Efficiency Improvement of Small Sorghum Farms in India and Nigeria

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I. INTRODUCTION

Sorghum is an important feed to human and animal used in countries like the United State, India, Mexico, South America, Nigeria and Australia. Good-quality sorghum is available with a nutritional feeding value that is equivalent to that of corn. Sorghum can be processed to further improve and increase its feed value and techniques such as grinding, steam flaking, crushing popping, steaming and extruding have all been used to enhance the grain for feeding. The products are then fed to beef, dairy cattle, swine, laying hens, poultry, sheep, and are used in pet foods. As much as 12 percent of domestic sorghum production also goes to produce ethanol and its various products. With the demand for renewable energy fuel sources increasing, demand for products like sorghum-DDGS (sorghum distiller's dried grains with soluble) will increase as well due to sorghum's favourable nutrition profile.Sorghum is about 70% starch, so is a good energy source. Its starch consists of 70 to enzymatic digestion.On cooking, the gelatinized starch of sorghum tends to return from the soluble, dispersed and amorphous state to insoluble 80% amyl pectin, a branched-chain polymer of glucose, and 20 to 30% amylase, a straight-chain polymer. Sorghum is the rich in protein, magnesium, copper and iron as compared to wheat, corn and rice (table below).

NUTRITIONAL VALUE OF SORGHUM AS COMPARED TO WHEAT, CORN AND RICE

Nutrient	Sorghum 100 g	Wheat 100g	Corn 100g	Rice 100g
Energy	339.0	342	365	360
Protein	**11.3**	**11.31**	**9.42**	**6.61**
Total Fat	3.3	1.71	4.74	0.58
Calcium	28	32	7	9
Magnesium	**190**	**93**	**127**	**35**
Copper	**1.08**	**0.363**	**0.314**	**0.110**
Iron	**4.4**	**4.56**	**2.71**	**0.81**

Sorghum is a good source of B-complex vitamins. Some varieties of sorghum contain β-carotene which can be converted to vitamin A by the human body; given the photosensitive nature of carotenes and variability due to environmental factors, scientists claim sorghum is likely to be of little importance as a dietary source of vitamin A precursor. Some fat-soluble vitamins, namely D, E and K, have also been found in sorghum grain in detectable, but insufficient, quantities. Sorghum as it is generally consumed is not a source of vitamin C.

Sorghum has a high yield potential and the highest recorded yield for the crop is 20.1 tons per hectare. However, yields in Africa and India remains very low due to many factor related to low technology. The United States harvested approximately 9.7 million acres of sorghum in 2014 and production is concentrated in the central and southern plains of five states - Kansas, Texas, Nebraska, Oklahoma and Missouri (listed in ranking order) - representing approximately 89 percent of total production. As a continent, Africa is the largest producer of sorghum with approximately 21.6 million metric tons (850.6 million bushels) produced annually. The leading producers around the world during the fiscal year 2014 include the United States (10.25 million metric ton), Nigeria (6.30 million metric tons), Mexico (7.0 million metric tons) and India (5.00 million metric tons).

Sorghum is one of the most drought tolerant cereal crops currently under cultivation. It offers farmers the ability to reduce costs on irrigation and other on-farm expenses. Having better nutritional value, the sorghum has taken an important place in the consumption basket of high income group people. Minimum Support Price as well as market price is also higher than the other cereals like wheat, maize and paddy. Sorghum in India is a grown by small farms in rainfed regions. Despite the significant growth in sorghum production, there is huge inefficiency in the production system of sorghum production. An improvement in the efficiency of production system will have direct positive impact on agricultural growth, nutritional security and rural livelihood in a country like India and Nigeria, where sorghum is one of the major crops.

The productivity growth may be achieved through either technological progress or efficiency improvement (Coelli, 1995). Several studies indicated that the existing low levels of efficiency hinder efforts to achieve progress in production (Beleteet al., 1991; Seyoumet al., 1997). This study was conducted to examine the technical, allocative and economic efficiency of sorghum farms in India and Nigeria.

