

Measuring Production Efficiency of Sorghum Small Farmers in Rahad Agricultural Scheme Season (2011-2012)

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Abstract

The main objective of this paper is to measure the production efficiency of sorghum small farmers in the Rahad Scheme. The other objective is to identify the main factors behind the tenants in efficiency and socio-economic factors affecting the tenants' level of efficiency; in the scheme. The paper used primary and secondary data. The primary data were collected by means of questionnaire for a sample of 120 farmers selected randomly from the northern and central divisions of Rahad Scheme. The data covered improved seeds cultural practices, number of irrigation's, market factors and the socio-economic characteristics of tenants (sex, age, educational level, marital status, and family size). The secondary data were collected from different intuitional sources including the Central Bank of Sudan. Ministry of Agriculture and Forest and Rahad Agricultural Corporation. The Stochastic Production Frontier (SPF) analysis was used to estimate the production efficiency. Descriptive statistics was also used to analyze the socio-economic characteristics of farmers. The results showed that most estimated parameters of efficiency of stochastic frontier model for sorghum production of small farmers has expected signs. The mean production efficiency was 78% for sorghum crop. This means that tenants could increase their output by 22% through a better use of available resources. The improved seed and the insufficient number of irrigation and market factors (packaging-transportation-storage have significant impact on sorghum predation of small farmers in Rahad Scheme. Sowing date, location of the farm, experience of growing sorghum, harvesting operations and agricultural income had no significant impact on sorghum production. Working time in the field had a positive sign. This indicates that increase working time in the field would increase the yield. Tenants in age group of (25-35) years had the highest production efficiency and oldest tenants had the lowest production efficiency. The study recommended the improvement of education level of farmers, increasing the working time in field. provision of necessary funds for the cultural operation and the maintenance of irrigation channels to increase production efficiency.

Keywords: Small farmers; Production efficiency; Rahad Scheme; Sudan

Introduction

Sudan is a large country in Africa with a total area of 1.882.000 km². The main activity of its population is agriculture. The agricultural production in Sudan depends on two sources of water direct rain fed and irrigation principally from the River Nile and its tributaries. There are also flood irrigation schemes fed by seasonal rivers in the eastern parts of the country in the Gash and Tokar deltas, the area of irrigated sub-sector is about 4 million feddan, the major components of this sub-sector are large scale schemes, which are Gezira, Rahad and New Halfa schemes. The irrigation sector contributes 27% of agricultural GDP and it produces most of the cotton, sugar, legumes, and cereals crops in Sudan [1]. Rahad scheme is one of the important national schemes in Sudan. It extends on the eastern bank of the Rahad river, between longitudes 22°-34" and 35°-55" east and latitudes 12°-35". The area of the scheme is 353 thousand feddan, 38% of it in Gedarif state and 62% in Gezira state. The climate is semi-desert rainfall is between 400 mm in the north and 600 mm south of the scheme. Rahad scheme is irrigated from the Blue Nile River, using 11 pumps during the dry season. The phase of the Rahad scheme was modeled on the same pattern of Gezira scheme with a central management system, the tenancy relationships, and the same crop mix, with one exception,

there is no follow. In the rotation yielding, 100% cropping intensity. Like other national corporations, the core of the scheme is the farmers plot with standard area of 21 feddan (10 ha) equally divided among the four field crops, cotton, sorghum, wheat, and groundnut. But eventually the scheme stopped wheat production. As shown in Table 1 there is a variation in sorghum production in the Sudan.

Season	Cultivated Area (1000 feddan)	Harvested Area (1000 feddan)	Production (1000 ton)	Productivity Yield kg /feddan
2005-2006	20453	15805	4327	274
2006-2007	20594	15655	4999	319
2007-2008	19857	15754	3869	246
2008-2009	20805	15968	4192	263
2009-2010	24908	13364	2630	197
2010-2011	22054	17278	4605	267

Table 1: Sudan Sorghum, cultivated area, harvested area, production, and productivity.

In the Sudan, it is the main stable food and a rank first among other cereals in importance and production and it is used by most the population. In addition to its importance as human food, sorghum

represents a major source of animal feed; the plant stem and foliage are used as chop hay silage or pasture. The stem and plant remains are also utilized for a variety of purposes such as building and energy.

Sorghum is the most important annual crop

For both domestic food security and the national economy. This crop is mainly produced in rain fed sector, contributing about 80% of the total production of sorghum, while the share of the irrigated sector is around 20%. In the rain fed sector many problems facing the production of sorghum such as fluctuations in the amounts and timing of the rain falls which in turn lead to fluctuating productivity and prices. Therefore, this paper seeks to investigate the efficiency of sorghum production in the irrigated sector in Sudan taking Rahad scheme as case study. The main problems concerning cost of production irrigation and weeds will be addressed.

The suitable solutions and recommendation will be suggested with the aim of increasing sorghum production in the irrigated sector and its contribution to the total country production.

problem statement

Sorghum is one of the most important tropical and subtropical grain crops. In Sudan, a great diversity of sorghum types was found especially in Kordofan in Western Sudan. It has been suggested that Sudan is an original home for sorghum [2]. It is used largely as human food in many parts of Africa, Asia, and some other countries also it is used as animal feed and forage in USA and Australia (FAO, 1996).

Objectives of the Paper

The overall objective of this paper is to measure and evaluate the production efficiency of sorghum in the Rahad scheme. The study is also aimed to achieve the following specific objectives:

- Identify and measure the tenant production efficiency
- Determine major problem that faces the tenants that may affect the efficiency of sorghum productions in Rahad scheme
- To recommend some policy measures to the policy and decision makers

Literature Review

The importance of Sorghum to Sudan economy

Sorghum is the staple diet for most Sudanese. It is the staple in the rural areas in the central zone, being only challenged for supremacy on the sandy lands of western Sudan by millet, and among urban areas, it is challenged in some of the large towns where wheat bread is consumed. Furthermore, sorghum production takes up more land than any other crop.

