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Economics of Resource Use in Millet Production under Subsistence Farming System of South Darfur State of the Sudan

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ABSTRACT

This study focusing on the economics of resource use in millet Production under subsistence farming system was conducted in Nyala Governate of South Darfur State (*Wilaya*) of the Sudan. The main objectives are: to test the situation of returns to scale for food grains production. Moreover, to evaluate the efficiency with which the farm households utilize their resources to maximize their farm output. Data were collected using structured questionnaire from multi - stage s stratified random sample. Cobb – Douglas was specified as suitable functional form for estimating the parameters. The main results are: the output elasticity of millet showed decreasing returns to scale. And the efficiency index of operational area for millet production was statistically not different from unity. We recommended the development of agronomic and appropriate technological packages and their dissemination to the traditional producers through extension agencies in order to realize high yield potential of millet crop.

Keywords: *Millet, Cobb–Douglas, Production, function, Return to scale.*

1. INTRODUCTION

Millet[1] is one of the most extensively cultivated cereals in the world, after rice, wheat, and sorghum, particularly in arid to semi-arid regions [4, 18]. Millet is a principal food cereal cultivated in drought prone semi-arid regions of Africa and Indian subcontinent. In the USA, Australia, Southern Africa, and South America, millet is grown most extensively as a forage crop [14, 10,18].Cultivation subsequently spread and moved overseas to India

The earliest archaeological records in India date to around 2000 BC, and it spread rapidly through India reaching South India by 1500 BC, based on evidence from the site of Hallu Cultivation also spread throughout eastern and southern Africa. Records exist for cultivation of millet in the United States in the 1850s, and the crop was introduced into Brazil in the1960s. Data in Table (1) indicated that the area devoted to millet and its production were about 4.19% and 6.75% respectively, were very low compared to total major cereal area and production in the world. Millet is an important food across the Sahel. It is a main staple (along with sorghum) in a large region of northern Nigeria, Niger, Mali, Burkina Faso, Chad and Sudan.

Recent archaeobotanical research has confirmed the presence of domesticated millet on the Sahel zone of northern Mali between 2500 and 2000 BC [10, 14, 15, and 18]. Millet was domesticated as a food crop in the tropical region of West Africa at least 4000 years ago. Its use as a food grain has grown over the centuries, with an estimated 64 million acres of millet being grown in Africa and India. In addition to grain and forage uses, millet crop residues and green plants also provide sources of animal feed, building material, and fuel for cooking, particularly in dry land areas [4]. The crop is used for a variety of food products, and is even made into a type of beer.In most growing regions it is usually grown as an intercrop with sorghum and cowpea. The different growth habits, growth period and drought vulnerability of the three crops maximize total productivity and minimize the risk of total crop failure, [11].

Among selected African countries on the basis of similar environmental conditions; millet yield remained stagnant or dropped through 2000/01 – 2012, because much of the expansion has been into areas with poor soils and low and erratic rainfall [2] stated that average yields of millet are lower than important grain crops Table (2).Where [13] mentioned that, yields of grain-type millet are expected to rapidly improve with the release of new hybrids over the next several years. Millet hybrids grown under better conditions yield 3000 to 4000 kg/ha compared to 300 to 800 kg/ha when moisture and soil fertility become limiting factors.

A majority of the subsistence farmers who typically cultivate this crop are unable to take advantage of high yield potential because they have limited options for improving their management practices.

[1] The term millet is applied to various grass crops whose seeds are harvested for food or feed.

Table 1: World Area and Production of Major Grain Crops during 2005

Crop	Area (Million ha)	%	Production (million MT)	%
Wheat	216	33.54	626	27.43
Rice	154	23.91	615	26.95
Maize	147	22.83	692	30.32
Barley	57	8.85	138	6.05
Sorghum	43	6.68	57	2.5
Millet	27	4.19	154	6.75
Total	644	100	2282	100

Source: Calculated from FAO report 2005

Table 2: Average yields of millet compared to other cereal crops

Crop	Average Yield (kg/ha) (World)
Maize	4859
Rice	3970
Wheat	2869
Barley	2720
Sorghum	1357
Millet	821

Source: FAO 2004

2. MILLET PRODUCTION IN SUDAN

Agriculture contributes to about 50 % of the Sudan Gross National Product (GNP). [3]stated that, about 80 % of Sudan's working population in rain fed sub-sector is engaged primarily in either crop production or livestock rearing. Within the agricultural sector, the traditional sub-sector contributed about 6.9% of GDP in ranking third after the livestock and irrigated subsectors, whose shares were about 20 percent and 14 percent respectively**.**

Pearl millet is grown in the Sudan on the sandy soils of Darfur[2]and Kordofan. In some parts of the Eastern State is produced by flood irrigation. Whereas in the Central, Eastern and South East States it is produced on clay plains under rains. However, pearl millet is a major cereal crop in Western Sudan. It contributes the stable food of the majority of inhabitants of Western part of Sudan (Darfur and Kordofan) where it occupies an area of 1.2 – 2.938 million hectares [17]. Over 90% of Sudan's pearl millet is grown in Kordofan and Darfur States, where it is well adapted to the relatively poor soils and prevailing climatic conditions [8].

