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Full Length Research Paper

Economic efficiency of small scale soyabean farmers in Central Agricultural Zone, Nigeria: A Cobb-Douglas stochastic frontier cost function approach

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This study employed the Cobb-Douglas stochastic frontier cost function to measure the level of economic efficiency and its determinants in small scale soyabean production in Central Agricultural Zone of Nigeria. A multistage sampling procedure was used to select 485 soyabean farmers in the Zone, in 2010, from whom input-output data and their prices were obtained using the cost-route approach. The parameters of the stochastic frontier function were obtained using the maximum likelihood method. The result of the analysis showed that average economic efficiency was 52%. The study found age, farm size and household size to be negatively and significantly related to economic efficiency at 5 and 1%. Education, farming experience, access to credit and fertilizer use were significantly and positively related to economic efficiency. No significant relationship was found between economic efficiency and extension contact and membership of farmers' association. It was recommended that policies that will increase farmers' economic efficiency level be targeted at improving their educational levels and easy access to credit and fertilizer, while experienced farmers should be encouraged to remain in soyabean farming.

Key words: Cobb-Douglas stochastic frontier cost function, economic efficiency, small scale soyabean farmers

INTRODUCTION

Soyabean (*Glycine max* (L) Merr), "the miracle seed", is the world most important oilseed legume with respect to total production and international trade (Salunke et al., 1992). It is a versatile crop from which products like soyabean oil, soyabean milk, soyabean "fufu'', soyabean "dadawa", livestock feed, soya sauce and baby foods, such as, Golden morn, Babeena, Nutrend and Cerelac are derived. The production figures for soyabean in Nigeria have been on steady increase since 1985 when over 114,000 metric tons were produced mainly due to the realization of the potential of the crop as a source of protein to blend with carbohydrate sources, as a good substitute raw material for vegetable oil and as concentrate supplement for poultry and other livestock

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feeds. Researchers have developed wide range of recipes which blend with traditional food habits or various cultural settings in Nigeria. This has increased soyabean consumption among low income groups that naturally cannot afford the expensive sources of protein such as meat, fish and eggs. The whole soyabean is already used in soy yoghurt, soy-burger, soy-cheese, soy-loaf, salad dressing, etc., and is also used in the manufacture of other food and non-food products such as paints, printing ink, cleaners capable of lifting grease, lipstick, mascara and drugs (OSAN, 2003).

Nigeria is the largest producer of soyabean in West and Central Africa; other producer countries include Zaire, Cameroon and Ghana (Singh et al., 1987). The crop was first introduced into the country in 1908 (Fennel, 1966), however, the first successful cultivation was in 1937 with the Malayan variety, which was found suitable for commercial production in Benue State (Nyiakura, 1982). Since then, many small-scale farmers have incorporated it in their cropping system as well as in their diets. Soyabean is produced in almost all the States of Nigeria with its concentration in the Northern States, particularly in the Central Agricultural Zone. Shaib et al. (1997) recorded that the Zone is the largest soyabean producer in the country, producing well over 64% of national production.

Recently there has been increased awareness campaign to farmers on inherent benefits of cultivation of soyabean. A strategy of accelerating production of soyabean in the Central Agricultural Zone of Nigeria should explore the potentials of the crop by increasing the production efficiency of the farmers which will culminate not only into incremental soyabean output and profitability but also sustainable food security for the country. Production efficiency mean attainment of a production goal without waste (Ajibefun and Daramola, 1999), while efficiency is concerned with the relative performance of the processes used in transforming given inputs into output (Onyenweaku et al.,1995).