The importance of sorghum in Sudan can hardly be overstressed. Ever since the establishment of the Anglo-Egyptian Condominium in 1898 it has been considered a strategic crop by all governments, and expansion of production and the maintenance of a sufficient supply to meet the needs of a rising population has been a primary consideration in all government policy and action in the agricultural sector. The most important single development, however, took place after the Second World War when the mechanical crop production schemes (MCPSs) were started in Gedarif [3].

Previous studies

Efficiency measurements have been attempted in Indian agriculture since 1970s [4-12]. Efficiency has been measured and decomposed into various components using both parametric as well as nonparametric methods. The two principal methods that have been employed to analyze the efficiency are data envelopment analysis (DEA) and stochastic frontier analysis (SFA), which involve mathematical programming and econometric methods, respectively. [6,7,10-14] are some of the studies that used SFA to analyze efficiency in Indian agriculture [10]. Points out that given the same access to inputs, the responsiveness of the small farmers to economic opportunities is the same as the case with the large farmers. His study is based on seventy farmers from Coimbatore district in the state of Tamil Nadu. Datta and Joshi [8] documented that the technical efficiency stands at eighty-four % and sixty-six% for wheat and rice respectively using the data on 120 farms from the district of Aligarh in Uttar Pradesh using the data from Ramanathapuram district in Tamil Nadu, estimated a Cobb Douglas production function for rice. He suggested that strengthening the farm extension services is necessary to bridge the gap between the farmers. Battese[7] performed a stochastic frontier analysis using a panel data for ten years. They documented that schooling increases efficiency while the age decreases it. Kalirajan [11] suggests a methodology to obtain economic efficiency of firms using returns to scale. He documents that half of the rice sample farmers in Karnataka are economically efficient. estimated a stochastic frontier production function for 234 rice farmers in Tamil Nadu. They obtained wide variation in technical efficiency, ranging from 46.5 % to 96.7%. [14] used the same methodology in case of rice farmers for Bihar. He shows the high elasticity of both: land and fertilizer. The technical efficiency ranges from 36.7% to 98.1%.

Efficiency Concept

Efficiency is a very loose term indeed; to an engineer efficiency may mean the ratio of output/input or output/theoretical capacity %. While the cost account use the ratio standard cost/actual cost %, or its inverse to measure the productive efficiency of a firm. The economist, when he refers to the efficiency of a firm generally means one of two ratios, the first concerns the firm's success in producing as large as possible an output from a given set of inputs; or what amounts to the same thing, producing a given output with the least inputs; this called productivity, or technical efficiency [15].

Allocative and technical efficiency

Technical efficiency is just one component of overall economic efficiency. However, to be economically efficient, a firm must first be technically efficient. Profit maximization requires a firm to produce the maximum output given the level of inputs employed (i.e. be technically efficient), use the right mix of inputs considering the relative price of each input (i.e. be input allocative efficient) and produce the right mix of outputs given the set of prices (i.e. be output allocative efficient) [16]. These concepts could be illustrated graphically using a simple example of a two input (x_1, x_2) -two output (y_1, y_2) production process (Figure 1). Efficiency could be considered in terms of the optimal combination of inputs to achieve a given level of output (an input-orientation), or the optimal output that could be produced given a set of inputs (an output-orientation).

In Figure 1, the firm is producing a given level of output (y_1^*, y_2^*) using an input combination defined by point A. The same level of

output could have been produced by radially contracting the use of both inputs back to point B, which lies on the isoquant associated with the minimum level of inputs required to produce (y_1^*, y_2^*) (i.e. Iso (y_1^*, y_2^*)). The input-oriented level of technical efficiency (TEI (y, x)) is defined by OB/OA . However, the least-cost combination of inputs that produces (y_1^*, y_2^*) is given by point C (i.e. the point where the marginal rate of technical substitution is equal to the input price ratio (w_2/w_1)). To achieve the same level of cost (i.e. expenditure on inputs), the inputs would need to be further contracted to point D. The cost efficiency (CE (y, x, w)) is therefore defined by OD/OA . The input allocative efficiency (AEI (y, x, w)) is subsequently given by $CE(y, x, w)/TEI(y, x)$, or OD/OB in Figure 1 [16].

$$\text{Economic Efficiency} = \text{Technical Efficiency} \times \text{Allocative Efficiency}$$

$$\text{Technical Efficiency} = OB/OA$$

$$\text{Allocative Efficiency} = OD/OB$$

$$\text{Economic Efficiency} = (OB/OA \times OD/OB) = OD/OA$$

$$\text{Economic Efficiency} = 1 - (OD/OA)$$

$$\text{Allocative inefficiency} = 1 - (OD/OB)$$

$$\text{Technical inefficiency} = 1 - (OB/OA)$$

The production possibility frontier for a given set of inputs is illustrated in Figure 2 (i.e. an output-orientation). If the inputs employed by the firm were used efficiently, the output of the firm, producing at point A, can be expanded radially to point B. Hence, the output oriented measure of technical efficiency ($TE_O(y, x)$), can be given by OA/OB . This is only equivalent to the input-oriented measure of technical efficiency under conditions of constant returns to scale. While point B is technically efficient, in the sense that it lies on the production possibility frontier, higher revenue could be achieved by producing at point C (the point where the marginal rate of transformation is equal to the price ratio p_2/p_1). In this case, more of y_1 should be produced and less of y_2 to maximize revenue. To achieve the same level of revenue as at point C while maintaining the same input and output combination, output of the firm would need to be expanded to point D. Hence, the revenue efficiency (RE (y, x, p)) is given by OA/OD . Output allocative efficiency ($AE_O(y, w, w)$) is given by $RE(y, x, w)/TE_O(y, x)$, or OB/OD in Figure 1b [16].

