Optimum Resource Use, Competitiveness and Food Security Nature of Crops Grown in Dry Land Areas in North Kordofan State

***Ashraf A.A.Hassan*[1], *Maruod E. Maruod*[2], Mohammed S. Elteama [1]**
[1]*University of Kordofan, Faculty of Natural Resources and Environmental Studies, Department of Agricultural Economics and Rural Development Elobied, Sudan,*
[2]*Colledge of Developmental and Technological sciences, Elobied, Sudan.*

Abstract This study was conducted in North Kordofan State covering cropping season (2010/11). The main objective of this study was to address the food security situation of small household farmers and to find out the optimum cropping pattern that maximize the gross margin, to test how the available resource were used, and to identify the comparative advantage of each crop. The study was based on primary and secondary data. The primary data were collected from field via structured questionnaire. A multistage random sampling technique was used to select 237 household. The secondary data was collected from other different sources of concerns. To reach the objectives of the study and find out the final result; descriptive statistics, cost of basic needs (CBN) method, linear programming, partial crop budget, dominancy analysis and policy analysis matrix (PAM) methods were used. The result of the study showed that, the percentage of the food insecure among residents' household of the study area was 43% and they spent about 16% from their crop selling income on food items. The daily food intake per person per day was 1,862.2K.cal. Accordingly, this state is marginally food insecure. The optimum crop pattern that maximizes the small householder Gross margin and improves his food security situation was to cultivate 5 feddans of sesame, 1 feddan of groundnut, 0.370 feddan of sorghum and 0.30 feddan of millet to get maximum profit of SDG 5,674.83. The result of partial budget showed that gross margin of crops are SDG 1046, 249.4, 242.6, and 318.9 for sesame, groundnut, sorghum and millet respectively. The dominancy analysis showed same result with linear programming. The PAM result revealed that the two cash crops (sesame and groundnut) had extremely high comparative advantage and international competitiveness. Finally the study concluded with some recommendations which may help and support the process of improving food security in the study area by using the recommended energy intake to improve nutritional status of the households by following the optimum crop combinations.

, [1]Key words: Food Security, Crop Combination, Resource Allocation, North Kordofan