Efficiency is at the heart of agricultural production because the scope of agricultural production can be expanded and sustained by farmers through efficient use of resources (Udoh, 2000). For these reasons, efficiency has remained an important subject of empirical investigation particularly in developing economies where majority of farmers are resource poor. There are four major approaches to measuring efficiency (Coelli et al., 1998).These are: the non-parametric programming approach (Charnes et al., 1978), the parametric programming approach (Aigner and Chu, 1968; Ali and Chaudhry, 1990), the deterministic statistical approach (Afriat, 1972; Schipper, 2000; Fleming et al., 2004), and the stochastic frontier approach (Aigner et al., 1977; Kirley et al., 1995). Among these, the stochastic frontier and non-parametric programming, known as Data Envelopment Analysis (DEA), are the most popular approaches. The stochastic frontier approach is preferred for assessing efficiency in agriculture because of the inherent stochasticity involved (Ezeh, 2004; Coelli, 1994).

This study estimates the level of economic efficiency and its determinants in soyabean production in Central Agricultural Zone of Nigeria using the Cobb-Douglas stochastic frontier cost function approach. The cost function approach combines the concepts of technical and allocative efficiency in the cost relationship. Technical and allocative efficiencies are necessary and when they occur together, are sufficient conditions for achieving economic efficiency (Yotopulous and Lau, 1973). Economic efficiency is the ability of farmers to maximize profit and is also described as the product of technical and allocative efficiency (Adeniji, 1988). It indicates the costs per unit of output for a firm which perfectly attains both technical and price efficiencies.

MATERIALS AND METHODS

Study area, sampling and data collection

The Central Agricultural Zone of Nigeria covers Benue, Kogi, Kwara, Niger, Nasarawa, Taraba and Plateau States, as well as the Federal Capital Territory, Abuja. Situated between latitudes 6° 30$^{/}$-11° 2$^{/}$N and longitudes 3°E and 14°E, the Zone has 22,664,756 million people with the rural population constituting 77% (NPC, 2006). The Zone has a land area of 296, 898 km^2 representing nearly 32% of the country's land area with the total available land estimated at 24.7 million hectares, but only 6.6 million hectares are under cultivation (Shaib et al., 1997). This indicates that the zone has substantial scope for expansion of the agricultural area as only about 25% of the available land is cultivated. Agriculture is the mainstay of the Zone's economy, with large proportion (43%) of rural adults involved in agriculture (CBN, 1993) The major crops of the Zone are maize, rice, millet, sorghum, cowpea, groundnut, yam, cassava, melon, soyabean, mango and citrus with most of the crops grown in mixtures. The Zone is the largest rice, groundnut and soyabean producer in the country, producing well over 40% of rice and groundnut, 64% soyabean with three other important crops, maize, sorghum and cowpea, contributing 25% each in addition to 34% yam and 98% Irish potato (Shaib et al., 1997).

A multistage and simple random sampling techniques were adopted to select respondents for the study. First, three States, namely: Benue, Niger and Plateau were purposively selected based on their lead in soyabean production in the Zone. Second, based on the classification of States into Zones by their respective Agricultural Development Projects (ADPs), Zones were purposively selected from the three States based on intensity of soyabean production. Third, respondents were randomly selected at a proportion of 0.2% from a list of farmers obtained from the selected States' ADPs which served as the sampling frame. Consequently 240, 125 and 120 were selected from Benue, Niger and Plateau States, respectively, giving a total sample size of 485 respondents. Primary data were collected through the use of well structured questionnaires/ interview schedules administered to the 485 sampled farmers on their socio-economic characteristics and production resources, such as land, labour, seed, fertilizer and agro chemicals and their prices using the cost – route – approach.

Analysis of data

The data collected were analyzed using the stochastic frontier cost function model defined by:

$$C = F(W_i, Y_i, a) \exp Є_i \quad (i = 1,2,3\ldots\ldots n) \quad (1)$$

Where
C = minimum cost of soyabean production
W = vector of input prices
Y = soyabean output
a = vector of parameters
$Є_i$ =composite error term ($v_i – u_i$)
Using shepphard's Lemma we obtain