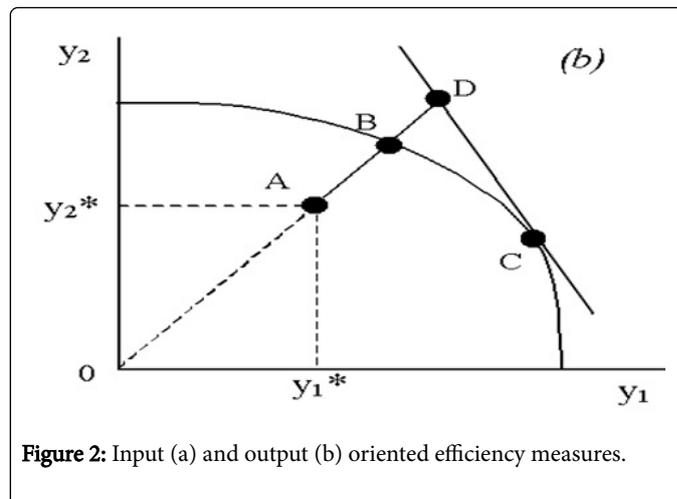


Figure 2: Input (a) and output (b) oriented efficiency measures.

Stochastic production frontier technique

Over the past two decades, the measurement of technical efficiency has received considerable attention within agriculture. Farrell [17] proposed an efficiency measure of a firm which consists of two components, namely technical efficiency, and allocative efficiency. Technical efficiency reflects the ability of a firm to maximize physical output subject to a given set of physical inputs [18].

Whereas most published studies have tended to enter the detail of efficiency measurement, conceptually the measurement of technical efficiency is relatively straightforward. Farrell [17] was the first to address the issue of measuring the relative efficiency of several producers with multiple outputs or inputs. This procedure focused on the construction of a hypothetically efficient unit, which was a weighted average of efficient units. This then acted as a comparator for an inefficient unit. Under this setting a firm's efficiency is given by: Firm_j efficiency:

$$= u_1 y_{1j} + u_2 y_{2j} + \dots / V_1 X_{1j} + V_2 X_{2j} + \dots$$

where, u_1 is the weight allocated to the output y_1 , and y_{2j} is the amount of output 1 produced by firm j . Correspondingly, v_1 is the weight allocated to input x_1 , and x_{1j} is the amount of input 1 produced by firm j . This continues over the number of outputs and inputs produced by firms in this sector. Graphically, Farrell's approach can be shown as Figure 3, which shows a series of hypothetical firms positioned relative to a frontier. A frontier can be drawn from observed data on firms operating at the optimal levels of efficiency, representing an appropriate functional form. This represents the best available technology and practice for firms within a region at a time. Consequently, the frontier establishes the distance between efficient and inefficient firms as they are measured relative to this frontier.

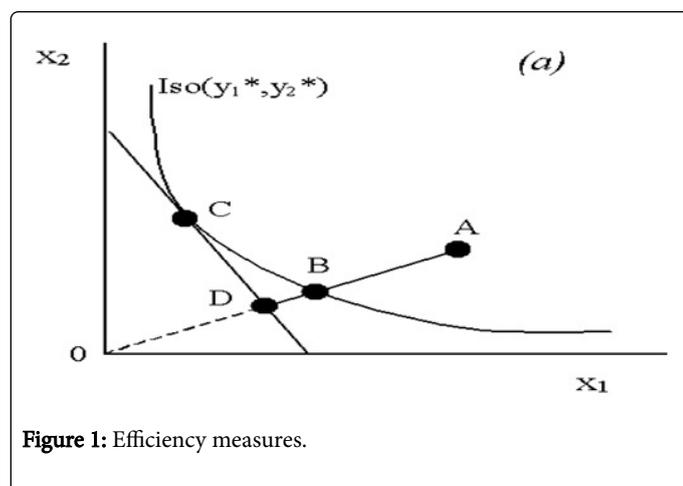


Figure 1: Efficiency measures.

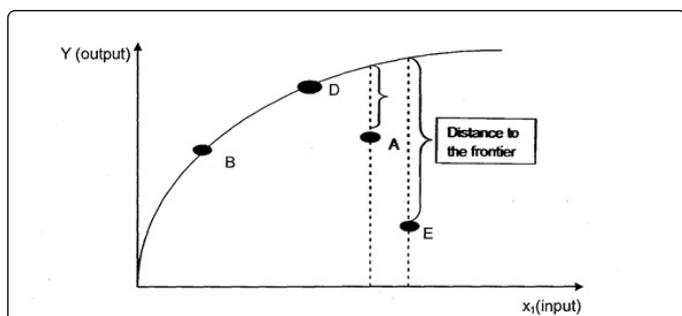


Figure 3: Measurement of technical efficiency using Farrell Approach (1957).

The Figure 3 shows four farms. Two of these (D and B) are positioned on the frontier, consequently they receive a relative score of 1. Firms A and E could be measured relative to this frontier. Consequently, their relative scores will be less than 1. This gives some idea of how Farrell’s approach could be applied within a firm benchmarking context, as the frontier represents best practice technology and technical efficiency could be ranked relative to that frontier within a unified measure which runs from 0 to 1, where 1 is the most efficiency attainable within a sector at a point in time.

Farrell’s measure remained relatively unused throughout the 1960’s and 1970’s. Two methods developed from this conceptually based approach to efficiency measurement; Data Envelopment Analysis. Charnes [19] which is non-parametric and based on a series of linear programming models, and Stochastic Frontier Analysis, which is a parametric approach applying econometric techniques to estimate efficiencies [20,21].

Stochastic production frontier software

Stochastic frontiers could be estimated using a different range of multi-purpose econometric software which could be adapted for the desired estimation. This software includes known statistical packages such as LIMDEP, TSP, Shazam, GAUSS, SAS, etc. The two most commonly used packages for estimating of stochastic production frontiers and inefficiency are FRONTIER 4.1 [21] and LIMDEP [22]. A review of both packages is provided by Greene and Sena [23,24].

