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# The optimum Cropping pattern and food Security nature in Elsemeih Agricultural Scheme,North Kordofan State,Sudan in

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**ABSTRACT:** The current study was conducted in Elsemeih Agricultural Scheme in North Kordofan State. The objectives of the study were to determine the optimum cropping pattern that maximizes farmer's income, to know the food security situation, and to identify the gross margin of crops grown in the scheme. The study depended mainly on primary data which was collected for the 2012/ 2013 season by direct interviewing of respondents through simple random sampling technique using a structured questionnairez. The data were analyzed via descriptive statistical analysis, gross margin analysis, linear programming model (L.P) and household economy approach (HEA). The results of gross margin analysis indicated a positive acceptable gross margin for all crops grown in the scheme. The results of linear programming model showed the optimum cropping pattern in the area was which to allocate 2.40, 2.14, 2.91 feddans for cotton, sorghum and tomato respectively to get maximum gross margin of 1990.57 SDG. Food security situation showed that daily energy received per person was 1522 k.Cal. which was found to be below the recommended amount by WHO. This indicates food insecurity in the area. Many scenarios were conducted for the basic solution of the linear programming model to measure the effects of change of cost of production, crops prices, and labor use on the optimum cropping pattern. According to the results of these scenarios farmer's gross margin will increase if the costs of production decreases, market prices increases and labor use increases by 20% each. The study recommends the adoption of the optimum cropping pattern that that sugest the production of cotton, sorghum and tomato, beside the improvement of education level, and extension services in the scheme.

***Keywords*:** Linear programming (L.P), food security, optimum cropping pattern.

## INTRODUCTION

North Kordofan State lies between latitudes 110 15" – 160 45" north and longitudes 270 50" – 320 15" east. The State occupies an area about 242,000 square kilometres or about 59 million feddan. The food-security situation in North Kordofan reflected chronic poverty rather than a transitory situation. It is seemed to improve gradually from the north towards the south, with northern households having much-less-favorable consumption indicators. This appeared to be due to the generally drier conditions in the north, which limited the livelihood options of the people in the area (ANLA - WFP Sudan - May 2007). According to Squire , (1979) in the household production, profit maximization can be answered by comparing the estimated increase in output accompanying an increase in factor input with the factor price. It is well-known result of the theory of the firm that, if a firm is making optimum use of productive inputs (Land, Labor and Capital) output will be carried to the point at which the costs of additional inputs are equal to the value of additional output. Droughts cause food shortages and most likely lead to famine. Cycles of food shortage and food insecurity frequently take place in the area (Maxwel,1992) . FAO (2012) stated that Africa is still most seriously affected by food shortages, this situation is more critical in East Africa and famine conditions are emerging in several parts of the Horn of Africa. As a result of recurrent droughts and food shortages, many initiatives have emerged over the years ranging from addressing the problem to mitigation efforts. Food security seems to improve gradually

from the northern towards the southern part of the study area, with northern households having much-less-favorable food consumption indicators. This appeared to be due to the generally drier conditions in the north, which limited the livelihood options of the people in the area . Hazell (1986) reported that linear programming model is a method of determining a profit maximization combination of farm enterprises that is feasible with respect to a set of farm constraints. Gross margin is a method of organizing experimental data and information about the cost and benefit of the various alternative treatments. Elsemeih agricultural scheme lies between latitudes 12o 40-13o N; longitudes 30º 40–31º75E, (figures 3.1).The area is generally flat characterized by some localized variations such as watercourses, gullies, small hills and drainage lines around the Khor, Faisal (2007).