Darfur is the most important area of the millet production in the Sudan. It ranks the first in millet cultivation in terms of area under cultivated and output. [8]Showed that, millet production in Darfur region is confined to the semi-arid zone and the high rainfall Savannah. The percentage share of Darfur in the Sudan production has largely fluctuated from about 44% to 32% during the period 2009/10 – 2011/12. Millet production decreased from 189 000 to 118 000 metric tons, a 62 percent decrease on last year [3]. This decrease is due to poor cultural practices and poor soil fertility have both contributed to low productivity. Cultural practices are primitive and traditional and carried out by female labor. There is no crop rotation, this had exhausted the soil. Seed rate is high for fear of crop failure and no thinning is practiced [7]. For these facts most farmers directed their primary efforts and resources to securing an adequate supply of millet grain each season for their home consumption for the unpredictable weather conditions.

However, most of millet grown in Western Sudan (Darfur and Kordofan) is used for home consumption by farmers, though; surplus is sold to the other farmers or to local middlemen.

3. OBJECTIVE OF THE STUDY

a. To test the situation of returns to scale for food grains production.
b. To evaluate the efficiency with which the farm households utilize their resources to maximize their farm output

4. METHODOLOGY

4.1 Study Area

The study was conducted in Nyala Governate of South Darfur State of the Sudan. It stretches from the semi–arid zone in the north to the stabilized sandy soil in the south. In the environmental context, Nyala Governate lies in the northern part of the central rainfall belt. It can

[2]This region comprises five states, North, West, Centre, East and South Darfur

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be subdivided into a northern part of the semi –arid region with rainfall below 300 mm per year, and the crop growing season about 70 – 90 days which is suitable to early maturing crops, and the southern part is poor savannah, with rainfall exceeding above figure, with the growing season about 100- 120 days, where grain production is possible. Five localities were sample for study, namely Shataya, Belial, Kass, Abu Ajura and Yassin. The agricultural population in Nyala Governate can be regarded as homogeneous with respect to farming techniques, pattern of cropping and farming is labor intensive. Farm sizes in the area are generally small ranging on the average between 4.22 to 18.17 feddan. The survey was carried out during, March and April of the year 2014. This period coincided with the end of the harvesting season. The respondents at this time were expected to recall all the relevant information thoroughly.

4.2 Sample Design

The sample size was determined according to the formula presented by [1].

$$n = K^2V^2/D^2$$

$$V^2 = R\ (1.0 - R),$$

Then

$$n = K^2\ R(1.0 - R) / D^2,$$

where

n = the desired sample size,

K = the standard normal deviation usually set at 1.96 which corresponds to the level of the 95 % confidence level,

V = the estimated standard deviation of population (assumed 0.1275).

R = the actual rate of farmers population.

D = the degree of accuracy desired usually set at 0.05.

Therefore, the sample size was then calculated according:

$$n = \frac{(1.96)^2\ 0.85\ (1- 0.85)}{(0.05)^2} = 195.9 = 196$$

Random samples were taken from each locality according to the above size. Therefore the sample size becomes 192 farm households.

4.3 Data Collection

The sample was two stages stratified random sample representing the five localities of Nyala Governate. First, five villages were selected at random from Shataya and Belial from each. Of the others, Kass, Abu Ajura and Yassin, six villages were also selected at random. This was done in a way that each village should be located at a direction different from the others and to represent the whole geographical area of the area study. In the second stage, from each village six to seven respondents were selected randomly from the list of Sugar Ration of farm households in the village.

Table (3) shows the distribution of farm households sampled from the selected villages. The total sample size mentioned above represents 3 per cent of the total farm population in selected villages.

The proportion of sample size was relatively small due to limited funds available to the researcher and transportation problems and some other barriers like language problems and customs especially in Shataya and Kass localities. To minimize these barriers field enumerators familiar with the people and their customs were employed for the survey. The data were tabulated and fed to the computer-using SPSS for simple statistic and econometric analysis.

Table 3: Number of Respondents Relative to the Total Farming Households (HH)

Locality	Total Number of Villages	No. of selected Villages	No. of farm HH. In selected village	Respondents	% of the total
Kass	37	6	1480	40	20.8
Shataya	22	5	1367	37	19.3
Abu Ajura	32	6	1353	38	19.8
Belial	23	5	1320	38	19.8
Yassin	31	6	1441	39	20.3
Total	145	28	6961	192	100

4.4 Analytical Ttechniques

Cobb-Douglas production function was specified as a suitable functional form for estimating the parameters to be used in economic resources efficiency and to test the constant returns to scale for farmer production. The Cobb-Douglas production function was considered as a suitable model for the following reasons as summarized by [15].

a. It is easy to estimate.
b. It resembles reality better than the linear form.
c. It has theoretical fitness to agricultural production.
d. It is easy to understand and easy to interpret.
e. The regression coefficients immediately give the elasticity of the product with respect to the factor of production and returns to scale.
f. It permits the phenomenon of diminishing marginal returns without using the degree of freedom.