FRONTIER 4.1 is a single purpose package specifically designed for the estimation of stochastic production frontiers (and nothing else), while LIMDEP is a more general package designed for a range of non-standard (i.e. non-OLS) econometric estimation. An advantage of the former model (FRONTIER) is that estimates of efficiency are produced as a direct output from the package. The user can specify the distributional assumptions for the estimation of the inefficiency term in a program control file. In LIMDEP, the package estimates a one-sided distribution, but the separation of the inefficiency term from the random error component requires additional programming.

FRONTIER can accommodate a wider range of assumptions about the error distribution term than LIMDEP (Table 2), although it is unable to model exponential distributions. Neither package can include gamma distributions. Only FRONTIER is able to estimate an inefficiency model as a one-step process. An inefficiency model can be estimated in a two-stage process using LIMDEP. However, this may create bias as the distribution of the inefficiency estimates is pre-

determined through the distributional assumptions used in its generation.

Distribution	LIMDEP	FRONTIER
Time invariant firm specific inefficiency		
Half-normal distribution	Yes	Yes
Truncated normal distribution	Yes	Yes
Exponential distribution	Yes	No
Time variant firm specific inefficiency		
Half-normal distribution	No	Yes
Truncated normal distribution	No	Yes
One step inefficiency model	No	Yes

Table 2: Distributional assumptions allowed by the software.

FRONTIER 4.1

The most commonly used package for estimation of stochastic production frontiers in the literature is FRONTIER 4.1 [21]. This incorporates the maximum likelihood (ML) estimation of the parameters. The estimation process consists of three main steps. At the first step OLS is applied to estimate the production function. This provides unbiased estimators for the β 's (except for the intercept term and the estimate). The OLS estimates are used as starting values to estimate the final ML model. First, the value of the likelihood function is estimated for different values of Y between 0 and 1 given the values for the β 's derived in the OLS. Finally, an iterative Davidson-Fletcher-Powell algorithm calculates the final parameter estimates, using the values of the β 's from the OLS and the value of Y from the intermediate step as starting values.

FRONTIER 4.1 has been created specifically for the estimation of production frontiers. As such, it is a relatively easy tool to use in estimating stochastic frontier models. It is flexible in the way that it could be used to estimate both production and cost functions, could estimate both time-varying and invariant efficiencies, or when panel data is available, and it could be used when the functional form have the dependent variable both in logged or in original units.

FRONTIER solves two general models. The error components model could be formulated as

$$Y_{it} = X_{it} \beta + (V_{it} - U_{it}) \dots (1)$$

Where Y_{it} is the (logged) output obtained by the i -th firm in the t -th time period; X_{it} is a $(k \times 1)$ vector of (transformation of the) input quantities of the i -th firm in the t -th time period; β is a $(k \times 1)$ vector of unknown parameters; and V_{it} are assumed to be independently and identically distributed (iid) $N(0, \sigma_v^2)$ random errors, and $U_{it} = U_i \exp(-\eta(t-T))$, where U_i are assumed to be iid as truncations at zero of the $N(\mu_i, \sigma_u^2)$.

This is the Battese [18] model. However, some other models could be summarized as special cases of this one and could also be solved using FRONTIER. Setting $\eta=0$, the time invariant model of is obtained. The Battese and Coelli model results from the previous one for the particular case of problems in which balanced data is available. If we add $\mu=0$ to the fore mentioned assumptions, the Pit and lee

model results. And if we finally set $T=1$ in the Pitt and Lee model, we obtain the original cross-sectional data model of [20].

If $\eta > 0$, the inefficiency term, U_{it} , is always decreasing with time, whereas $\eta < 0$ implies that U_{it} is always increasing with time. That could be one of the main problems when using this model, technical efficiency is forced to be a monotonous function of time.

The second model included in the FRONTIER package is the Technical Efficiency (TE) effects model [18]. It could be expressed as $Y_{it} = X_{it} \beta + (V_{it} - U_{it})$, where Y_{it} , X_{it} , β and V_{it} are as defined earlier and $U_{it} \sim N(m_{it}, \sigma_u^2)$, where $m_{it} = Z_{it} \delta$, Z_{it} is the vector of firm-specific variables which may influence the firms' efficiency. FRONTIER offers also the solution of the model of Stevenson which is a case of the previous model that can be obtained for the cases in which T is equal to 1 (for cross-sectional data).

There are two approaches to estimating the inefficiency models. These may be estimated with either a one step or a two-step process. For the two-step procedure, the production frontier is first estimated and the technical efficiency of each firm is derived. These are subsequently regressed against a set of variables, Z_{it} , which are hypothesized to influence the firms' efficiency. A problem with the two-stage procedure is the inconsistency in the assumptions about the distribution of the inefficiencies. In the first stage, the inefficiencies are assumed to be independently and identically distributed (iid) to estimate their values. However, in the second stage, the estimated inefficiencies are assumed to be a function of several firm specific factors, and hence are not identically distributed unless all the coefficients of the factors are simultaneously equal to zero [18]. FRONTIER uses the ideas of Kumbhakar [25] and Reifschneider [26] and estimates all the parameters in one step to overcome this inconsistency. The inefficiency effects are defined as a function of the firm specific factors (as in the two-stage approach) but they are then incorporated directly into the maximum likelihood estimates (MLE). This is something that should be taken into consideration when programming in some of the general statistical packages.

FRONTIER offers a wide variety of tests on the different functional forms of the models that could be conducted easily by placing restrictions on the models and testing the significance of the restrictions using the likelihood ratio test. The FRONTIER program is easy to use. A brief instruction file and a data file should be created. The executable file and the start-up file could be downloaded from the Internet free of charge at the CEPA (University of New England).

