



Measuring the Efficiency Profile of Crop Production in Traditional Rainfed Sector of North Kordofan state, Sudan.

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ABSTRACT

The main objective of this study was to measure and analyzes economic efficiency of crop production in North Kordofan State. Secondary objectives included: estimate technical, allocative and economic efficiency and construct efficiency profile determination and the effect of socio-economic factors behind inefficiency. Primary data was collected by a structured questionnaire following stratified random sampling technique from 205 farmers, while secondary data was collected from relevant Institutional sources. The stochastic frontier production and cost function model analysis was used to estimate the technical, allocative and economic efficiency of producing crops. The predicted technical efficiency and economic efficiency are the basis for estimating allocative efficiency of farm. Results indicated that the mean technical efficiency of sorghum, millet, groundnuts and sesame were 0.57, 0.73, 0.53 and 0.74, respectively. The mean allocative efficiency of sorghum, millet, groundnuts and sesame production were 0.84, 0.83, 0.92 and 0.90, respectively. The mean economic efficiency of sorghum, millet, groundnut and sesame were 0.48, 0.62, 0.49 and 0.67, respectively. Farmers who have credit access are more technically efficient than those who have no credit access.

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Introduction

About 80 percent of the population in North Kordofan state depends on agriculture as their main source of food and income. The farming systems in the area are predominantly rain-fed, traditional, and operate with limited resources. They are characterized by the small size of holdings, being dependent on manual family labor, and using few or no external inputs such as fertilizers, chemicals or seeds. Farmers have poor access to information and relevant research results, and yields obtained are very low (Osman, 2007).

Traditional rain-fed agriculture at the present is the basis of economic and social development in the state. Agriculture is the main occupation of the 80% sedentary population in the region. Most livelihood activities and sources of income in the state revolve around agriculture. Livelihood activities include: rain fed traditional agriculture, horticultural activities, livestock and trade in livestock as major activities. The state offers more than 89 million feddans of arable lands. Only 8 million feddans (9%) is exploited for agriculture (melon seeds, hibiscus, gum Arabic and melon pulp), while 51 million feddans (57%) is used for grazing. The agricultural sector contributes to about 48% of non-oil exports of the state.

Traditional cultivation is widely practiced in North Kordofan state particularly in the central and southern

parts where rainfall is relatively higher. It forms the main occupation of settled communities and is increasingly practiced by nomadic and semi-nomadic groups to provide grains for household consumption. However, in years of good rainfall surpluses are produced and are channeled to local markets. Types of crops are closely related to soil type and moisture availability. Sandy soils are devoted mainly to millet (Dukhun) the staple food of the area and cash crops as sesame, groundnut, "Karkade" (roselle) and watermelon. Sorghum (Dura) is grown on clay and alluvial soils. Vegetables as okra, local type of cucumber (Tibish) and other vegetables are produced on small scale particularly on sites that receive runoff. Some households have own "Hashab" gardens for gum Arabic production. A large part of the holding is devoted to sorghum and millet the staple food of the households to ensure reasonable production which means food security. The average area under millet is 8 ha and for sorghum is around 3.5 ha according to the results of the Household Survey.

Materials and Method

Data for this paper were collected from both primary and secondary data. Primary data were collected from 205

farmers of groundnuts and sesame cash crops in north Kordofan state who were selected randomly from four localities namely Sheikan, Umrwaba, Elkhowi and El-Nuhoud. The data were collected through survey using a standard structured questionnaire.

Stochastic frontier analysis was used to analyze the technical efficiency, allocative efficiency and economic efficiency of sorghum, millet, groundnuts and sesame crops.

The Stochastic Frontier Production Function

The stochastic frontier production function was specified as:

$$\ln (y_i) = \beta_0 + \beta_1 \ln x_i + (v_i - u_i) \tag{1}$$

Where:

$\ln (y_i)$ is the logarithm of the (scalar) output of the i -th firm; x_i is a $(k+1)$ –row vector whose first element is “1” and the remaining elements are the logarithms of the K -input quantities used by the i - th firm; $b = (b_0, b_1 \dots b_k)$, is a $(K+1)$ - column vector of unknown parameters to be estimated; u_i is a non–negative random variable, associated with the technical inefficiency in production of firms assumed to be i.i.d $N(0, \sigma^2 v)$. v_i is random variable represents the statistical error which are assumed to be independently and identically distributed as normal random variable with mean zero and variance $\sigma^2 v$, i.i.d $N(0, \sigma^2 v)$.