$$ӘP_i = ӘC / X_i (w, y, a) \quad (2)$$

This is a system of minimum cost input demand equations (Bravo-Ureta and Pinheiro, 1997). Substituting a farm's input prices and quantity as output in Equation 2 yields the economically efficient input vector $X_{c,}$. With observed levels of output given, the corresponding technically and economically efficient cost of production will be equal to $X_{ii}P$ and X_{ie}, respectively, while the actual operating input combination of the farm is X_ip. The cost measures can then be used to compute the economic efficiency indices as follows:

$$TE= (X_{ii}P)/(X_iP) \quad (3)$$

$$EE= (X_{ie}.P)/(X_i.P) \quad (4)$$

The combination of Equations (3) and (4) is used to obtain the allocative efficiency (AE) index following Farrel (1957).

$$AE=EE/TE = (X_{ie}.P)/(X_i.P) \quad (5)$$

The efficient production is represented by an index value of 1.0, while the lower values indicate a greater degree of inefficiency. Using the method by Bravo-Ureta and Pinheiro (1997) which was based on the work of Jondrow et al., (1982), efficiency can then be measured using the adjusted output as shown in Equation (6)

$$Y^*= f(X_i,\beta)-u \quad (4)$$

Where U can be estimated as:

$$E (u_i/\varepsilon_i) = \sigma\lambda/1+\lambda^2/ [f^* (\varepsilon_i \lambda/\sigma)/1- f^* (\varepsilon_i.\lambda)- \varepsilon_i.\lambda] \quad (5)$$

Where
$f^*(\varepsilon_i\lambda/\sigma)$ and $f^*(\varepsilon_i\lambda)$ are normal density and cumulative distribution functions, respectively.
$\lambda =, \sigma_u/ \sigma_v$; $\varepsilon_i = v_i-u_i$ and
f* = observed output adjusted for statistical noise.

When $\varepsilon_{i,}\sigma$ and λ estimates are replaced in Equation 7, it will provide estimates for v_i and u_i The term V is a symmetric error, which accounts for random variations in output due to factors beyond the control of the farmer (e.g. weather, disease ,outbreaks, measurements errors, etc). The term U is a non-negative random variables representing inefficiency in production relative to the stochastic frontier. The random error V_i is assumed to be independently and identically distributed as $N(\sigma^2)$ random variables independent of the u_is which are assumed to be non-negative truncation of the $N(\sigma,u^2)$ distribution (that is, half normal distribution) or have exponential distribution. Micro economic theory holds that for profit maximation, firms should produce at the point where the marginal value product (MVP) equals its price.

Empirically, economic efficiency was measured using Cobb-Douglas stochastic frontier cost function for soyabean production, using the maximum likelihood method. The model is specified as follows:

$$LnC = bo + b_lLnP_l + b_2LnP_2 + b_3LnP_3 + b_4LnP_4 + b_5LnP_5 + V_i-U_i \quad (8)$$

Where:
C = the cost of production in Naira,
P_1 = price of seeds in Naira per kilogramme,
P_2 = price of fertilizer in Naira per kilogramme,
P_3 = price of agro chemicals in Naira per litre,
P_4 – average wage rate in naira per manday
Y = output of soyabean in kilogrammes per hectare
$b_0 – b_5$ = parameters to be estimated
V_i and U_i = as earlier defined

The determinants of economic efficiency were modeled in terms of socio-economic variables and other factors. Economic efficiency was simultaneously estimated with their determinants by:

$$Exp(-U_i) = \delta_0 + \delta_1Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7 + \boldsymbol{\delta_8 Z_8} + \delta_9 Z_9 \quad (9)$$

Where:
Exp (-Ui) = economic efficiency of the i-th farmer
Z_1 =age of farmers in years
Z_2 =educational level of farmers in years
Z_3=farming experience of farmers in years
Z_4=farm size in hectares
Z_5=number of extension contacts in a year
Z_6=fertilizer use (dummy variable, 1 = used fertilizer, 0 otherwise)
Z=access to credit (dummy variable, 1 = access, 0 otherwise)
Z_8=membership of farmers cooperatives (dummy variable, 1 = member, 0 otherwise)
Z_9=household size in numbers
$\delta_1 - \delta_9$ =parameters to be estimated

A priori expectation is that educational level, farming experience, extension contact, farm size, fertilizer use, credit access and membership of farmers' cooperatives will be positive while age of farmers and household size will be negative.