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In addition to the above reasons [9] reported that the mathematical properties of Cobb-Douglas equation are:-

a. It is the function that cannot be used satisfactorily for data where there are ranges of both increasing and decreasing marginal productive.
b. Neither can the function be used satisfactorily for data, which might have both positive and negative marginal products.
c. It is homogenous of degree one, with respect to the input bundle.

The general formula of Cobb-Douglas production function is:-

$Y = ax_i^{b1} X_{i2}^{b2}$ where,

Y = dependent variable

X_i = independent variables

$b_1 \ldots\ldots b_n$= regression coefficients, where ($b_1 + \ldots\ldots b_n = 1$)

a = intercept

The above general form of Cobb- Douglas production function was transformed to the linear form by logarithmic transformation. The parameters were empirically estimated from appropriate data using OLS techniques.

$\text{Log } Y = \log A + b_1 \log X_1 + b_2 \log X_2 \ldots + \mu$

Where μ_i = regression error term or disturbance term.

5. RESULTS AND DISCUSSION

5.1 The Farm Size – Productivity Relationship

For testing the hypothesis of the farm size-productivity relationship is constant returns to scale, a Cobb-Douglas production function was tried. But it did not give good fitness results. A normal statistic regression, μ-N (0, σ^2) was applied. $Y = a + bX$ where Y represents output of millet, X, indicates farm size in feddan. The results of regression equations were presented in Table (4).

Coefficients were statistically significant at 1 % level, with the expected signs and significantly different from zero. As the equation was regressed in linear form, the researcher calculated the elasticity's of the equation separately using the following formula:

$$\frac{\Delta y}{\Delta x} * \frac{\bar{x}}{\bar{y}} = b * \frac{\bar{x}}{\bar{y}}$$

The results are depicted in column 4 Table (4).

The elasticity was significantly different from unity indicating decreasing returns to scale. This is not surprising since the land in traditional production of Darfur have low elasticity for producing the main food grain, whether produced in isolation or in mixed. This might be true if the land is utilized alone (other things kept constant) - which have effect on the output, through the land variable. However, the above finding gives support the rejection of the null hypothesis that, there are constant returns to scale for the farm size-productivity relationship.

Table 4: The Relationship between Farm size and Output per Farm Coefficients

Equation	N	a	b	Elasticity	R^2
Millet (Y)	192	5.0273	1.0127*X (0.09236)	0.64	39

Data in the parenthesis are Standard Error.
* Significant at 0.1 % of level.

5.2 Constant Returns to Scale

To test the hypothesis that the farmer in Darfur produces the main food grains in a constant return to scale, a Cobb-Douglas production function was formulated for millet equation. The result of the equation is depicted in Table (5).The multiple coefficient of determination, R^2, for millet equation was 40 which showed that 40 percent of the variation in millet output would be explained by independent variables included in the equation. The low R^2, is not a problem for cross-sectional data as[12], mentioned that, the cross-sectional data were typically based on micro units where such variations has not been averaged out.

The coefficients of explanatory variables specified in millet production equation are significant at 1 percent and 5 percent level of significance, with expected positive signs. These indicated that as the explanatory variables (area cultivated, labor and farm capital) are increased by 1 percent in utilizing land for millet production. The output of millet would increase by 0.6156, 0.116 and 0.9783 percent respectively. The high increment of millet output due to utilization of 1 percent of excess of farm capital had led to greater use of cash inputs.

Generally, the return to scale was measured as the sum of the regression coefficients (elasticity's) of the Cobb-Douglas production function. The returns to scale are greater than, equal or less than unity. However, the sums of regression coefficients of the estimated Cobb-Douglas production function are illustrated in Table (5). The findings confirmed that the sum of regression coefficient is 1.71 for millet output. This result confirms the increasing returns to scale for the main food grains production in Darfur. However, farm capital input made the most significant contribution and followed by cultivated area to millet output. This result will lead to reject the hypothesis of constant returns to scale.

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Table 5: Returns to Scale

Variable	Millet
Constant	0.0429
N	196
Cultivated Area	0.6156* (0.064)
Labour (m.d)	0.1160 ** (0.0629)
Farm Capital	0.9783* (0.626)
R^2	40
Σb_i, s'	1.7094
F-ratio[a]	41.79

Source: field survey 1999.
* Significant at 1 percent level.
** Significant at 5 percent level.
a F-ratio was calculated for testing the hypothesis of millet output return to scale.
Dates in parentheses are standard error.

6. CONCUSION AND RECOMMENDATIONS

1- The output elasticity of millet showed decreasing returns to scale. This is because when land is utilized (others things kept constant) will not produce high yields without other inputs, because the inputs will add their MP to that of the land.
2- The efficiency index of operational area for millet production was statistically not different from unity which indicated that the farm households has used their cultivated area efficiently for millet than unity showed that farm households had underutilized their operational area.
3- To develop agronomic and appropriate technological packages and to disseminate them to the traditional producers through extension agencies for realize high yield potential of millet crop and others.
4- Studies are needed to revise the farming system to minimize the instability of food grains production in the State.

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