The Stochastic Frontier Cost Functions

Tim Coelli (1996) cited that if we wish to specify a stochastic frontier cost function, we simply alter the error term specification from:

$$(V_i - U_i) \text{ to } (V_i + U_i).$$

For example, this substitution would transform the production function defined by (1) into the cost function:

The stochastic frontier cost function model for estimating farm level overall economic efficiency is specified as:

$$\ln C = \beta_0 \ln(Q) + \sum_{j=1} \beta_j \ln x_{ij} + (v_i + u_i) \tag{2}$$

Where:

\ln = the natural logarithm;

C = Total cost of inputs for sorghum, millet, groundnut and sesame.

Q = the output of sorghum, millet, groundnut and s

Where;

$\ln (c)$ is the (logarithm of the) cost of production of the i -th firm; x_i is a $k \times 1$ vector of (transformations of the) input prices and output of the i -th firm; β is an vector of unknown parameters; The v_i are random variables which are assumed to be iid $N(0, \sigma_v^2)$, and independent of the u_i which are non-negative random variables which are assumed to account for the cost of inefficiency in production, which are often assumed to be iid $|N(0, \sigma_u^2)|$.

In this cost function the u_i now defines how far the firm operates above the cost frontier. If allocative efficiency is assumed, the u_i is closely related to the cost of technical inefficiency. If this assumption is not made, the interpretation of the u_i in a cost function is less clear, with both technical and allocative inefficiencies possibly involved. The exact interpretation of these cost efficiencies will depend upon the particular application.

$$EE = 1/ CE \tag{3}$$

EE = Economic Efficiency
CE = Cost efficiency

That is EE is the inverse of CE.

$$AE = EE/TE \tag{4}$$

AE= = Allocative Efficiency

Results and Discussion

Distribution of Farmers' Efficiency Indices

The frequency distribution of farmers' technical efficiency, allocative efficiency and economic efficiency estimates obtained from the stochastic frontier analysis model is presented in Table 1, Figure 1, Figure 2 and Figure 3. It is clear from the histogram; it was observed that the farm efficiency varied from farmer to farmer. As shown in Table 1, the mean technical efficiency of sorghum, millet, groundnut and sesame is 0.57, 0.73, 0.53 and 0.744 respectively. It can be said that, on average, farmers in North Kordofan state are producing sorghum, millet, groundnut and sesame at about 57%, 73%, 53% and 74.4% respectively of the potential frontier production levels at the present state of technology and input levels. It also means that farms can reduce their inputs by 43%, 27%, 47% and 25.6% respectively, and still produce the same level of output.

As presented in Table 1. The predicted economic efficiencies (EE) for sorghum, millet, groundnut and sesame estimated as inverse of cost of efficiencies differs substantially among the farmers, the economic efficiency of sorghum ranging between 1% and 88% with a mean economic efficiency of 48%. Economic efficiency of millet was ranging between 4% and 96% with a mean economic efficiency of 65%. Economic efficiency of groundnut ranging between 1% and 96% with a mean economic efficiency of 92%. Economic efficiency of sesame ranging between 7% and 97% with a mean economic efficiency of 67%. This means that if the average farmer in the sample area were to reach the economic efficiency level of its most efficient counterpart, then the average farmer could experience a cost saving of 45.5% [i.e. $1-(48/88) \times 100$], 30.9% [i.e. $1-(61.5/89) \times 100$], 4.2% [i.e. $1-(92/96) \times 100$] and 31% [i.e. $1-(67/97) \times 100$] for sorghum, millet, groundnut and sesame respectively.