RESULTS AND DISCUSSION

Average statistics of soya bean farmers

The average statistics of the sampled soyabean farmers are presented in Table 1. The average age of the soyabean farmers was found to be 46 years. This result agrees with the findings of Ezedinma and Ohi (2001), and Ogunwale (2000) that the average age of farmers in Nigeria is between 45 and 48 years and that this age group forms the productive work force. On the average, soyabean farmers had 12 years of schooling with 21 years of farming experience. This finding contradicts the often reported illiterate status of farmers from many previous studies, such as Shaib et al. (1997), who reported low literacy level of farmers as a constraint to agricultural development in Central Nigeria, but agrees with Ochepo (2010), who found that 92.8% of the rural people, who are mostly farmers, were educated at various levels.

The farmers were found to own a mean farm size of 1.57 ha. This result shows that soyabean farmers in Central Nigeria are predominantly small-scale, based on the classification of farm holdings in Nigeria by Olayide

Table 1. Average statistics of soyabean farmers in Central Agricultural Zone of Nigeria.

Variables	Percentage mean	Minimum	Maximum
Sex			
Male	86.6		
Female	13.4		
Marital status			
Single	05.5		
Married	86.8		
Widowed	5.2		
Divorced	02.5		
Access to Credit			
No access	71.8		
Access	28.2		
Age (years)	46.0	17	78
Household size (no.)	9.19	1	22
Edu status(years)	12	4	18
Farming exp (years)	21	2	0.3
Farm size(ha)	1.57	0.1	55
Farm income (₦)	280,185.58	45,000.00	558,000.00
Off-farm income (₦)	**114,683.52**	170.00	216,000.00

Source: Field Survey, 2010.

(1980), that small, medium and large scale farmers hold 0.1-5.99, 6.0-9.99 upward of 10 ha, respectively. The average household size of farmers was found to be 9 members. This result agrees with the findings of Ochepo (2010) that the mean household size of farmers was 9 members. Majority (86.6%) of the farmers were males predominantly married (86.8%). The result of gender is in contrast with the findings of Sigot (1995), that women in Africa are responsible for an estimated 70% of total food production throughout the continent. Marriage, according to Igben (1980), is one of the most important factors influencing production and productivity.

The result showed that the sampled farmers had a mean annual farm income of ₦ 280,185.58, with a mean off-farm income of ₦114,683.52. Huffman (1980), argued that though increased non-farm work increases income of farmers and reduces financial constraint, particularly resource poor farmers, by enabling them to purchase productivity enhancing inputs, the situation is likely to decrease farmer’s efficiency by limiting their time available for supervision of farm activities. The result of accessibility to credit shows that majority (71.8%) of the soyabean farmers had no access to credit. The lack of access to credit by farmers could reduce their efficiency by limiting procurement of farm inputs and information needed for improved productivity, since according to Tijani et al. (2006), access to credit provides a farmer with a means of expanding and improving his farm.

Estimated cost function

The maximum likelihood estimates of the parameters in the Cobb-Douglas frontier cost function for soyabean in Central Agricultural Zone of Nigeria is shown in Table 2. The sigma squared (σ^2=0.78) is high and significant at 1% level of probability, which indicates goodness of fit and correctness of the specified assumption of the composite error term distribution (Idiong, 2005). The gamma (γ=0.32) is significant at 5% level and shows that only 32% of variability in the output of the soyabean farmers unexplained by the function is due to economic inefficiency.