***2. Problem statement***

The study area, like most of drought stricken areas in Kordofan region, is jeopardized by environmental, socio-economical and political problems. These exhibit themselves in terms of resource degradation, shortage of potable water, lack of services and fluctuation in agricultural output. They collectively deteriorate standard of living and increase poverty incidence among the population. In spite of the huge natural resources bestowed upon the flood irrigated agricultural sector, the area has experienced frequent situations of food insecurity. The majority of the population is rural farmers, where the main forms of livelihood include flood irrigated crop farming, village-based livestock raising and employment-generated income from labor migration to national agricultural schemes. Production of food crops in the region is continuously fluctuating rendering food security of people at jeopardy.

***3. Objectives***

The objectives of this paper were to determine optimum crop combinations, assess food security situation and net income in the study area.

## MATERIALS AND METHODS

The study depended on Primary and secondary data; primary data was collected by questionnaire using random sample that selected from the farmers in the scheme, secondary data were collected from reference books and scientific papers and previous research.

***4.1linear programming models***

Doll and Orazem, (1984) reported that linear programming model is mathematical technique for finding the best uses of a firm's limited resource. The adjective "linear" is used to describe a relationship, which is directly and precisely proportional. "Programming" refers to the use of certain mathematical technique so as to get the best solution to the problem involving limited resource.

Hazell (1986) reported that linear programming model is a method of determining a profit maximization combination of farm enterprises that is feasible with respect to set of farm constraints. Linear programming model has been developed to determine the area to be used for different crops for maximum contribution and for improving farmer's income.

**4.1.1 Expression of linear programming model**

**Maximize Z** $= \sum_{c_j} x_j + \sum c_j^* x_j^*$ objective function

Subject to:

$\sum a_{ij} x_j \leq b_i$ constrained equation

$X_i$ and $x_j^* \geq 0$ non-negativity constraint activities

Where:

Z = Gross margin

$C_j$ = price of production activities

$C^*_j$ = price of non production activity

$X^*_j$ = level of jth non production activity

$a_{ij}$ = the ith resource required for unit of jth activity

$b_i$ = the resource available in sample farmers

j = refers to number of activities from 1 to n

i = refers to number of resource from 1 to n

***4.1.2Model specifications***

Three crops were grown in the scheme, $X_1$= cotton, $X^2$= sorghum, $X_3$= tomato.

***4.1.2.1The model constrains***

***Land***

The land variable was the total land resources actually cultivated by farmers it was measured in feddan. In the study total land cultivated in the scheme is 965.

***Capital***

The capital expenses variable was the cash expenditure reported by the farmers for all agricultural operation. In the study the total cost of the all agricultural operation for the crops per feddan were SDG 368, SDG 428, and SDG 525 for the cotton, sorghum, and tomato, respectively.

***Labor***

The labor variable represents the total labor employed by each farm during a season; in the study the number of labor of one feddan for crops were 4, 4, and 5 for cotton, sorghum, and tomato respectively.

***Production***

Production of all crops growing in the scheme was 82395Kg, 41220Kg, and 42522 Kg for cotton, sorghum, and tomato respectively.

**Obj: Function** = 248.014X1 + 221.80X2 + 316.6X3

**Res: constrain:**

| | | |
|---|---|---|
| Land (feddan) | X1 + X2 + X3 | < 965 |
| Capital (SDG) | 368X1 + 428X2 + 525X3 | < 97119 |
| Labor (MH) | 4X1 + 4X2 + 5X3 | < 3270 |
| | 0X1+ X + 0X3 | = 214 |
| | X1 + 0X2 +0X3 | < 82395 |
| | 0X1+X2 + 0X3 | < 41220 |
| | 0X1 +0X2 +X3 | < 42522 |

Where:
Obj = Objection Function
Res = Resources
MH = Man hours
SDG = Sudanese pounds

***4.1.3 Sensitivity analysis***

Scenarios analysis tries to answer: "what happens if one or more elements in the model change". In the model scenarios analysis was applied to obtain new results by changing some parameter values of the model. The scenarios are considered here as tools used to achieve the main objective of the study by exploring the optimal plan that might lead to efficiency resources use, generally, some changes have been applied on the study constraints (land, labor and capital) and comparison is made between the basic solution and the scenarios.