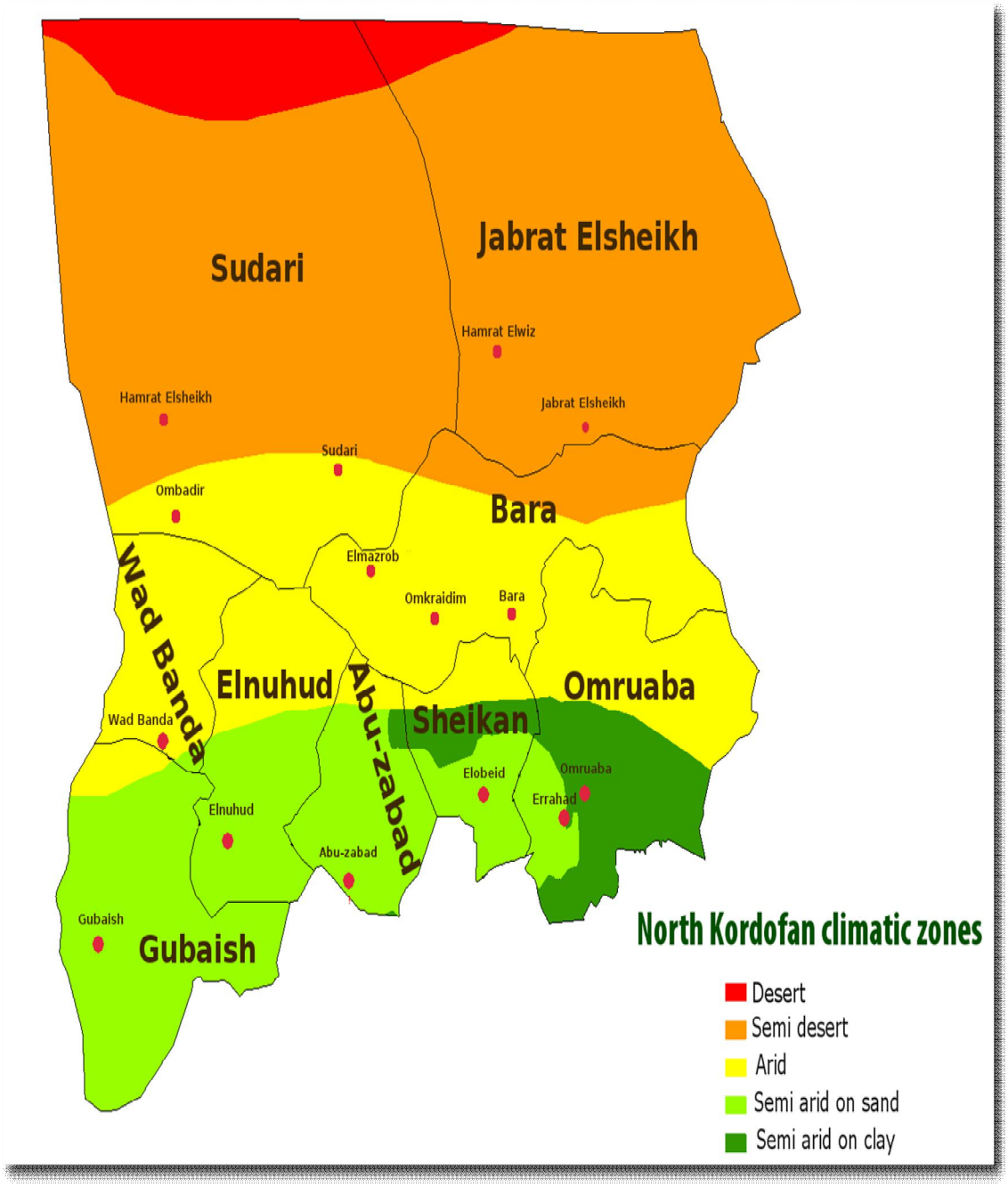

Fig1: North Kordofan State

INTRODUCTION

North Kordofan State lies between latitudes 27-32 N and longitudes 12-10 and 16-35 E. It occupies about 190, 480 km; the population is estimated in 2008 to be 1,554,000 persons. Livestock populations according to 2013 statistics are about 21,302,230 heads including camels, cattle, sheep and goats (*Makeen et al* 2013). The state is considered to be one of the world leading regions for producing and exporting Gum Arabic and agricultural products as well as animal resources.

The climate of the state generally lies between the arid and semi arid dry regions of the world. The average temperature ranges between 6 C in winter and more than 45C during summer periods. The degree of temperature decrease towards of the north Kordofan state and by nights while in increase towards the South between latitudes 10 and 20 N. The winds direction differs according to the climate periods. It is north and north east during winter (Nov. - Feb.) and south west during the summer periods (March- April) during autumn the humidity of the temperature wind direction and rainfall have very important role of plant growing. The rainfalls are less than 50 mm/year in the north and more than 400 mm in the south of the state. The types of soil in the area are sandy soil at the western parts, claypediplains soils and some clay soils plus valleys in some depressions (in northern and southern parts). (*Abbo, 2002*). *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. The food-security situation in North Kordofan reflected chronic poverty rather than a transitory situation. It 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* , 2007).In a study on food security,Olayemi (1998) gave the thresholds for food security as the ability of a household to meet 2260 k.cal .Olayide (1982) gave daily consumption of 2470 kcal of energy. In the views of Joseph and Ajayi (2002),the recommended minimum nutrient requirements to be consumed per day per capita is 2191.Stephen (2006), reported that the optimum energy need per person per day is 2100 kcal. Hazel (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. Partial budgeting is a method of organizing experimental data and information about the cost and benefits of the various alternative treatments (Cimmyt, 1988). Cafiero, (2003) stated that, PAM is best organized in terms of commodity systems, which are defined as the vertically integrated chains of production activities that go from the farm production to the retail market for consumption, including any processing and marketing activity that may exist in between.

MAREIALS AND METHODS

The study depended on Primary and secondary data; primary data was collected by questionnaire using random sampling techniques; secondary data was collected from reference books and scientific papers and previous research.

2.1 Gross margin analysis:

Gross margin analysis was used for cost and benefits analysis of the various crops grown in the area of study, and it is a method of organizing data and information about the costs and benefits of various alternative activities to calculate gross field benefit. It is necessary to know the field prices of crops and the total cost of production for each crop. The calculations are based on the following formulas:

Gross product = productivity/Feddan x selling price.

Gross margin = Gross product — total variable cost

Hence the income from cash crops is quantified as the main source of household income. Other sources such as livestock and the off-farm incomes are also determined.

Returns of Livestock production is calculated as follows:

$$\text{Income} \quad \frac{N \times Q \times S \times P}{100}$$

Where: N = the total number of households in each rural council of the locality.

Q = the percentage of households owned animals in each rural council.