The estimated coefficients of the variables show that wage rate (0.64), price of seed (0.78) and price of agrochemicals (-0.04) were significant at 1% while price of fertilizer (0.15) and output (0.11) were significant at 5%. All the independent variables included in the cost function were found to be significant. This indicates the importance of these variables in the cost structure of the farmers. Wage rate (0.64) and price of seed (0.78) were highly significant at 1% level. This shows that the cost of soyabean production in the study area increases by 6.4 and 7.8% as the prices of wages and seed, respectively, are increased by 1%. The significant influence of wage rate and seed is in line with the findings of Okoh (2009). The inverse relationship of agrochemicals with cost of soyabean production implies that using agrochemicals

Table 2. Maximum likelihood estimates of the parameters in the Cobb-Douglas frontier cost function model for soyabean farmers in Central Agricultural Zone of Nigeria.

Variables	Parameter	Coefficient	t- value
Constant	β_0	6.58	6.64***
Ln wage rate	β_1	0.64	4.46***
Ln price of fert	β_2	0.15	2.44**
Ln price of seed	β_3	0.78	5.13***
Ln price of agroch	β_4	-0.04	-4.73***
Ln output	β_5	0.11	2.12**
Variance parameters			
Sigma squared	σ^2	0.78	11.88***
Gamma	Y	0.32	2.64**
Log likelihood function	-	-602.86	-602.86
LR test	-	44.10	44.10

Source: Field Survey, 2010. ***and ** t-test significant at 1 and 5%, respectively.

Table 3. Maximum likelihood estimates of the determinants of economic efficiency in soyabean production.

Constant	Parameters	Coefficient	t-value
Age	σ_1	-0.19	-2.55**
Education	σ_2	2.31	2.28**
Farm size	σ_3	-3.11	-4.96***
Farm experience	σ_4	0.26	2.96***
Extension contact	σ_5	0.02	0.03
Membership of ass	σ_6	0.13	0.07
Access to credit	σ_7	0.55	2.88**
Household size	σ_8	-0.17	-3.42***
Fertilizer use	σ_9	0.27	2.80**

Source: Field Survey, 2010. ***and ** t-value significant at 1 and 5% respectively.

even at higher prices is more cost effective in soyabean production than manual control of weeds.

Determinants of economic efficiency

The factors that influence economic efficiency are shown in Table 3. The results reveal that the coefficients of farm size (-3.11), farming experience (0.26), and household size (-0.17) were significant determinants of economic efficiency at 1% while those of age (-0.19), education (2.31) access to credit (0.55) and fertilizer use (0.27) were significant at 5%. The negative influence of age on economic efficiency agrees with the assertion of Idiong (2005) that the older a farmer becomes the more he or she is unable to combine resources in an optimal manner given the available technology. Also, Tsaku (2009) found that young farmers were more efficient in minimizing cost in yam production in Nasarawa State. The negative relationship of farm size with economic efficiency implies that small farm holdings are economically efficient. This result is in agreement with Yotopoulos and Lau (1971) that smaller farms were more efficient in cost allocation, and corroborates the findings of Van-Zyl et al. (1995) that commercial farms could become significantly more efficient if they become smaller.

The positive relationship of education with economic efficiency agrees with the findings of Amaza and Olayemi (2000) that increasing years of formal education increases farmers' level of allocative and technical efficiency which implies improved economic efficiency. Also, Laha and Kuri (2011) opined that schooling and farming experience positively influence the level of economic efficiency in agriculture. The positive and

Table 4. Distribution of economic efficiency estimates of soyabean production in Central Agricultural Zone of Nigeria, 2009.

Efficiency range	Frequency	%
≤0.30	41	8.5
0.31-0.60	292	60.2
61-0.90	151	31.1
0.91-1.00	1	0.2
Total	485	100
Mean	0.52	-
Minimum	0.10	-
Maximum	0.99	-

Source: Field Survey, 2010.

significant coefficients of access to credit and fertilizer use by soyabean farmers enhances their economic efficiency. Extension contacts and membership of farmers' cooperatives were positively signed but not significant.