***4.2 Gross margin analysis***

Gross margin values (GMVs) per unit of crop and head of livestock are widely used for comparative analysis of activities between farms in similar environments. It is also a useful to first step in deciding on the best combination of activities on the farm. Gross margin analysis is a method of organization experimental data and information about the cost and benefit of the various alternative treatments (Cimmyt, 1988).

## RESULTS AND DISCUSSION

### *5.1 The optimal solution*

The optimal solution in the area came with cultivation of 2.39 feddans (feddan= 0.42 ha) of cotton , 2.14 feddans of sorghum and 2.91 feddan of tomato to get a total gross margin equals to SDG 1990.572 (799 USD), Table (1)

Table 1. Optimal solution of crop cultivation in Elsemeih agricultural scheme

| Crop | SDG |
|---|---|
| cotton | 594.6136 |
| Sorghum | 474.652 |
| tomato | 921.306 |
| total | 1990.572 |

#### *5.1.1 Sensitivity analysis*

In this section the basic linear programming model was developed by changing of parameters (cost production, crops prices, and labor use), to reflect a range of production options found in the system.

##### *5.1.1.1 Effect of the 20 percent decrease of costs of crops production*

This scenario was developed to examine the effect of lowering the present operating cost of all crops by 20 percent. Accordingly farmers' income increased from SDG 1990.572 to SDG 1196.78 and no change the crops pattern.

##### *5.1.1.2 Effect of 20 percent increase of crops prices*

This scenario was developed to examine the effect of increasing the prices of crops by 20 percent. This scenario resulted was increasing farmers' income from SDG 1990.572 to SDG 2388.58, with no change in crops pattern.

##### *5.1.1.3 Effect of the 20 percent increase of labor use*

This scenario resulted was increasing of farmer's income from SDG 1990.572 to SDG 1245.31, and change crops production, increase the area cultivation by cotton form 2.39 to 2.90 Fadden.

### *3.2 Gross margin analysis results*

#### *3.2.1 Total variable costs of production*

The average variable costs of production of crops in the scheme were SDG 368, SDG 428, SDG 525, of cotton, sorghum, and tomato crops, respectively, as shown in Tables (2). Tomato and Sorghum production reported both high cost of cultivation and crops harvest.

#### *3.2.2 Productivity of the scheme selected crops*

The average productivity of crops in the scheme were 195.56, 137.67, 160 Kg per feddan for cotton, sorghum, and tomato respectively.

#### *3.2.3 Gross returns of the scheme selected crops*

The gross returns for the crops grown were SDG 616.014, SD 649.80, and SDG 841.6 per feddan of cotton, sorghum, and tomato crops respectively.

#### *3.2.4 Gross margin of the scheme selected crops*

On average gross margin per feddan of cotton, sorghum, and tomato crops were SDG 248.014, SDG 221.80, and SDG 316.6, respectively, as shown in table (2) Tomato crop obtained high gross margin followed by cotton. The tomato crop scored the highest gross margin due to the good tomato price, and cotton crop came second as result of high yield obtain for cotton. The results of gross margin analysis indicated positive profit per feddans for all crops grown in the scheme.

Table 2. Gross margin of the crops, season, 2011/2012 SDG/feddan

| Costs of agricultural operations | Crops Cotton | sorghum | Tomato |
|---|---|---|---|
| Land preparation: | | | |
| Cleaning | 38 | 34 | 35 |
| Plowing | 30 | 24 | 25 |
| Agricultural operations: | | | |
| Cultivating | 40 | 39 | 32 |
| Patching | 24 | 22 | 16 |
| Cultivation | 118 | 142 | 149 |
| Harvesting | 69 | 115 | 180 |
| Inputs used: | | | |
| Seeds | | 6 | 35 |
| Cost of marketing: | | | |
| Transporting | 10 | 10 | 15 |
| Loading cost | 8 | 6 | 7 |
| Other costs: | | | |
| Land rent | 31 | 31 | 31 |
| Average Total variable cost | 368 | 428 | 525 |
| Average productivity (Kg/fed) | 195.56 | 137.67 | 160 |
| Average market price | 3.15 | 4.72 | 5.26 |
| Gross returns | 616.014 | 649.80 | 841.6 |
| Gross margin | 248.014 | 221.80 | 316.6 |