P = the number of animals sold annually.

S = the selling prices. (Musab, 2009).

2.2 linear 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.

2.2.1 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 = maximization function subject to the following constraints
Land/feddan.
Labor (man-days)
Capital (S.D)
The activities:
Sorghum =X_1
Millet =X_2
Sesame production = X_3
Groundnut production = X_4
(i)Land (feddan)
a I jxj $\leq$ Cl ……. (3.1)
a I j is the available land
Where cL is the size of household cultivated land.
(ii) Labor (man-days)
rndij $\leq$ D …… (3.2)
Where:
D is the available man-days for the production activities.
mdij is the required man-days fir the production activities.
(iii) Capital (S.D)
k I j x j $\leq$ Wk …….. (3.3)
Where:
Wk is the amount of available working capital
Kij is the amount of required working capital.
(iv) Productivity Kg/fed.
a ij P D $\geq$ p …….. (3.4)
Where:
P is the available productivity for production activities.
aijPD is the required productivity for production activities.
Maximize Z = 2 cjxj + cj^* xj^* (i.e. objective function) *(3.5)* Subject to constraints
aijxj $\leq$ bi constrain equation
Xj an dxj $\geq$ o
Where:
Z = gross margin.
Cj = price of production.
Cj^* = price off-farm production.
Xj^* = level at productivity activity".
Xj^* level of off-farm.
aij = resources required.
bi = resource available.
J = number of activities.

i = number of resources.

2.3 Policy Analysis Matrix (PAM):

In the pioneer work Monke and Person (1989) have construction the police analysis matrix (PAM) shown in table 1, to help researchers and policy markets in designing macroeconomic strategies of production geared towards maximizing the economic efficiency of the country's resource endowments and policy of trade with others, internationally.

The central purpose of PAM analysis is to measure the impact of government policy on the private profitability of agricultural system and on efficiency of resources used by each. Private profitability and competitiveness are likely the uppermost in the time minds of those concerned specifically with agricultural productivity and income, e.g. ministry of Agriculture. On the other hand, economic planners whose concern is the allocation of resources among sectors and growth of the aggregate income in the economy, often emphasize social profitability and efficiency. Both sets of issues ultimately focus on the incentive effects of policy and how they might be altered. Accordingly, the PAM approach is well suited to empirical analysis agricultural price policy and farm incomes, public investment policy and efficiency, and agricultural research policy and technological change (Person & Monke, 1987).

Table (1) Expanded Policy Analysis Matrix (PAM)

	Revenue	Tradable inputs	Domestics factors	profits
Private prices	A	B	C	D
Social prices	E	F	G	H
Effect of divergences From policy	I	J	K	L
Effect of market failures	M	N	O	P
Effect of distorting policy	Q	R	S	T
Effect of efficient policy	U	V	W	X

Source: Monke and Person, (1989)

The matrix is thus can be characterized by the following identities:

D = is private (market) profit, equal to A – (B+C)

H = is social (economic) profit, equal to E – (F+G)

I = is output transfers, equal to (A- B)

J = is tradable input transfers, equal to (B- F)

K = is factor (land, labor, and capital) transfers, equal to (C – G)

L = is net transfers, equal to (D – H); also equal to I – (J - K) or (P/T+X)

RESULTS AND DISCUSSION

3.1 Gross margin analysis:

3.1.1 Total costs of production:

The average total variable costs of production of crops in the study area were SDG 779, 240, 1103, and 664 of Sorghum, millet, groundnut, and sesame crops, respectively, as shown in (Table 2).

3.1.2 Yield of the crops:

The average yields of crops in the study area were 378, 207, 483, and 450 kg, per feddan for Sorghum, millet, groundnut, and sesame respectively (Table 2).

3.1.3 Gross Margin:

The gross margin for the crops grown in the study area were SDG 1020.6, SDG 558.9, SDG 1352.4 and SDG 1710 per feddan of Sorghum, millet, groundnut and sesame crops respectively (Table 2).

3.1.4 Gross margin:

On average net benefit per feddan of Sorghum, millet, groundnut, and sesame crops were SDG 242.6, SDG 318.9, SDG 249.4 and SDG 1046, respectively, as shown in table (Table 2). The results of the analysis have indicated positive and acceptable returns in all crops.