Estimation of economic efficiency

The results of frequency distribution of economic efficiency estimates presented in Table 4 reveal that economic efficiency ranged from 0.10 to 0.99 with a mean of 0.52. This result indicates that for the average farmer in the study area to attain the level of the most cost efficient farmer, he/she would save costs by 47% (1-0.52/0.99) while the most cost inefficient farmer would save 90% (1-0.10/0.99) cost. Thus, in the short run, there is scope for increasing the farmers cost (economic) efficiency in the study area by 48%, by adopting the technology and techniques used by best-practiced soyabean farmers. The results further show that majority (60.2%) of the soyabean farmers operated within the cost efficiency range of 0.31 to 0.60 indicating moderate economic efficiency among the farmers across the Zone.

CONCLUSION AND RECOMMENDATIONS

The study found that majority of soyabean farmers in the Zone were male with moderate education and highly experienced in soyabean farming with small farm holdings and were not fully economically efficient. Economic efficiency ranged between 0.10 and 0.99 (10 and 99%) with a mean of 0.52 (52%), which indicates substantial economic inefficiency, hence considerable potential for enhanced profitability by reducing costs through improved efficiency. There is scope for improving economic efficiency in the Zone by 48%. The average soyabean farmer would be able to reduce cost by 47% by employing best practices. Important factors directly related to economic efficiency were found to be education, farming experience and fertilizer use, while age, farm size and household size were indirectly related. Policies aimed at improving soyabean farmers socio-economic and farm specific factors that significantly determined economic efficiency will be useful in increasing farmers efficiency levels in production of soyabean in the Zone. These policies should be targeted at encouraging young farmers to produce soyabean, experienced farmers to remain in farming soyabean cultivation and the farmers encouraged to attain higher levels of education. Also, credit and fertilizer should be made easily accessible to the soyabean farmers.

Conflict of interests

The authors have not declared any conflict of interests.

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Comparative analysis of small scale irrigation schemes government funded and private small scale community project in Namibia

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The aim of this study was to examine factors influencing household income from small scale irrigation schemes using a case study of a government funded irrigation scheme of Etunda and a community initiated irrigation scheme of Epalela in Namibia. A weighted least square model was used to analyze data that was collected from household heads from the schemes. The key finding of this paper were that small scale irrigation is dominated by male farmers. In terms of factors influencing household income levels from government funded irrigation scheme gender whereas for community initiated scheme access to farm equipment was the main determinant, respectively. It is interesting to note the estimated coefficient were negative implying that as age increase the productivity will be reduced implying that the requirement for policy shift. The implication is that there is need for policy instruments to address gender balance. Moreover, it is highly recommended to (i) strengthen technical and organizational capacity (farmers associations, groups, cooperatives) of farmers, (ii) strengthen producers' human capital so as to improve their ability to draft viable business plans and record keeping, and (iii) to extend public sector support to community initiated irrigation schemes in the area of technology and irrigation infrastructure required.

Key words: Small scale irrigation production, weighted least square model, institutional arrangements, livelihoods.

INTRODUCTION

The vast majority of the resource poor farmers in sub-Saharan Africa rely on rain-fed agriculture for their livelihood. This thereby makes them to be vulnerable to the highly variable and unpredictable rainfall whereby the period of rainfall in Africa has a ten to fifteen days delay at critical stages in crop growth which thereby spell disaster for thousands, even millions, of farmers in Southern Africa. For example, the United Nations estimates about 15% world's population live undernourished today, this accounted for that about 870

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million people (FAO, 2013), the highest prevalence of undernourishment in sub-Saharan Africa, which is that almost 16 000 children die from hunger related causes the ratio being one child every five seconds (FAO/WFP, 2012). Periodic drought and famine have become a common phenomenon in the sub-Saharan Africa as shown by frequent devastating droughts, floods, and famines. Consequently, there has been drastically reduced economic growth rates, serious malnutrition among children which have compounded the already serious impacts of malaria, HIV/AIDS, and other diseases (FAO/WFP, 2012).