Source: Field survey, 2012

### *3.3 Food security nature in the Scheme*

According to food security situation and households' annual income and expenditure, food item costs was found to be negative and the daily energy received per person was 1522 Kcal. This result gives indication to the unbalanced food intake by households in terms of energy need and in term of net income and accordingly, cluster the area is food insecure, Table 3

Table 3. Household Weekly Food Need and the equivalent K.cal in Elsemeih agricultural scheme

| | | Summer | | Autumn | | Winter | |
|---|---|---|---|---|---|---|---|
| Food item | Kcal/kg | qt.kg | Total Kcal | qt.kg | total kcal | Qt.kg | total Kcal |
| Sorghum | 3350 | 12.00 | 402*00* | 12.00 | 40200 | 12.00 | 4*0*200 |
| Millet | 3350 | 1.57 | 5259.5 | 1.43 | 4790.5 | 1.67 | 5594.5 |
| Wheat | 3320 | 0 | 0 | 0 | 0 | 0 | 0 |
| Meat | 2020 | 3.19 | *6*443.8 | 3.19 | *6*443.8 | 3.19 | *6*443.8 |
| Milk | 660 | 0 | 0 | 0 | 0 | 0 | 0 |
| Sugar | 4000 | 2.57 | 10280 | 2.50 | 10000 | 2.53 | *1*0120 |
| Tea | | 0.13 | | 0.12 | | 0.12 | |
| Coffee | | 0.058 | | 0.058 | | 0.058 | |
| Dry okra | 350 | 0.93 | *325.5* | 0.93 | *325.5* | 1.00 | 350 |
| Onion | 410 | 1.46 | 598.6 | 1.46 | 598.6 | 0.82 | 336.2 |
| Sauce | 210 | 0 | 0 | 0 | 0 | 0 | 0 |
| Salt | - | 0.44 | - | 0.42 | - | 0.42 | - |
| Oil | 8840 | 1.21 | 10696.4 | 1.22 | 10784.8 | 1.44 | 12729.6 |
| Total | | | 73803.8 | | 74143.2 | | 75774.1 |
| Per person/day(8) | | | | | | | 1522 |

Source: Field survey, 2012

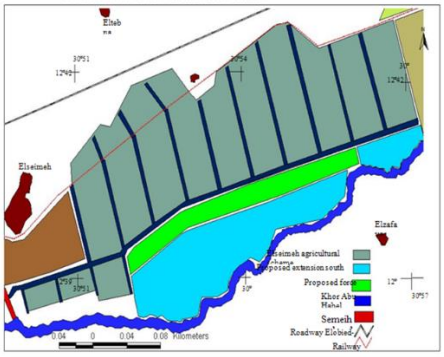


Figure 1. Elsemeih agricultural scheme

## CONCLUSION

In this study, several crops were tested for optimality. In this area optimality showed three crops to be grown, 2.39 feddans of cotton , 2.14 feddans of sorghum and 2.91 feddan of tomato to get a total gross margin equals to SDG 1990.572 (799 USD).Gross margin per feddan for cotton, sorghum, and tomato crops were SDG 248.014, SDG 221.80, and SDG 316.6, respectively,these results were validated with linear programming results. According to the annual income and xpenditures, the net household income found to be negative. Also, the daily energy received per person per day was less than the amout recommended by WHO and Stephen (2006). This result explicitly conferred evidence to the ubalanced food intake by households in terms of energy need and in terms of net income for the scheme area.

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