The predicted allocative efficiencies for sorghum, millet, groundnut and sesame of differ substantially

among the farmers estimated in Table 1 showed that. The allocative efficiency of sorghum was ranging between value 34% and 100% with the mean AE of 84%. The allocative efficiency of millet was ranging between 45% and 97% with the mean AE of 83%. The allocative efficiency of groundnut was ranging between 59% and 98% with the mean AE of 92%. The allocative efficiency of sesame was ranging between value 67% and 100% with the mean AE of 90%. This implies that if the average farmer in the sample was to achieve AE level of its most efficient counterpart, then the average farmer could realize cost saving of, 66% [i.e. $1-(34/100) \times 100$], 44% [i.e. $1-(54/97) \times 100$], 39.8% [i.e. $1-(59/98) \times 100$] and 33% [i.e. $1-(67/100) \times 100$] for sorghum, millet, groundnut and sesame respectively.

Frequency distribution of farmers technical efficiencies: As shown in Table 1 and Figure 1, the frequency distribution of farmers' technical efficiency for sorghum was ranging between 1.4% and 93% with a mean technical efficiency of 57%. The frequency distribution of technical efficiency of sorghum indices showed that 32.7% of farmers obtained technical efficiency bellow mean technical efficiency while 64.4% of farmers have a technical efficiency level greater than mean efficiency, and majority of farmers (36.6%) or the highest class have technical efficiency ranged between (70% and 80%).

The frequency distribution of millet ranged between (5.3% and 94%) with a mean of 73%. It was found that about 15.5% of millet farmers obtained technical efficiency bellow mean technical efficiency, and 84.5% of farmers have technical efficiency more than 70%. However, majority of millet farmers (41.5%) in north Kordofan state with efficiency (70% and 80%).

For groundnut, the technical efficiency indices ranged between (0.22% and 100%) with an average of 53%. The frequency distribution of sorghum and millet results is in line with the findings of Mohamed (2007) who found that the majority of farmers operate within technical efficiency class between (70% and 80%).

The frequency distributions of farmers' groundnut reveal that the maximum farmers' technical efficiency has been observed to be in the range of (80% and 90%) and the majority of farmers (47.9%) obtained technical efficiency bellow the average efficiency (53%).

The frequency distribution of sesame farmers' technical efficiency was ranged between (8.4% and 98%). The majority of sesame farmers (53.6%) have a technical efficiency observed to be in range of (80% and 90 %.)

The level of technical efficiency of groundnut and sesame observed in this study appears to be higher than the (50% and 60%) efficiency reported by Bravo-Ureta and Evenson for farmers in eastern Peru, higher than (70% and 80%) technical efficiency reported by Mohamed (2007) for farmers in Southern Kordofan of Sudan and in line with the finding reported by Himayatullah and Saeed (2011) for farmers in Pakistan.

Frequency distribution of farmers allocative efficiency: Figure 2 reveals that the frequency distribution of farmers' allocative efficiency for sorghum, millet, groundnut and sesame is vary from 34% to 100% for sorghum, 54% to

97% for millet, 59% to 98% for groundnut and 67% to 100% for sesame. The maximum farm allocative efficiency has been observed to be in the range of (80% and 90%) for millet and in the range of (90 and 100%) for sorghum, groundnut and sesame. These results indicate that the farmers had relatively larger farms, had relatively higher level of education, were comparatively younger, and had more experience. The level of allocative efficiency observed in this study appears to be higher than the finding of Himayatullah and Saeed (2011) which found the farmers' class (50% and 60%) had higher allocative efficiency or the majority of farmers operate within allocative efficiency level between (50% and 60%). While the frequency distribution of sorghum, groundnut and sesame allocative efficiency level is in line with the finding of Ogundari and Ojo (2006).

Frequency distribution of farmers economic efficiency: The economic efficiency is a combination of technical and allocative efficiency and can be obtained by multiplying technical efficiency and allocative efficiency. It was observed that the farmers' economic efficiency ranged from 1-88% with mean economic efficiency 48% for sorghum, (4% and 89%) with mean of 61.5% for millet, (0.13% and 96%) with mean of 49% for groundnut and (7% and 97%) with mean of 67% for sesame.

The frequency distributions of farmers economic efficiencies obtained from the stochastic model are presented in figure (3) showed that 36% of sorghum farmers operated below efficiency level of 50%, while the majority of sorghum farmers (59.1%) were economically efficient attained efficiency level greater than 50%.

For millet, the frequency distribution of the efficiency estimates obtained showed that the maximum farm economic efficiency has been observed to be in the range of 80-90%.