Table (2): Gross margin for crops by Kg. and SDG/Feddan in North Kordofan State

Cultural practices	Crops			
	Sorghum	Millet	Groundnut	Sesame
Bush clean	180	35	90	135
Sowing	65	25	160	65
Ist.weed	75	35	145	60
2nd weed	70	30	145	55
Seeds	29	10	15	33
Harvesting	180	40	190	171
Threshing	60	25	165	20
Packing	30	10	43	25
Loading	40	10	70	50
Transportation	50	20	80	50
Total variable cost	779	240	1103	664
Yield (Kg/fed)	378	207	483	450
Farm gate price (SDG/fed)	2.7	2.7	2.8	3.8
Cross output (SDG/fed)	1020.6	558.9	1352.4	1710
Gross margin (SDG/fed)	**242.6**	**318.9**	**249.4**	**1046**

3.2 Linear programming analysis:

Table (3): linear programming tableau in North Kordofan State

Raw name	X_1	X_2	X_3	X_4	RHS
Obj: function	242.6	318.9	249.4	1046	
Res: Constrains					
Land / fed	1	1	1	1	1852
Capital / SDG	779	240	1103	664	975892
Labor	2.3	3.3	4	2.2	5319
Av. Cult.area	87	225	70	251	

Source: Field survey (2011).

Where:

Res = recourses, Obj = objective function, fed = feddan, SDG = Sudanese pound, capital = working capital, Av.cult = average cultivated area.

The first row in the tableau, four crops were grown in this state, X_1= Sorghum, X_2= millet, X_3= groundnut, and X_4 = sesame.

3.2.1 Objective function:

The objective function which represents the gross margin for Sorghum, millet, groundnut, and sesame equals SDG 246.6, 318.9, 294.4, and 1046, respectively.

3.2.2 Constrains of the model:

3.2.2.1 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 1852.

3.2.2.2 Capital:

The average variable cost reported by the farmers for all agricultural operation in the study area for all agricultural operation for the crops per feddan were SDG 779, 240, 1103 and 664 for the Sorghum, millet, groundnut, and sesame respectively.

3.2.2.3 Labor:

The labor variable represents the total labor employed by each householder during a season; in the study the number of labor of one feddan for crops were 2.3, 3.3, 4, and 2.2 for Sorghum, millet, groundnut, sesame respectively.

3.2.2.4 Average cultivated area:

The average cultivated area of all crops growing in the study area was 87, 255, 70, and 251 feddan for Sorghum, millet, groundnut, and sesame respectively.

3.2.3 Optimal solution of the linear programming model:

The optimum crops combination for the householder in the study area was to cultivate 5 feddans of sesame, 1 feddan of groundnut, 0.370 feddan of sorghum and 0.30 feddan of millet to get maximum profit of SDG 5,674.83.

Table (4): optimal solution for farm plan or base model of crops grown (SDG/ feddan) in North Kordofan State

Crop	Area	Value/SDG
Sorghum	0.370	89.76
Millet	0.30	95.67
Groundnut	1.00	249.4
Sesame	5.00	5,230
Total	**6.670**	**5,674.83**

Source: field survey (2011).

3.3 policy analysis matrix:

3.3.1 Financial profitability (FP) and Economic profitability (EP):

Financial profitability are define in the first row of table (1) as D = A- (B-C). The letter A is used to define the financial revenues (the revenues at the current prices), and Economic profitability is the differences between the values of output (revenues) and costs of inputs, The PAM coefficients in tabless (5 and 6) showed various positive financial (private) and economic (social) profitability for the addressed tow cash crops. Sesame and groundnut production in the study area showed high financial (894.96 and 262.92) /SDG /feddan, respectively and economic profitability of sesame and ground nut were (287.49 and 113.86) respectively, this result agrees with Maruod (2010). These positive level of profitability because of the private factors costs (Land, Capital, and Labor) and tradable inputs were less than the financial revenue of the producers, and this, in term reduces the effect of the government intervention (distorting policies) which have great incidence on tradable inputs and the low direct taxes being passed on production states of these crops and, hence, this contributes positively the financial returns.

3.3.2 Nominal protection coefficient (NPC):

The nominal protection coefficient on tradable output is estimates by dividing the revenues in private price (A) by the revenues in social prices (E) in table (1). In tables (5 and 6) the NPC of sesame and groundnut are equal 3.03 and 2.82 respectively, showed high burden of Direct and implicit taxes imposed on sesame and groundnut production within the farming system (97%) and (18%) for sesame and groundnut respectively.

3.3.3 Effective protection coefficient (EPC):

The effective protection coefficient (EPC) is indicators of incentives. EPC is defined as the ratio of value added in private prices (A-B) to value added in world prices (E-F) as shown in table (1). In tables (5 and 6) The EPC of sesame and groundnut are 3.08 and 2.82 respectively, showed high burden of Direct and implicit taxes imposed

on sesame and groundnut production within the marketed product (92%) and (18%) for sesame and groundnut respectively.