Study Area, Data, and Research Methodology

Study area

The Rahad Scheme, in which the current study was conducted, is one of the schemes which the Government has chosen to expand the agricultural production in Sudan. The scheme started production in the season 1977/78 with the aim of raising the living standard of the population in the area and increasing cash crops exports, namely cotton and groundnuts. The scheme lies east of the Blue Nile, on the Easter Bank of the Rahad River between longitudes 22°-34" and 35°-55" east and latitudes 14°-35" and 13°-43" north it extends for 160 km from Mafia village in the south to Abuharaze town near Wad Medani City in the north. On average, it covers a width of 5.26 km across the eastern part of the central clay plain of the Sudan. The scheme headquarter is at Elfau town which lies about 260 km south-east of Khartoum. The area of the scheme is 353 thousand Feddan. 38% of it in Gedarif state

and 62% in Gezira state. The climate is semi desert; rain fall varies between northern and southern parts of the scheme. The northern and southern part has an annual rainfall of 400 mm and 600 mm on average respectively. The core of the scheme in the farmer's plot with a standard area of 21 feddan (8.82 ha) equally divided among between the four field crops, cotton, sorghum, wheat, and groundnuts. Overall, there are 14 thousand farmers organized in a union and through the union the farmers do participate in the management board and the various councils at all levels of the scheme. Another characteristic of the scheme is that there are tarmac roads across the area and all parts are reachable during the rainy season, unlike all other schemes. The scheme is also connected by high-way to the seaports and to the capital Khartoum; an advantage that could facilitate specialization in export crops, especially horticultural crops, and animal production. The scheme draws water for irrigation from the Blue Nile using 11 giant electric pumps situated at Miena near Singa town in Blue Nile into a siphon across the River Dinder to the scheme main canal. Also, water is diverted from Rahad seasonal River to the scheme main canal. The arrangement is that from July up to end of October, water for irrigation is to be delivered from the Rahad River and from November to the end of June the necessary irrigation water is to be pumped out of the Blue Nile.

Objective of the scheme

El samani [27] summarized the scheme objectives as follows:

- Utilized Government investments in water diversion and storage works at El-roseires dam in crop production by developing the Rahad Scheme
- Generation of additional values from cotton and groundnuts to contribute to the GNP
- Offer an opportunity to improve further upon irrigation and agricultural technologies
- Increase the quantity, quality, and value of domestically consumed crops
- Improve the welfare at economically marginal population, through the increase of their income, standard of living, housing, nutrition, health, education and corresponding changes in attitudes and value
- Provide employment for a national agricultural wage Labour force.

Research methodology

Include sources of data, data analysis, efficiency model and inefficiency effect model.

Sources of data

Primary and secondary data were used to fulfill the objective of the study. Primary data were collected by mean of questionnaire following multistage stratified random sampling technique of 120 tenants were interviewed from the northern and central divisions of Rahad agricultural scheme. The primary data include basic information about the agricultural input, agricultural practices, capital, harvesting input market factors also the information about the socio-economic characteristics, e.g. age, education level, marital status of tenants, location of the tenancy, information about concerning sorghum ... etc.

Secondary data collected from different institutional sources including Bank of Sudan Ministry of Agriculture and Forests, Rahad Agricultural Corporation using their reports, records, journals ...etc.

Data analysis

The objectives of this paper were achieved by using the stochastic frontier production (SFP) model. Stochastic frontier production analysis in method of estimating frontier function involving the use of econometrics and the rely measuring the efficiency of production. Economic efficiency is generally defined as the ability of production organization to produce a well specified output at the minimum cost. In our study two models will be used. The ideas of Kumbhakar [25].

Efficiency model

This model includes the tenant's factors affecting the tenant efficiency for sorghum production. Stochastic production frontier model of the cobb-Doglas form was used. The model is written as follows:

$$\ln y_i = B_0 + B_1 \ln x_{ij} + \sum B_j \ln x_{ij} + v_i - u_i \quad (2)$$

Where:

$\ln y_i$ = the logarithm of sorghum production.

Yield in Kg /feddan;

X_1 = harvesting operation input;

X_2 = market factor; (packaging-transportation-storage).

X_3 = level of education; (Illiterate, Khalwa, Primary, Secondary, and University)

X_4 = location of the farm; 1 for the farm near irrigation canal 0 otherwise.

X_5 = improved seeds; 1 for the improved seeds 0 otherwise.

X_6 = experience of sowing sorghum; (years).

X_7 = family size; numbers.

X_8 = working time; hours/day.

D = Dummy variable; A dummy variable is a numerical variable used in regression analysis to represent subgroups of the sample in this paper. In research design, a dummy variable is often used to distinguish different treatment groups.

B_1 and B_j are unknown parameters to be estimated for the dummy and continuous variable, respectively.

V_i represent statistical error and the others factors which are beyond the tenants control such as whether, topography and other factors which are not included and may be either positive, negative or zero U_i is a non-negative random variable, associated with the tenant's technical inefficiencies in production and assumed to be independently distributed. For the technical inefficiency effect for j^{th} tenants, it will be obtained by truncation (at zero) of the normal distribution with mean U_i and variance σ^2 .

Inefficiency effect model

As mentioned in the tenant's model U_i in the stochastic production frontier model is a non-negative random variable, associated with tenants' technical inefficiency in production and assumed to be independently distributed, such that the technical efficiency effect for the it tenants, U_i will be obtained by truncating (at zero) of the normal distribution with mean U_i and variance σ^2 such that

$$U_i = \sigma^2 + \sum \delta_j Z_j \quad (3)$$

Where:

Z_{1i} = capital; (purchase seeds, water rent, fertilizers).

Z_{ni} = cultural practices;

Z_{3i} = Tenants age; (years).

Z_{4i} = Marital status; (1 for married and 0 for other wise).

Z_{5i} = Tenants experience; (years).

Z_{6i} = Agricultural income; (the income can be obtained from the farm).

Z_{7i} = Number of irrigation; (1 for the sufficient number of irrigation and 0 other wise).