For groundnut, the frequency distribution of the economic efficiency estimates obtained from the stochastic frontier model showed that about 42% of the farms operate at less than (40-50%) efficiency level while 50% of the farms had economic efficiency exceeding the average economic efficiency of groundnut.

For sesame, the economic efficiency indices range from 7 to 97% with an average of 67%. The level of economic efficiency observed appears to be about 57.5% of farmers operate at efficiency level greater than 67%, while only 28.3% of sesame farmers operate at less than the average economic efficiency.

Efficiency Profile in North Kordofan State

Based on the model discussed in the previous section, figures (4, 5, 6 and 7) present the maximum likelihood (ML) estimates of the production and cost function parameters for efficiency profile for sorghum, millet, groundnut and sesame (mean technical, allocative and economic efficiency).

The measurement of efficiency profile (technical, allocative and economic), to investigate how efficiency varies according to characteristics of households (educational level, gender, credit access and extension contacts).

Table 1 Summary statistics of efficiency estimates

Statistics	Efficiency score											
	Sorghum			Millet			Groundnut			Sesame		
	TE	AE	EE	TE	AE	EE	TE	AE	EE	TE	AE	EE
Mean	0.57	0.84	0.48	0.73	0.83	0.615	0.53	0.92	0.49	0.744	0.90	0.67
Minimum	0.014	0.34	0.01	0.053	0.54	0.04	0.022	0.59	0.01	0.084	0.67	0.07
Maximum	0.93	1	0.88	0.94	0.97	0.89	1	0.98	0.96	0.98	1	0.97
St.deviation	0.28	0.14	0.26	0.19	0.12	0.18	0.32	0.079	0.30	0.263	0.11	0.25

Source: Field survey, TE means technical efficiency; AE mean allocative efficiency and EE mean economic efficiency

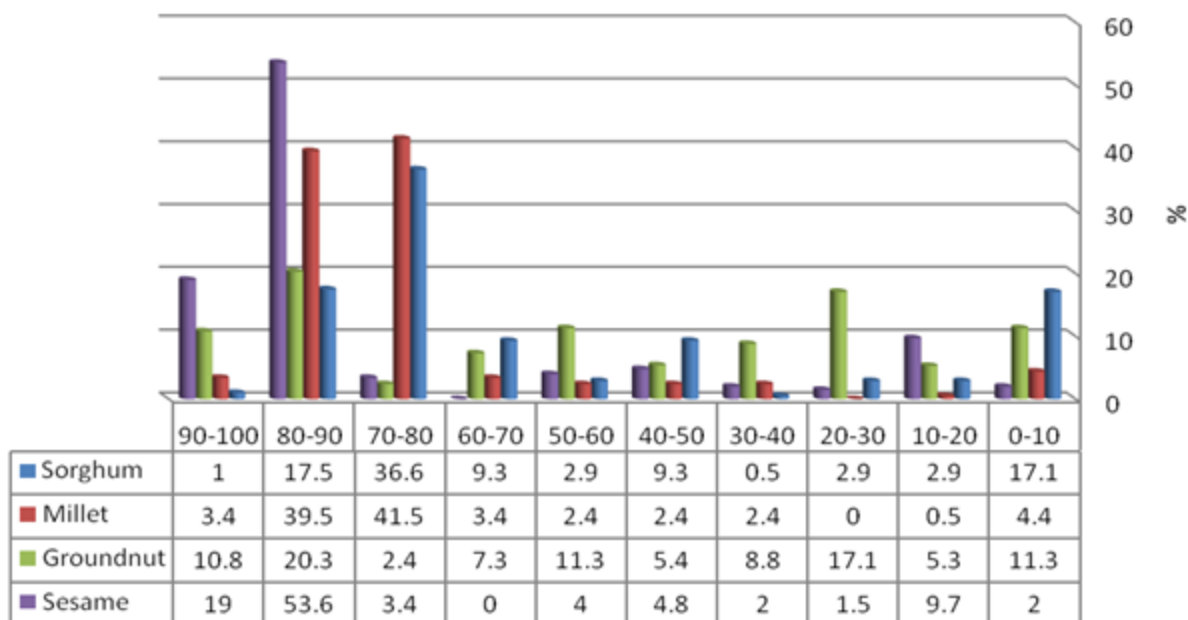


Figure 1 Percentage distribution of farmers' technical efficiency score, Source: derived by author, 2013