Table (5) Structure of policy analysis matrix sesame production and export season 2010/2011

	Revenue	Tradable inputs	Domestic Rescore	Profit
Private prices	1773.60	358.20	519.84	894.96
Social prices	585.00	125.73	171.79	287.49
Transfers(policy effect)	1188.00	232.47	348.05	607.48

FP	EP	PC
894.96	287.98	3.11

NPC	EPC
3.03	3.08

DRC	CIC	CFED	IVA
0.37	1.13	0.40	459.27

3.3.4 Domestic Resources Cost (DRC) and Coefficient of international competitiveness (CIC):

Table (4.25, 4.26) show the CIC of sesame It measure was competitiveness coefficient of international (CIC) and domestic resources coefficient (DRC) 0f sesame. The DRC Is defines as the ratio of domestic resources costs measured in social prices and expressed in domestic currency. The DRC and CIC results obtained in such respect revealed that sesame production in the area has extremely very high comparative advantage and international competitiveness, since the DRC ratio is far less than one (0.37) and the CIC expresses that only SDG 1.13 is invested to gain US$ that can be acquired by the SDG 2.82 (OER)\ 2.03 (SER). and this results coincides with Maroud(2010) and Alhashimee (2013).For groundnut the table (4.26) shown that the DRC and CIC results obtained in such respect revealed that so production in the area has a high comparative advantage and international competitiveness, since the DRC ratio is far less than one (0.70) and the CIC expresses that only SDG 2.12 is invested to gain US$ that can be acquired by the SDG 2.82 (OER)\ 3.03 (SER) and this results agrees with Maroud (2010). The daily energy received per person per day was equal to 1,862 Kcal (Table 7)

Table (6) Structure of policy analysis matrix of groundnut production and export season 2010/2011

	Revenue	Tradable inputs	Domestic Resources	Profit
Private prices	1608.39	551.94	793.53	262.92
Social prices	569.94	195.54	260.54	113.86
Transfers (policy effect)	1038.45	356.40	532.99	149.06

FP	EP	PC
262.92	113.86	2.31

NPC	EPC
2.82	2.82

Table (7): Household Weekly Food Need and the equivalent K.cal in North Kordofan State

Food item	Kcal/kg	Kilo calories/week/H-H	
		qt.kg	Total Kcal
Sorghum	3350	5.10	17,085
Millet	3350	3.80	12,730
Wheat	3320	2.70	8,964
Meat	2020	2.85	5,757
Milk	660	3.13	2,066
Sugar	4000	3.50	14,200
Tea	1080	0.23	248
Coffee	685	0.42	288
Dry okra	350	0.93	322
Onion	410	3.70	1,517
Salt	710	0.11	78
Oil	8840	1.40	12,376
Vegetables	9000	2.25	20,250
Rice	2000	2.20	4,400
Macaroni (Dry	3350	0.50	1,750
Fruits	2080	1.00	2.080
Total K.cal./H-			104,311
Total			1,862

Source: Study Field survey, 2011

CONCLUSION

In this study, several crops were tested for optimality, which comes with the cultivation of 5 feddans of sesame, 1 feddan of groundnut, 0.370 feddan of sorghum and 0.30 feddan of millet to get maximum profit of SDG 5,674.83. The results of partial budget showed that, gross margin of crops are SDG 1046, 249.4, 242.6, and 318.9 for sesame, groundnut, sorghum and millet respectively.The entire abovementioned partial budget result were validated with linear programming result and with the dominancy analysis. The result of the food security situation in the area reflect the bad condition in all area that about 43%, of respondent are food insecure, also the daily energy received per person per day was 1862 K.cal which was below than that amount of Joseph (2002), this result explicitly conferred evidence to the unbalanced food intake by households in term of energy need, But after applying the optimality this will reduce the insecure from 43% to 10%. According to the PAM results for the cash crops production in North Kordofan State are highly profitable from financial point of view. This is mainly due to using fewer amounts of tradable inputs rather than domestic resources. Financial and economic profitability for the tow cash crops (sesame and groundnut) showed the burden of direct implicit taxes imposed on crops production within marketed product farming system. The DRC and CIC result obtained in the state for the tow crops revealed that, the production had highly comparative advantage and international competitiveness, since the DRC ratio is far less than one and the CIC expresses that the farmers had invested less to gain one USD $.

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