$\sigma^2 = \sigma_8^2$ are unknown parameters' to be estimated; [21].

Results and Discussion

This section presents the empirical results of the study. Namely the input and the socio-economic characteristics of the tenants in Rahad scheme and the stochastic production frontier and inefficiency model using the data of growing season (2011-2012).

Social characteristics of farmer in Rahad scheme

Gender

Asante [28] stated that the word gender refers to socially constructed roles and socially learned behaviors and expectations associated with females and males. It could be defined as more than biological differences between men and women. It includes the ways in which those differences, whether real or perceived, have been value used and relied upon to classify women and men and to assign roles and expectations to them.

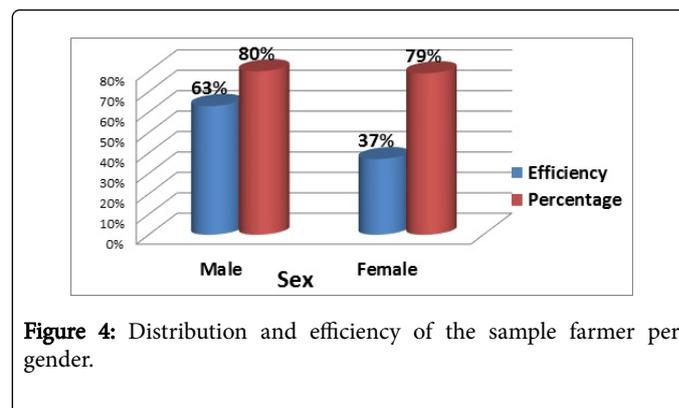


Figure 4: Distribution and efficiency of the sample farmer per gender.

Figure 4 show that most of the farmers are male of 63% of total respondent's distribution and with mean production efficiency of 80% in the Rahad Scheme and 79% for female. In developing countries, where technological change is radically altering life style, education is necessary for survival; it help people to understand and benefit from change and obtain their economic rights.

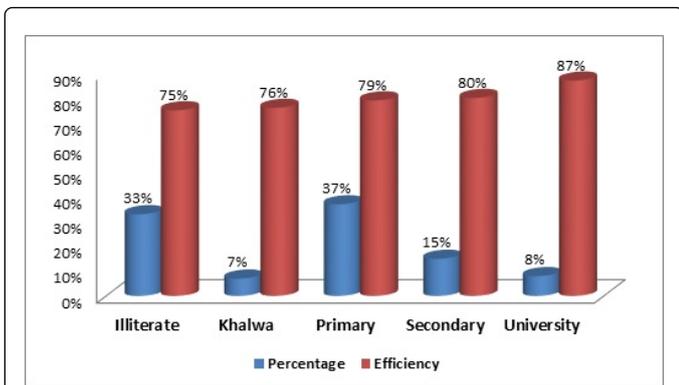


Figure 5: Distribution and efficiency of the sample farmer per education level.

(World Bank, 1980). Figure 5 shows that about 33% of the respondents received no education with least mean efficiency 75%, 7% received some khalwa, 37% received primary education, about 15% of the tenant got secondary education, and 8% of them have university agree with highest efficiency level of 87%. From this table, it could be if the production efficiency of farmers increases with the increasing in their education level

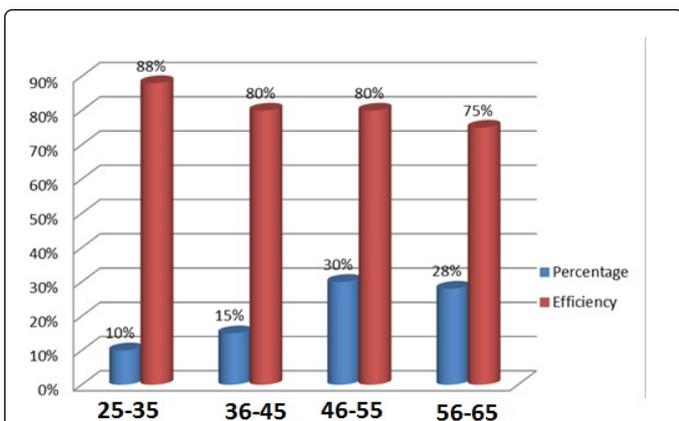


Figure 6: Distribution efficiency of the sample farmers per age.

Age has an important effect on productivity and output of the individual as it affects the mental and the manual abilities. Many writers reported that, age has a positive effective on productivity until a certain level beyond which it would have a negative effect [7].

Figure 6 shows the age distribution in the tenant sample. As we see in the figure the age distribution ranged (25-75) years. 10.8% of the tenants are in the age group of 25-35 with the highest production efficiency (88%) while the age groups of 35-45 and 45-55 have the same production efficiency. The least production efficiency (73%) is among the oldest farmers (65-year-old and above).

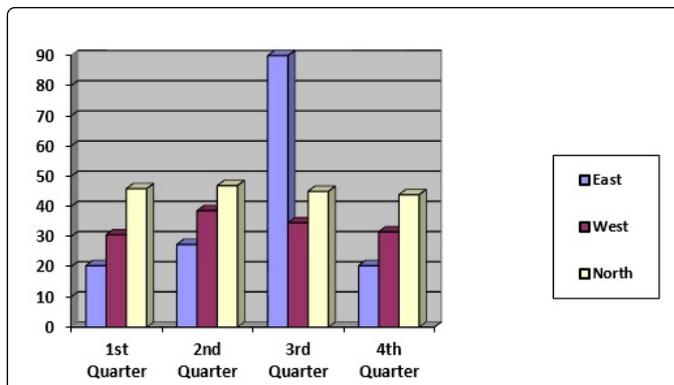


Figure 7: Distribution of the sample farmers according to marital status.

Figure 7 shows that most the sample respondents (85%) are married and (15%) are single, with the same production efficiency for the same group.