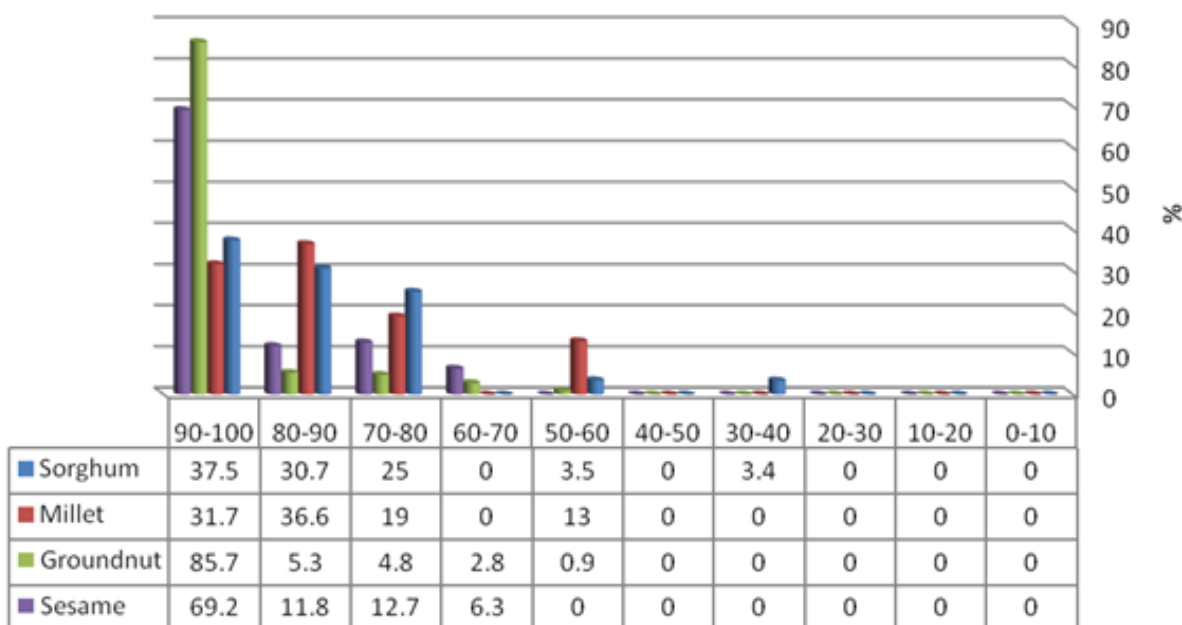


Figure 2 Percentage distribution of farmers' allocative efficiency score, Source: derived by author, 2013