II. METHODOLOGY

In India the second highest sorghum producing state Karnataka was purposively selected. The state has six Divisions with 28 Districts; two highest sorghum producing districtsviz.Tumkur and Bijapur were selected purposively. Two villages from Tumkur and two villages from Bijapur(viz. Harati, Belladamadugu, Markabinahalli and Kappenimbergi were purposively selected on the basis maximum Sorghum production.Where by 240 sorghum farmers were extracted from a penal data for the study. Adamawa State on the basis of highest production level was selected purposively in Nigeria. The state has twenty-one Local Government Areas which are categorized into four agricultural zones; South West, Central, North West and North East Zone. Twenty percent Local Government Area have been (i.e four LGA) have been purposively selected from each zone, comprise Viz, Mubi south; Ganye, Guyuk and Girei. The data pertained to year 2013 cropping season, primary data from farmers were collected from Adamawa, Nigeria which also pertained to 2013 cropping season. Secondary data were collected from publications and ministry of Agriculture, India. while Primary data was collected directly from 240 sorghum farmers from Nigeria. Thus the total sample size was 480.

III. ANALYTICAL TOOL

Technical efficiency (TE) is the ratio of actual output to the potential output on the deterministic frontier production function and it was calculated as per Timmer's measure.

$$TE_i=\frac{Yi}{Yi*} \quad \text{or} \quad lnTE_i = lnY_i - lnY_i^* \text{ ………………. (4)}$$

TE_i =Technical efficiency of $_i$th farm

Y_i= Actual gross return in Rs. Per hectare of $_i$th farm

Y_i*=potential output (maximum output of $_i$th farm at present input use

ln = natural logarithms

Yi* is estimated by substituting ith farmers level resources into the estimated deterministic frontier production function. Kopp (1981) suggested an alternative approach within the Farrell framework. Here the measure of technical efficiency compared the actual level (Xi) of input used to the level (Xi*) at which it should be used, by farm 'i', to obtain the same output Y, but at the efficient level. This level of input (Xi*) to realize the same output Y is calculated as follows.

If, $1n\ Y = b0^* + b1\ lnX1 + b2\ lnX2 + \text{……..} + e$

$$\text{Let } R1 =\frac{X1}{X2}, R2 =\frac{X2}{X2} \text{…… } Rn\text{-}1 =\frac{Xn}{X2}$$

Then,

$$lnX_2 = \frac{lny-b0-b1lnRn-1}{\sum_{i=1}^{n} bi} \text{…………..(5)}$$

$1nX_1$*, $1nX_3$*………. 1nXn* is calculated in a similar fashion.

X_1*, X2*, X3*, X4* …Xn* indicate the frontier values of the corresponding input use. Then, the technical efficiency of the ith farm would be:

$$TEi=\frac{X2*}{X2}, =\frac{X1*}{X1},\ldots =\frac{Xn*}{Xn}\text{------------------(6)}$$

Using Kopp measure of technical efficiency the frontier usage of input was worked out and compared with the actual usage of inputs to know the savings in input use had the sorghum farm operated at higher efficiency level.

Allocative efficiency measures the degree of correctness in the adoption of factor proportions to current input prices. A producer is allocatively efficient if production occurs in a sub set of the economic boundary of the production possibilities set that satisfies the producer's behavioral objective.

The Allocative Efficiency (AE) in the use of variable inputs is worked as the ratio of,

AEij=MGRj/ OGRij

Where,

MGRj= Maximum possible gross revenue of the j^{th} farmers'

OGRij= Gross revenue at the optimum level of the i^{th} input with all input remaining at the same level of the activity by j^{th} farmers'

Farm specific optimum input level (Xij) equated by marginal value product of an input with its price.

