operating capital by themselves and relatives assistance. The formal or informal credits were not recorded.

4. Consumption Activity: The average annual household consumption (sack) of millet and sorghum in Dar Elsam in the season 2006/07 was about 7.98 and 2.64, respectively.

5. Crop Balance Activity: This constraint means that what is produced is equal to what is consumed and /or sold.

C. Activities:

1. Production: These activities in Dar Elslam, represent the production of millet, sorghum, groundnuts, and okra.

Table 4: The main crops labour requirements (mandays / feddan) in Dar Elslam, in the agricultural season 2006/ 07.

Period	Millet	Sorghum	G/nuts	Okra	Total
Land clearance	2.31	6.47	3.5	9.36	21.64
Planting	2.2	2.42	4.08	4.85	13.55
Weeding	7.03	9.07	6.94	11.63	34.67
Harvesting	2.86	7.30	9.1	43.17	62.43
Total	14.4	25.27	23.62	69.01	132.3

Source: Field survey, 2007.

2. Selling: Selling activities represent the selling of the crops that are produced.

3. Labour Hiring: It represents labour hiring to add to the available family labour to be utilized in production activities.

4. Consumption And Buying: Millet and sorghum in Dar Elslam, are produced to meet farmers households consumption requirements. When the farmers' own production of these crops is not sufficient to meet their consumption requirements, it will be supplemented by purchasing from the market (through buying activities).

5. Transferring: These activities ensure that the surplus operating capital can move from one period to another.

RESULTS AND DISCUSSION

1. The Basic Linear Programming Model Solution:

1.1 Cropping Pattern: The basic model solution, gave a cropping pattern different from actual farmers practices in reality (Table 6). The model allocated most of the area to millet 8.58 feddan compared to real practice {11.41feddan} followed by sorghum 5.82 feddan which was more than the actual practice {2.59feddan}. The model gave okra the smallest area among all crops {.94feddan} while groundnuts did not enter the plan.

1.2. Optimum Return: The model objective function values are different from the real practices of farmers in the district. Table (6) depicts the cropping pattern and objective function value. The basic model objective function gained profit which was about SDG62.77after satisfying house hold requirements of millet and sorghum while the actual practice rcorded a loss SDG-150.08. The variation between the objective function of the basic model (profitable) and real situation (loss) can be attributed to:

* Farmers in reality allocated most of the area to millet, 11.41feddan, compared with the result of the basic run which allocated only 8.58 feddan of millet (25 % decrease).
* Farmers in reality allocated only 2.59feddan of sorghum while the basic model allocated 5.82 feddan of sorghum (125% increase).
* Farmers allocated only 0.68feddan to okra while the basic run allocated 0.94 feddan of okra (38% increase).
* Farmers in reality entered groundnuts into their plan for diversification and risk avoidance, 2.4 feddan, while groundnut did not enter in the optimal plan.

1.3. Resources Use: The total land exploited by the model was about 8.58 feddan (32%) of sandy soils and about 6.76 feddan (77%) of clay soils while in reality the farmers planted 13.81 feddan (51%) of sandy soils and 3.27 feddan (37%) clay soils.

The labour employed in the basic model solution was (mandays) 66.24, 37.5, 124 and 107.4 during land preparation, planting, weeding and harvesting, respectively. The employed labour revealed two peaks of labour in the third and fourth periods. These results were consistent with reality because they represented the peaks of weeding and harvesting. The labour employed in the basic run solutions was the family labour and hired labour was not employed.

1.4. Marginal Value Productivities (MVPs): The MVPs of land were zeros for millet in sandy soils, sorghum and okra in clay soils. They add nothing to the profit function if they are increased while groundnuts in sandy soils recorded SDG 10.79, this indicates that profit can be increased by SDG 10.79 in case of additional one feddan of groundnuts at the prevailing prices and yield.

All periods registered zero MVPs of family labour in the basic run solution except the fourth period (harvesting), which represented one of the labour peaks. It registered SDG 0.02 MVP indicating that labour was a constraint in hatvesting period. These results are consistent with theories confirming that labour in the developing countries is abundant and some times with negative marginal values but still there are times when labour may become a constraining factor of production during the time of

Table 6: Cropping pattern and objective function: basic model solution and reality

Item	Unit	Model	Real
Millet	Feddan	8.58	11.41
Sorghum	Feddan	5.82	2.59
Groundnuts	Feddan	0	2.4
Melon seed	Feddan	-	-
Okra	Feddan	0.94	0.68
Objective function	SDG	+62.77	-150.08

Table 7: Cropping pattern & objective function: plough technology scenario

Item	Unit	Scenario	Basic
Millet	Feddan	8.58	8.58
Sorghum	Feddan	5.43	5.82
Groundnuts	Feddan	0	0
Okra	Feddan	0	0.94
Objective function	SDG	+105.8	+62.77

Table 8: Cropping pattern & objective function: pupils' (mandays) participations scenario

Item	Unit	Scenario	Basic
Millet	Feddan	8.58	8.58
Sorghum	Feddan	4.36	5.82
Groundnuts	Feddan	0	0
Okra	Feddan	2.31	0.94
Objective function	SDG	+63.89	+62.77