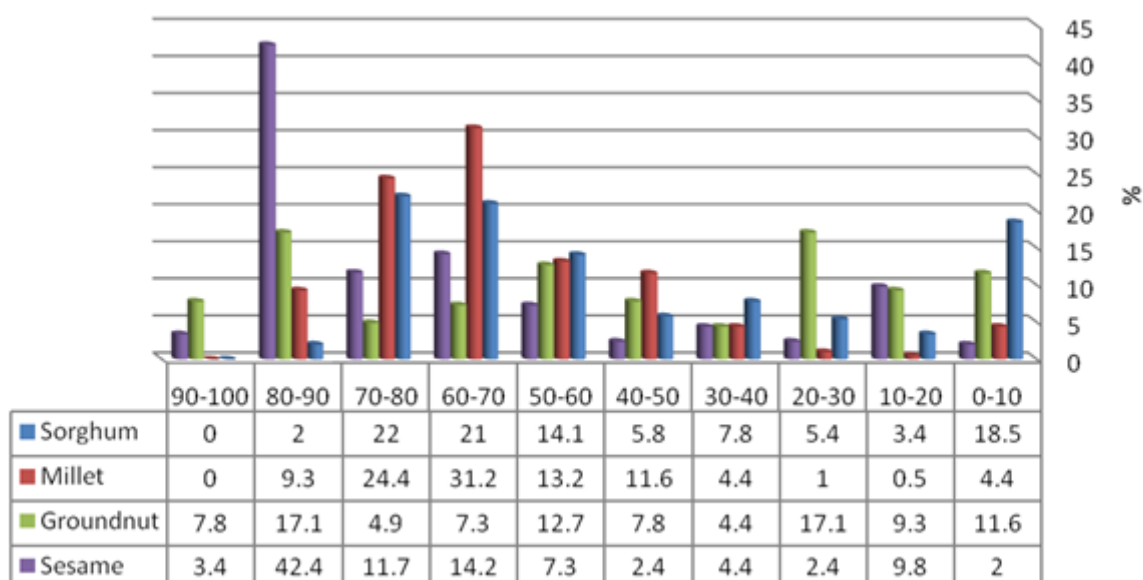


Figure 3 Percentage distribution of farmers economic efficiency score, Source: derived by author, 2013

Educational level: The results of sorghum, millet, groundnuts and sesame maximum-likelihood estimate for the parameters of the stochastic frontier function model results reveal that the mean technical efficiency and mean economic for all crops according to heads of family educational level showed that the high technical efficiency among households heads had a university education followed by secondary education, primary education and illiterate. Various studies have found a positive connection between technical efficiency, allocative efficiency and economic efficiency and education. This finding agrees with comparable findings by Battese et al. (1996), Coelli and Battese (1996), Seyoum et al (1998), Mohamed (2007), Ado (2010) and Himayatullah and Saeed (2011).

The implication is that farmers with higher education schooling tend to be more efficient in crop production, because education enhance the ability of farmers to make good use of information about production inputs and acquire technical knowledge which makes them move close to the frontier output, thus improving the efficient use of inputs. It is very plausible that the farmers with education respond readily to the use of improved technology.

Credit access: The distribution of farmers according to credit access showed that the average technical efficiency, average allocative efficiency and average economic efficiency of sorghum, millet, groundnut and sesame are higher among farmers who have credit access than farmers who had no credit access. This implies that the farmers who have credit access are more technical efficient than farmers who had no credit access. Also, the availability of credit helps to finance purchased inputs which has positive effect on the productivity of farmers. This is in line with Okike et al (2001), Ahmed (2004) and Amaza et al (2006) showed that receiving credit contributed to farmers' efficiency. If production credit is invested on the farm, it is expected that this will lead to higher levels of output.

Extension contact: The distribution of farmers according to extension service contact results showed that: For groundnut and millet, the average technical efficiency, allocative efficiency and economic efficiency are greater among farmers who have extension services contacts than farmers without extension services. For millet and sesame, the mean technical efficiency is higher among farmers have contacts with extension service than farmers without extension services, while the mean allocative efficiency of sorghum and sesame and mean economic efficiency of sorghum showed a high efficiency among farmers who have no extension contact.

The findings of millet and groundnut show that extension visits important factor in determining efficiency. This is in consistent with several other studies that have found a positive connection between farm level efficiency and availability of extension services; Kaliranjan and Shand, 1985; Bravo-Ureta et al, 1994). While the finding of sorghum and sesame agreed with the above finding from technical efficiency side and disagree from a side of allocative efficiency and economic efficiency. This because the extension service contact increase cost inefficiency and decrease allocative efficiency and economic efficiency.

Gender: The results also showed that the mean technical efficiency, allocative efficiency and economic efficiency for producing sorghum, and millet, (food crop) for female-headed households are found to be more efficient than their male-headed households. This underlies the important role that females have in agricultural production apart from their burden in household chores, otherwise, reflects the importance of food crops for female headed households to provision of sustenance that achieve self-sufficiency and food security. While the mean technical efficiency, allocative efficiency and economic efficiency of farmers for cash crops (groundnut and sesame) showed that the male-headed households were more efficient than female-headed households. This result reflects the interesting and

focusing of male head households more on cash crops and then planting large areas in order to achieve the greatest possible return which may help to increase income for providing non-consumed goods requirements of family which including the provision of clothing, school fees for students, medicine and all other non food expenditure.