Xij*= [Pi/bo*]-1/ [1-bi]

Pi= per unit price of input (i)

$b_o =$ bi $= \sum_{i=0}^{n-1} \text{bi}$

In order to determine optimal use of a resource, keeping the use of other resources constant, MVP and opportunity cost (factor cost) of that resources were compared. The marginal product (MP) was estimated from the parameters of Cobb-Douglas production function and the geometric mean levels of the output and input. The MVP of each resource was calculated. The formula used to compute MVP is:

MVP (Xi) = bi $.\frac{Y^{-}}{X^{-}i}$. P_y……………4)

Where,

bi = Elasticity of production of i^{th} input

$\overline{Y}$ = Geometric mean of output

$\overline{X}$i = Geometric mean of ith input

Py = Price of the product

The criterion for determining optimality of resource use was,

MVP/MFC > 1 underutilization of resource

MVP/MFC = 1 optimal use of resource

MVP/MFC < 1 excess use of resources

COST FUNCTION

$$LnC_y=\beta_0+\beta_1L_nP_1+\beta_2L_nP_2+\beta_3L_nP_3+\beta_5L_nP_5+\beta_5L_nP_5+\beta_6L_nP_6+\beta_7L_nP_7+V_i-U_i \quad (9)$$

Where:

Ln=Logarithm to base e

C_y=Total production cost (₦/ha) of the i^{th} farmer

P_1=Cost of land

P_2=Cost of hired labour (in man days)

P_3=Cost of family labour (in man days)

P_5= Cost of seed in kg

P_5=Cost of fertilizer in kg

P_6=Cost of herbicide in litres

V and U as previously defined above

ECONOMIC EFFICIENCY

Economic Efficiency is combination of both technical and allocative Efficiencies. Technical and allocative efficiencies are mutually exclusive and simultaneous achievement of both efficiencies provided sufficient condition to ensure economic efficiency.

TEj= Actual output/Potential output

AEj= Optimum output/Actual output

EEj =TEj x AEEj

Where;

TEj = farm specific technical efficiency of j^{th}farmer

AEEj = allocative efficiency of all input on j^{th}farm

IV. RESULTS AND DISCUSSION

It is revealed from table 1 that farm size is the most important factor of production having an elasticity of 0.5901 and 0.2152 for India and Nigeria respectively, indicating `that the output in sorghum production is inelastic to changes in the level of cultivated land area. A 1% increase in hectares of land used in production ce*teris paribus,* would increase the total output of sorghum by almost 0.6% and 0.2% for India and Nigeria respectively

TABLE 1
MAXIMUM LIKELIHOOD ESTIMATES OF THE PARAMETERS OF THE STOCHASTIC FRONTIER PRODUCTION FUNCTION

Variable Production factors		India		Nigeria	
	Parameter	Coefficient	t-ratio	Coefficient	t-ratio
Constant	β_0	5.4426***	14.7894	2.8465***	9.7321
Farm size (X1)	β_1	0.5901***	4.9384	0.2152***	3.3895
Labour (X2)	β_2	0.2773**	2.1424	0.1952**	2.1981
Seed (X3)	β_3	0.1726***	3.1038	0.2061**	2.3258
Fertilizer (X4)	β_4	0.1489	0.9850	-0.0091	-0.5849
Chemicals (X5)	β_5	0.0467	0.8680	0.0490	1.4212
Diagnostic statistics					
Sigma squared (d^2)		0.1836***	7.1208	0.6688***	5.2574
Gamma (΄Υ)		0.4382***	3.6641	0.4530***	0.1368

**** Estimates are significant at1% level, ** Estimates are significant at 5% level.*
**Estimates are significant at 10% level*

This suggests that land is a significant factor associated with changes in sorghum output. This is in harmony with the study of Maurice et al., (2005) ,Zalkuwi (2014) and Daniel et al.,(2013).Subsequently labour and seeds were also important factor in the sorghum production in both India and Nigeria , so from the results, it was revealed that farm size, labour and seed are important factor in sorghum production in both areas while fertilizer and chemicals are not significant factor in the sorghum production . This same pattern in the factors significant and insignificant may be as because of the two countries are developing countries and might be operating at the same level of production .So if you want to increase the viability of sorghum production in the study areas there is need to increase the farm land , labour and quantity of seed in the production