Table 9: Cropping pattern and objective function: cropped area restricted scenario

Item	Unit	Scenario	Basic
Millet	feddan	11.41	8.58
Sorghum	feddan	2.59	5.82
Groundnuts	feddan	0.55	0
Okra	feddan	0.68	0.94
Objective function	SDG	+42.73	+62.77

Table 10: Cropping pattern and objective function: pupils' mandays return and area restricted scenarios

Item	Unit	Scenario	Basic
Millet	feddan	11.41	8.58
Sorghum	feddan	2.59	5.82
Groundnuts	feddan	0.55	0
Okra	feddan	0.68	0.94
Objective function	SDG	+42.73	+62.77

weeding and harvesting and such operations demand large amount of labour during limited times[12].

The operating capital registered SDG 0.43 MVP during the fourth period pointing out that the operating capital is one of the constraints of agricultural production in Dar Elslam . The results indicated the importance of agricultural credit in the developing countries where farmers are poor.

2. Policies Scenarios: The study carried out some scenarios through changing the parameters of basic linear programming models. These scenarios can be used by the farmers, planners and policy makers to develop the traditional rainfed agriculture in Dar Elslam district. These scenarios were:

2.1. Usage of ploughs technologies.
2.2. Pupils participation.
2.3. Restriction of the cropped areas.
2.4. Pupils participation and restriction of the cropped areas.
2.5. Prices after harvest time.
2.6. Reducing the production cost by 25% and 50%.
2.7. Increasing the operating capital by 25% and 50%.
2.8. Adoption of improved technologies.
2.9. High productivity achieved by some farmers.

2.1. Usage of Ploughing Technologies: There were pervious experiments testing the advantages of ploughs used in clay soils in Dar Elslam district and the experiments gave the following results:

a. Increase of sorghum productivity by about 32% per unit area.
b. Save the weeding time by about 78% per unit area.

Also, usage of ploughs in Azagrfa district, led to an increase in okra productivity by about 20 % per unit area. The study proposed the same okra productivity in Dar Elslam district, since Dar Elslam , is not far a way from Azagrfa, and the expected productivity will be the same. According to the above experiments, the study applied the same figures in Dar Elslam district and gave the following results.

The model solution gave the same area for millet but with a decrease in sorghum area by about 0.39 feddan and omitted groundnut and okra from the plan. The usage of technology led to improvement and increase in the objective function from SDG 62.77 to 105.8 (increase 69%)

2.2. Pupils' Participation (mandays): In school year 2006/ 07, the calendar of basic school was changed and the new calendar starts on 14th June and ends on 15th February. Therefore most of the school period falls within the farming period which restricted pupils' participation in the agricultural work. The scenario of old calendar was tested giving the results below.

The allocated area to millet in the basic model plan did not change but sorghum area decreased by about 1.46 feddan and no area allocated to groundnuts while okra area increased by about 1.37 feddan.

The objective function value increased due to pupils' participation from SDG 62.77 to 63.89 (2%).

2.3. Restricted Area: The basic model was free but in reality the farmers tend to avoid the natural and market risks by diversification and restriction of maximum area to each crop. In this scenario, crops area restricted as farmers practiced in season2006/07. The crops areas were restricted by 11.41, 2.59, 2.4, and 0.68 (feddan) for millet, sorghum, groundnut, and okra, respectively. Accordingly, restricted model was tested and the results were obtained.

Millet area increased by about 2.83 feddan while sorghum area decreased by about 3.23 feddan and groundnuts entered the plan and taking 0.55 feddan while okra area decreased by about 0.26 feddan (Table 9).

The value of the objective function due to restricted areas decreased from SDG 62.77 to 42 (31%) from the basic run.

2.4. Pupils' Participation And Area Restricted: This scenario represented the combination of two pervious scenarios (pupils' participation plus area restricted scenarios). The scenario tested gave the below results (Table 10).

Millet area increased by about 2.83 feddan, sorghum area decreased by about 3.23 feddan, groundnuts entered the new plan by about 0.55 feddan, okra area decreased by about0.26feddan.

The value of the objective function decreased due to additional pupils' mandays and restricted area from SDG 62.77 to42.73 (31%).

2.5. Prices After Harvest Time: Farmers of the study area usually sell their products immediately after crop harvest and usually the products prices increase after crops withdrawn from farmers' hands. The prices usually increase from February and reach the highest levels during May and June. The prices in Dar Elslam , increased from SDG 50 to75 (increased by 50%), from SDG 31to 45 (45%), from SDG23.13 to 50 (116%) and SDG 47.53 to 95.05 (100%) after the harvest in agricultural season 2006/07 for millet, sorghum, groundnut and okra, respectively. This scenario tested the impact of changing prices from the at harvest. The following results were obtained:

Millet area remained the same as that of the basic model. Sorghum area decreased by about 3.96 feddan. Groundnuts entered the plan with an area of 0.27 feddan but okra did not enter the plan.