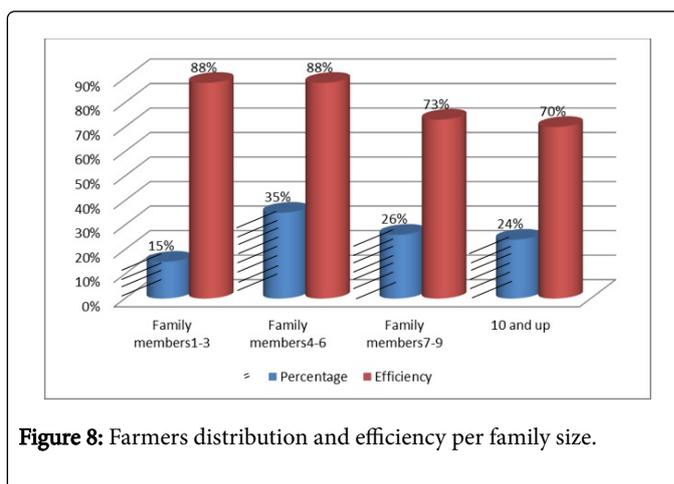


Figure 8: Farmers distribution and efficiency per family size.

Figure 8 shows that family size ranged between (1 and 13), members, 15% of respondents have family size group ranged between (1-3) members. 35% of the respondents have family size group ranged between (4-6) Members. This group and the former have the same efficiency, (88%). The figure also indicates that most the farmer in the study area has a family size of 7 members and above (50%) and has the lowest production efficiency.

Stochastic frontier production function analysis

Stochastic frontier version 4.1 program [21] was used within this paper to estimate the level of production efficiency for sorghum production in Rahad scheme. The maximum likelihood (MLE) estimate of Cobb- Douglas stochastic production frontier model with the assumption of sorghum production efficiency, and production inefficiency were presented in Table 3.

As shown in Table 3 the mean production efficiency of sorghum production is 78% with a minimum of 64% and maximum of 92%. This means that on average. The tenants in the scheme yield attainable by the best practice. This result implies that the tenants could increase

their sorghum output by 22% using the same mix of production inputs if the tenants are efficient.

Sorghum production efficiency

The presence or absence of technical inefficiency was tested in the study using the important parameter of Log likelihood in half-normal model $\lambda = \sigma_u / \sigma_v$, if $\lambda = 0$ there were no effect of technical inefficiency, deviation from the frontier were due to noise the estimated value of $\lambda = 0.41$ significantly different from zero.

Statistic	Sorghum efficiency Score%
Mean	87
Minimum	65
Maximum	92

Table 3: Summary of statistics of efficiency estimate from the stochastic frontier model of sorghum.

Variable	Parameter	Estimate	Standard error	t-ratio
Constant	B_0	1.1512	0.8311	1.3851
Harvesting operation input X_1	B_1	0.2997	0.1825	1.6419
Market factors X_2	B_2	0.9674	0.0892	10.8410***
Education level X_3	B_3	0.0050	0.0128	0.3948
Location to the farm= X_4	B_4	0.0212	0.0170	1.2432
Improved seed= X_5	B_5	0.0818	0.0285	2.8666***
Experience of sowing sorghum= X_6	B_6	0.0063	0.0044	1.4248
Working time= X_7	B_7	0.0829	0.0601	1.3779
Family size= X_8	B_8	0.0142	0.0079	1.8018
Constant	δ_0	-27.6806	0.5288	-0.5234
Water rent	δ_1	0.0167	0.0840	0.1993
Cultural practices	δ_2	0.0005	0.0609	0.0084
Tenants age	δ_3	0.0023	0.0013	1.7674
Marital status	δ_4	0.0002	0.0618	0.0033
Tenants experience	δ_5	0.0043	0.0047	0.9107
Agricultural income	δ_6	0.00000	0.00000	1.4141
Numbers of irrigation	δ_7	0.0636	0.0263	2.4162***
Sigma squared	$\sigma^2 = (\sigma_u^2 + \sigma_v^2)$	0.0197	0.0025	7.8009
Gamma λ	$\lambda = \sigma_u^2 / (\sigma_u^2 + \sigma_v^2)$	0.1413	0.3430	0.4153
Mean production efficiency	MPE			78%
Log likelihood	Ha			65.396%

Table 4: Maximum likelihood estimates for the parameters of the statistic frontier function and technical efficiency effect model for production of Sorghum.

The null hypothesis that there is no inefficiency effect was rejected, suggesting existence of inefficiency effects for sorghum farmers in Rahad Scheme.

Table 4 present maximum likelihood (ML) of sorghum stochastic frontiers coefficients of the stochastic frontier model for sorghum production model in Rahad Scheme have they expected signs. The coefficients of harvesting operation input have a positive sign the efficiency of sorghum increase with the increase of harvesting operation but are not significant. The coefficients of market factors input (transportation-packaging) have a positive sign and significant effect.

The estimated coefficients of education level have a positive sign but not significantly different from zero.

Positive sign of the parameter of education means that production efficiency of sorghum increase with increase in education level of farm operator's levels of education of farmers are indicators of the farmers' awareness and their abilities of taking decision on how and what to produce, approaching credit allocating their available resources and adopting new agricultural technologies. The coefficient of the location of the farm has a positive sign but is not significantly different from zero. This means that the farm near the irrigation canals has larger efficiency. The estimated coefficient of the improved seed has a positive sign and significant different from zero at 1.96 level of significant.

The coefficient of the experience of sowing sorghum has a positive sign but is not significantly different from zero. That means technical efficiency of the tenants increase with increase in experience of farmers. The coefficient of working time in the model for efficiency effect is estimated to be positive and not significant for sorghum production.

As shown in Table 2 for sorghum inefficiency, the estimated δ coefficient with explanatory variable in the model for inefficiency effects. The capital input (fertilizer, water rent) has appositive sign that means increase in capital lead to increase in the inefficiency model of sorghum production.