TABLE 2
TECHNICAL EFFICIENCY RATING OF THE SORGHUM FARMERS

Efficiency	India		Nigeria	
	Frequency	**Percentage**	**Frequency**	**Percentage**
<0.40	13	16.25	2	0.8
0.40 – 0.49	4	5.0	12	5.0
0.50 – 0.59	6	7.50	24	10.0
0.60 – 0.69	15	18.75	22	9.2
0.70 – 0.79	14	17.50	64	26.7
0.80 – 0.89	22	27.50	78	32.5
0.90 – 1.00	6	7.50	38	15.8
Total	80	100	240	100
Minimum efficiency	0.1076		0.353	
Maximum efficiency	0.9375		0.964	
Mean efficiency	0.6312		0.775	

Source: Computed from Stochastic Frontier Result

The distribution of technical efficiency of the farmers in table 2 reveals that about 21.25% had technical efficiency of less than 50 percent, while about 26.25% had technical efficiency of 50-69 percent. 52.50% of the respondents had technical efficiency of 70% and above in India. the distribution of technical efficiency of the farmers in Nigeria reveals that about 6% had technical efficiency of less than 50 percent, while about 19% had technical efficiency of 50-69 percent, 75% of the respondents had technical efficiency of 70% and above The magnitude of the mean technical efficiency of the farmers is a reflection of the fact that most of the sampled farmers carry out sorghum production under technical conditions, involving the use of inefficient tools, local seed varieties and so on

TABLE. 3
MAXIMUM LIKELIHOOD ESTIMATE OF THE PARAMETERS OF THE STOCHASTIC COST FUNCTION

VariableCosts	Parameter	Coefficient	t-ratio	Coefficient	t-ratio
Constant	β_0	6.0650***	6.1501	4.5348***	25.0180
Cost of land (P1)	β_1	0.3884**	2.3783	0.1554***	4.3465
Cost of labour (P2)	β_2	0.6254***	3.2387	0.0092	0.8391
Cost of seed (P3)	β_3	0.3299	1.0650	0.1105***	2.6001
Cost of fertilizer (P4)	β_4	0.3474***	3.3047	0.2780**	2.522
Cost of chemical (P5)	β_5	0.0233	0.3901	0.0269	1.6628
Diagnostic statistics					
Sigma squared (d^2)		0.4491***	0.4637	0.7123***	6.4063
Gamma (ϒ)		0.3672***	0.3148	0.8314***	3.842

Source: Calculated from collected data
***** Significant at 1% **Significant at 5%*Significant at 10%**

The maximum likelihood estimates of the parameters of the stochastic cost frontier model used in estimating allocative efficiency is presented in Table 3**.** Three parameters out of five estimates have the expected sign and are statistically significant ,ie cost of land (P_1), cost of labour (P_2), cost of fertilizer (P_4) while cost of seed (P_3) and cost of chemical (P_5) are not statistically significant, meaning that these factors(cost of land, labour and fertilizer are important determinants of total cost associated with sorghum production in the study area. The cost elasticities with respect to this three input variables used in the production analysis are positive, implying that an increase in the cost of land, cost of labour, cost of fertilizer increases total production cost. That is, 1% increase in the cost of land will increase total production cost by approximately 0.388%, 1% increase in the cost of labour will increase total production cost by 0.63%, 1% increase in the and cost of fertilizer will increase total production cost by 0.35%.While in Nigeria Three parameters out of five estimates have the expected sign and are statistically significant, ie cost of land (P_1), cost of labour (P_2), cost of fertilizer (P_4) while cost of seed (P_3) and cost of chemical (P_5) are not statistically significant, meaning that these factors (cost of land, labour and fertilizer are important determinants of total cost associated with sorghum production in the study area. The elasticities with respect to these three inputs used in the production are positive, implying that an increase in the cost of land, cost of labour, cost of fertilizer increases total production cost. That is, 1% increase in the cost of land will increase total production cost by approximately 0.1554%, 1% increase in the cost of seed will increase total production cost by 0.1105%, 1% increase in the and cost of fertilizer will increase total production cost by 0.2780%.