Conclusion

This study used stochastic frontier approach analysis to estimate the efficiency profile of agricultural

production in North Kordofan state of Sudan. The study results showed that the farmers who had credit access is more efficient than farmers who had no credit access. The results also showed that the mean technical efficiency, allocative efficiency and economic efficiency for producing sorghum, and millet, (food crop) in case of female-headed households were more efficient than their male-headed households. While the mean technical efficiency, mean allocative efficiency and mean economic efficiency of farmers for cash crops (groundnut and sesame) showed that the male-headed households were more efficient than the female-headed households.

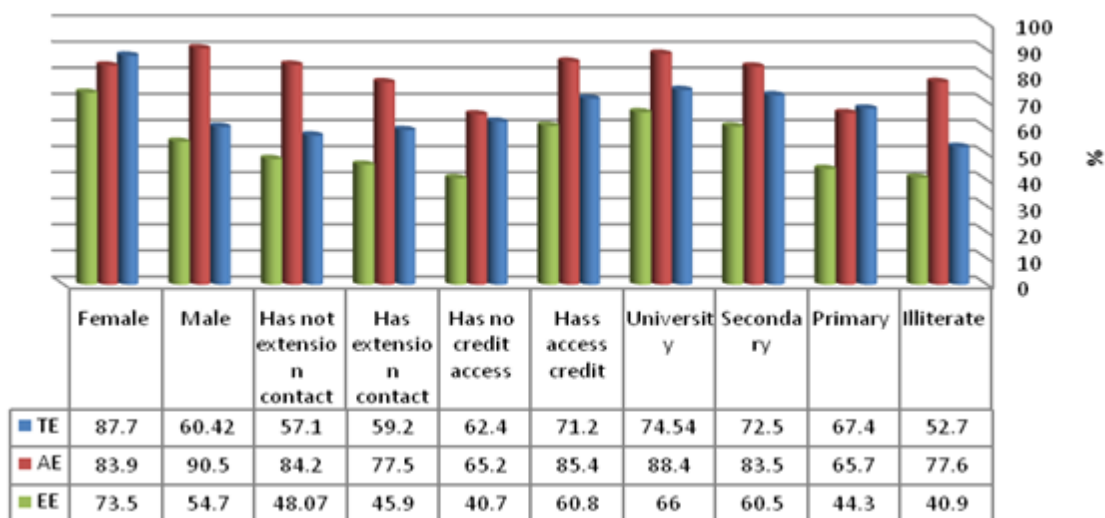


Figure 4 Sorghum mean efficiency profile in North Kordofan State, Source: Derived by author, 2013

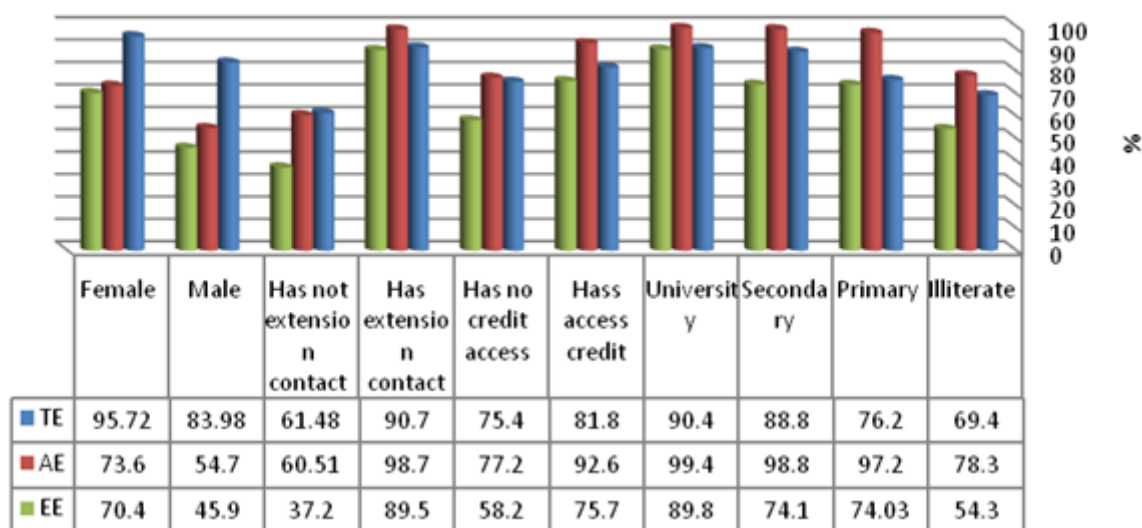


Figure 5. Millet mean efficiency profile in North Kordofan State, Source: Derived by author, 2013