The objective function increased from SDG 62.77 to 295.15 (370%) due to increases in the prices.

2.6. Reduction Of Production Cost By 25% and 50%: The scenario of production cost reduction by 25% and 50% was tested assuming that the governmental and non governmental institutions interfered through.

Table 11: Cropping pattern & objective function: change prices (prices after harvested season 2006/07) scenario

Item	Unit	Scenario	Basic
Millet	feddan	8.58	8.58
Sorghum	feddan	1.86	5.82
Groundnuts	feddan	0.27	0
Okra	feddan	0	0.94
Objective function	SDG	+295.15	+62.77

Table 12: Cropping pattern & objective function: reduction production cost by 25% and 50% scenarios.

Item	Unit	25%	50%	Basic
Millet	Feddan	8.58	8.58	8.58
Sorghum	Feddan	7.47	6.58	5.82
Groundnuts	Feddan	0	2.06	0
Okra	Feddan	0.53	0	0.94
Objective function	SDG	+219.96	+390.45	+62.77

Table 13: Cropping pattern & objective function: capital increased by 25% and 50%

Item	Unit	25%	50%	Basic
Millet	feddan	8.58	8.58	8.58
Sorghum	feddan	6.89	4.11	5.82
Groundnuts	feddan	1.65	5.28	0
Okra	feddan	0	0	0.94
Objective function	SDG	+138.85	+194.14	+62.77

Table 14: Cropping pattern & objective function: improved technology

Item	Unit	Scenario	Basic
Millet	feddan	4.74	8.58
Sorghum	feddan	0.94	5.82
Groundnuts	feddan	0	0
Okra	feddan	0	0.94
Objective function	SDG	+361.22	+62.77

Table 15: Cropping pattern & objective function: High productivity achieved by some farmers.

Item	Unit	Scenario	Basic
Millet	Feddan	4.14	8.58
Sorghum	Feddan	0.93	5.82
Groundnuts	Feddan	0	0
Okra	Feddan	0.25	0.94
Objective function	SDG	+376.66	+62.77

a. Distribution of agricultural inputs especially seeds through payment (in kind) after harvesting
b. Introduce hand implements through rent system
c. Train the local blacksmiths and support them by cheap raw material to provide relatively cheap hand implements.

Reduction of production cost by 25% and 50% did not affect millet area (8.58 feddan). Sorghum area increased by about 1.65 and 0.76 feddan due to cost reduction by 25 %and 50%, respectively. Groundnuts entered the new plan only in case of cost reduction by 50% (about 2.06 feddan). Okra entered the plan only

in case of cost reduction by 25% (about 0.53 feddan).

The value of the objective function increased from SDG 62.77 to 219.96(250%) and 390.45 (522%) where the cost was reduced by 25% and 50%, respectively.

2.7. Operating Capital Increased By 25% And 50%: The scenario assumed the operating capital increased by 25% and 50 %through the agricultural finance. The results obtained was as follow:

Millet area did not change due to increase in the operating capital by 25% and 50%. Sorghum increased by 1.07 feddan in case of capital increased by 25% but decreased by about 1.71 feddan when capital increased by 50%. Groundnuts entered the new plan by about 1.65 and 5.28 feddan when capital increased by 25% and 50%, respectively. Okra did not enter the new plan in both cases of capital increase.

The objective function value increased from SDG 2.77 to 138.85 and 194.14 by 121% and 209% when capital increased by 25% and 50%, respectively.

2.8. Improved Technology: The modern technology contributes in rational exploitation of resources, improving efficiency and quality of production[13]. The efficiency of economy in doing its job depends on technical and economical efficiencies. A dynamic contribution of economic development from the agricultural sector and significant improvement in rural welfare depends upon the modernization of agriculture through technological change[1]. There are recommended technological packages by the Agricultural Research Corporation for rain-fed crops. Due to adoption of the above described packages, the productivity (per feddan) of millet, sorghum, groundnuts, and okra increased. The scenario of the improved technology was tested giving the results below.

Millet area decreased by about 3.84 feddan, also sorghum area decreased by about 5.33 feddan but groundnuts and okra were omitted from the plan.

The adoption of technological packages increased the objective function from SDG 62.77 to 361.22(475%).

2.9. High Productivity Achieved By Some Farmers: The study found that there were some farmers in the district with higher productivity (sack/ feddan) compared to other farmer.

In comparing the productivity of some farmers to others, millet productivity(sack/ feddan) ranged from 0.93 to 3.43, for sorghum from 1.42 to 2.85, groundnuts from 3.09 to 9.13 and okra from 1.46to 6.84.

The scenario of the difference in productivity was tested giving the results below.

Millet area decreased by about 4.44 feddan and also sorghum and okra areas decreased by about 4.89 and 0 .69 feddan, respectively while groundnuts was omitted from the plan.

The objective function increased from SDG 62.77 to 376.66 (500%).

Conclusion: The most important scenarios affecting the resources use and the value of the objective function in the study area were the calendar of the schools, prices after harvest, cost of production, credit and improved technologies

In order to improve the resources use and farmers' incomes, polices should address the above mentioned factors.

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