The estimated gamma parameters (γ) and the Sigma squared (σ^2) were statistically significant at 1% level indicating correctness of fit of the model as assumed for the composite error term.

TABLE 5
ALLOCATIVE EFFICIENCY RATING OF THE SORGHUM FARMERS

Efficiency	India		Nigeria	
	Frequency	Percentage	Frequency	Percentage
<0.40	17	21.25	24	10.0
0.40 – 0.49	4	5.00	50	20.8
0.50 – 0.59	15	18.75	52	21.7
0.60 – 0.69	12	15.00	54	22.5
0.70 – 0.79	19	23.75	50	20.8
0.80 – 0.89	13	16.25	10	4.2
0.90 – 1.00	0	0	0	0
Total	80	100	240	100
Minimum efficiency	0.2080		0.1156	
Maximum efficiency	0.8664		0.8709	
Mean efficiency	0.6128		0.5802	

The distribution of farmers' allocative efficiency indices derived from the analysis of the stochastic cost function is presented in Table 4. The allocative efficiency of the sampled farmers ranged from 0.2080 to 0.8664. The mean allocative efficiency is estimated to be 0.6128, meaning that an average farmer in the study area has the scope for increasing allocative efficiency by 39% in the short-run under the existing technology. This would enable the average farmer equate the marginal value product (MVP) of the inputs to the total production while for Nigeria the distribution of farmers' allocative efficiency indices derived from the analysis of the stochastic cost function is presented in Table 5. The allocative efficiency of the sampled farmers ranged from 0.1156 to 0.8709. The mean allocative efficiency is estimated to be 0.5802, meaning that an average farmer in the study area has the scope for increasing allocative efficiency by 42% in the short-run under the existing technology. This would enable the average farmer equate the marginal value product (MVP) of the inputs to the total production

TABLE 6
ECONOMIC EFFICIENCY RATING OF THE SORGHUM FARMERS

India			Nigeria	
Efficiency	Frequency	Percentage	Frequency	Percentage
<0.40	37	46.25	98	40.8
0.40 – 0.49	14	17.50	46	19.2
0.50 – 0.59	16	20.00	38	15.8
0.60 – 0.69	9	11.25	34	14.2
0.70 – 0.79	2	2.5	18	7.5
0.80 – 0.89	1	1.25	6	2.5
0.90 – 1.00	0	0	0	0
Total	80	100	240	100
Minimum efficiency	0.0761		0.0912	
Maximum efficiency	0.8021		0.8356	
Mean efficiency	0.4008		0.4515	

It is evident from table 6that economic efficiency of sorghum farmers ranged from 0.08 – 0.80. More than 46% respondents had economic efficiency of 40% and below, while about around 18% had economic efficiency of 41-50%, 20.50% of the respondents had economic efficiency of 51- 59%, 13.75% had economic efficiency of 51-80%, while only 1.25% had economic efficiency above 80%. The mean economic efficiency is 0.40, indicating that sorghum farmers are fairly economically efficient in the use of production resources while The distribution of the farm efficiency for sorghum production in Nigeria shows that only (41 %) of them operated below 40 % of their maximum efficiency and 59 % operated above 40%. The mean efficiency is 45%

V. CONCLUSION

Sorghum is one of the most drought tolerant crop grown in rainfed regions by small farmers. Having better nutritional value, the sorghum has taken an important place in the consumption basket of high income group people. Minimum Support Price as well as market price is also higher than the other cereals like wheat, maize and paddy. Despite the significant growth in sorghum production, there is huge inefficiency in the production system of sorghum production. The analysis of economic efficiency indicated there exists a scope of increase by 60 percent in India and 55 percent in Nigeria.Therefore it is suggested that in the climatic change scenario sorghum farmers in rainfed regions should be well trained to exploit the full potential of resources so that their income can be enhanced by more than 60 percent.theefficiency of production system will have direct positive impact on agricultural growth, nutritional security and rural livelihood in a country like India and Nigeria, where sorghum is one of the major crops.

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