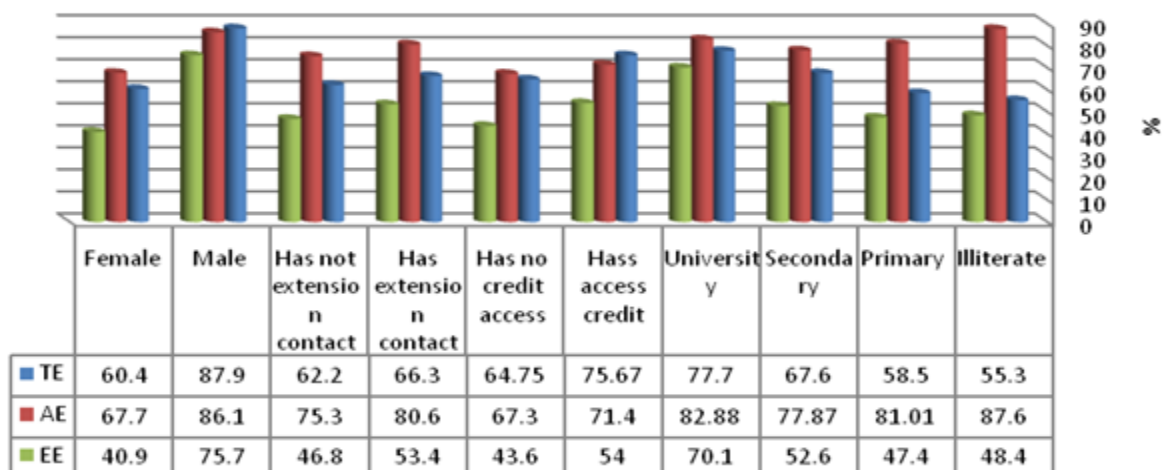


Figure 6 Groundnut mean efficiency profile in North Kordofan State, Source: Derived by author, 2013

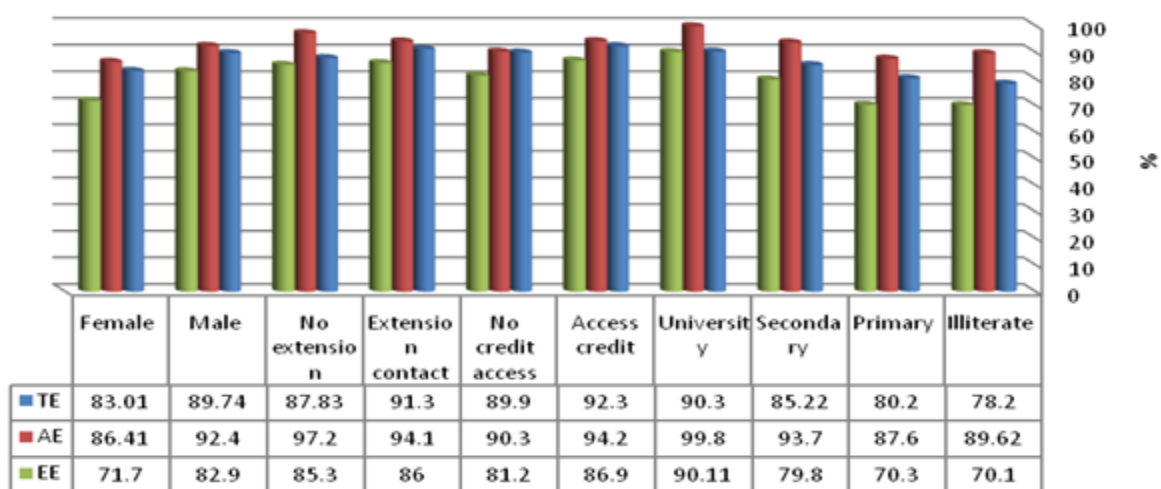


Figure 7 Sesame mean efficiency profile in North Kordofan State, Source: Derived by author, 2013

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