The coefficient of cultural practices has a positive sign and has no significant effect up on the inefficiency model for sorghum production.

The age of farmer has positive sign and significant, positive sign of coefficient of farmers' age for sorghum means that the inefficiency increases and decreases with increase and decrease in age of farm's operator, respectively. That means the older farmers have higher inefficiency than younger famers, or the older farmers are technically less efficient than younger farmers.

The marital status has appositive sign but it is not significant. The coefficient of experience of farmers has a positive sign and not significant the positive sign indicates that the inefficiency increases and decreases with increase and decrease in experience of farm's operator respectively. The coefficient of agricultural income in the model of inefficiency effects is estimated to be positive and not significant for sorghum production. This means that inefficiency increase with the increase of agricultural income. The coefficient of in sufficient number of irrigation have a significant impact on production in Rahad scheme the decrease in number of irrigation lead to increase in the inefficiency of sorghum production.

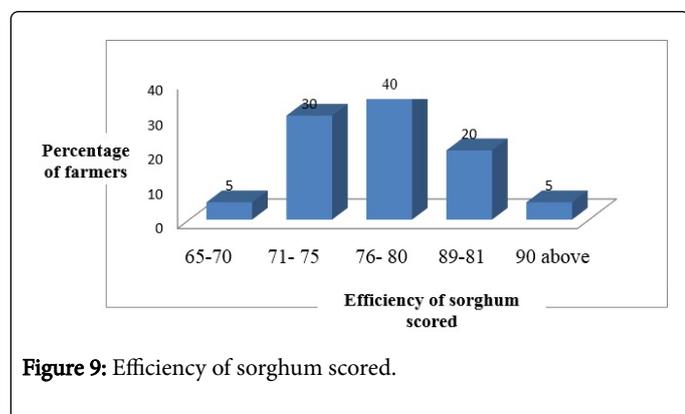


Figure 9: Efficiency of sorghum scored.

Frequency distribution of Tenant's technical efficiency

The tenants in Rahad Scheme have range of production efficiency from low 65% ages up to 92 high% for sorghum production. The frequency distribution of the efficiency estimates obtained from the stochastic frontier for sorghum production. Figure 9 shows that 40% of the tenants operate with the efficiency ranged between 76-80 levels of efficiency for sorghum. This implies that on average, the farmers producing sorghum in Rahad scheme achieved 78% of the potential stochastic frontier sorghum production level given their current level of production inputs and technology used.

Summary Conclusions and Recommendations

In this paper summary of the main result and some recommendations are presented.

Summary

This study was carried out in Rahad agricultural scheme. The main objective of the study is to measure and evaluate the production efficiency of sorghum practices in the Rahad scheme. The specific objectives are to identify the main factors behind the tenant's inefficiency, to identify the socio-economic factors affecting the level of efficiency of tenants, to develop specification and estimations of stochastic frontier econometric models for producing sorghum and draw some policy recommendations.

The paper used primary and secondary data. Primary data were collected by means of questionnaire using multistage stratified random sampling technique for tenants in the northern and central divisions of the scheme; the data cover the socio-economic characteristics of tenants, the quantities of the input used in sorghum agricultural practices. Secondary data collected from different institutional sources including Bank of Sudan, Ministry of Agriculture and Forests, Rahad Agricultural Corporation...etc.

The stochastic production frontier (SPF) analysis was used to estimate the production efficiency of sorghum in the scheme and to determine the factors behind inefficiency such as gender, age, educational level, marital status, and the family size. Also, descriptive statistics were used to analyze the socio-economic characteristics of farmers.

The results showed that most of estimated parameters of the stochastic frontier model for sorghum production model have the expected signs. The mean technical efficiency is 78% for sorghum crop. This means that the tenant can increase their output by 22% through the better use of available resources if the tenants are technically efficient. The marketing factor s (transportation-packaging-storage) and improved seed, insufficient number of irrigation are significant in explaining production efficiency in the Rahad scheme, while the gender, age, education level, marital status and tenants experience are not significant for sorghum production in the scheme.

The descriptive statistic of socio-economic characteristic of farmers in the scheme showed that most of the tenants in the study area are males (63%) with production efficiency of (80%). The age distribution range between (25-35) years with mean production efficiency of (88%) the tenants in the age group of (35-45) and (45-55) have same production efficiency (80%).

About 33% of the respondents received no education with the least mean efficiency 75%, while 8% of the tenants got a university

education with the highest production efficiency level of 87% in producing sorghum. 85% of the sample is married while 15% are single with the same level of production efficiency (78%) for the two groups.

The highest efficiency level is among farmers with a family size of (3-6) members and lowest is for those with a family size of more than 7 members.

Conclusions

Based on the results of the stochastic production frontier the following conclusions could be drawn from this study:

Tenants in Rahad scheme are efficient; the average production efficiency is 78% this indicates that tenants could increase output by 22% under the existing input and technology.

Market factors (transportation-packaging-storage) and improved seeds have a significant impact on production in Rahad scheme. The estimated coefficient of the improved seed has a positive sign and significantly different from zero at 1.96 level of significant. The water rent and harvesting operation and agricultural income have no significant impact for sorghum production. Location of the farm, experience of sowing sorghum has no significant impact for the production efficiency of sorghum. Working time in the field has a positive sign this indicator increase hour of working in field will increase the yield. Gender, age of tenants, marital status has no significant impact on sorghum production efficiency. The tenant in the age group of (25-35) has the highest production efficiency and the oldest tenants have the lowest production efficiency. The most efficient tenants have families of (3-6) members and the lowest efficient tenants have families of more than 7 members.

Recommendations

Lastly, to improve production efficiency for sorghum in Rahad agricultural Scheme the study recommended that:

- Improvement in education level
- Maintenance of irrigation canals
- Increasing working time in the field
- Provision of credit from formal financial institution for cultural practices
- Farmer should be aware and acknowledge the importance of crop rotation through the extension service

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