Namibia has not been spared from the challenges faced by the agriculture sector as about two-thirds of its population (1.5 million) live in communal lands and are dependent on rain-fed agriculture (Namibia Statistics Agency, 2010). The high income inequality (with estimated Gini coefficient at 0.59), high unemployment (with 29% unemployment rate), and high poverty incidence (with estimated rate of 21% of individuals consumption below $1.25/day) (World Bank, 2013) are making the situation even worse. Investment in irrigation is often identified as one of the possible responses to this problem, and has had considerable success in Asia in terms of achieving national as well as local food security, reducing poverty, and stimulating agricultural growth (FAO/WFP, 2012). In sub-Saharan Africa (SSA), irrigation investments never kept pace with those in Asia and for that reason region has the lowest percentage of cropped area under irrigation (FAO/WFP, 2012).

Although there has been serious call to increase irrigation investments in SSA (IFAD, 2013), a critical review of budget commitments to the agriculture and particularly irrigation development in the region does not show much practical progress. Research however shows that increasing investments in irrigation projects is a sustainable option that can make a major contribution to long term economic growth given that low-cost irrigation technologies can be affordable to the farmers (FAO/WFP, 2012). Within that backdrop, the government of Namibia's agriculture policy has been developed as part of poverty alleviation strategy after the acknowledgement of the potential of irrigation development. This has been pronounced clearly in the Green Scheme Policy that was formulated in 2004 in line with the national vision 2030 (GRN, 2008a; Werner, 2011). The Namibian irrigation strategy is modeled on joint enterprise that tie small scale irrigation farming units to an adjacent commercial irrigation so that the small scale irrigation schemes would learn from the experience of the large scale irrigation scheme's operations.

In Namibia, FAO has identified about 47,300 ha that can be put under irrigation production, though currently, only about 0.2% of the potential irrigation land is utilized (FAO/WFP, 2012). Namibia has invested about N$1.4 billion in the establishment of irrigation (Green Scheme projects) mainly in Karas, Kavango, Kunene, and Omusati regions (GRN, 2008a). Communities around the country have also mobilized resources to initiate small scale irrigation schemes. While a lot has been invested in the irrigation projects, there still remain misgivings on the performance and quantified income levels accruing to the participating households as also alluded to by Werner (2011). This paper therefore compared the contributions of the small scale irrigation schemes to households' income using a case study of Etunda government funded and Epalela community initiated irrigation schemes. The paper used data from Omusati region which is part of the country with high irrigation potential.

MATERIALS AND METHODS

Data was collected from small scale irrigation farmers at Etunda government funded irrigation scheme and Epalela community initiated irrigation scheme. Etunda irrigation scheme is located at about 50 km west of Outapi town in Omusati region and its 900 ha large of which 450 ha are reserved for large scale commercial irrigation with the remaining 450 ha being divided into 3 ha plots for small scale irrigation. A service provider was appointed to provide farmers with mechanization services, while the local Agricultural Development Centre provides farmers with extension services (GRN, 2008b). Epalela community initiated irrigation scheme is located at about 40 km west of Outapi, on the Oshakati-Ruacana main road in Omusati region. The scheme was initiated in the 1990s by the local community to harness the potential of Olushandja/Etaka earth dam and the Calueque–Oshakati water canal. There are 65 small scale irrigation farmers at Epalela, farming under the umbrella name Olushandja Horticulture Project Producers Association (OHPA). These small scale farmers are responsible for their individual plots' irrigation development and its management (GRN, 2008a).

Thirty-four respondents were randomly selected out of 67 small scale irrigation farmers from Etunda government funded irrigation scheme, with 33 out of 65 small scale irrigation farmers being randomly selected from Epalela community initiated irrigation scheme. This sample size was considered sufficient due to (i) the population and the livelihood activities around the study area are homogenous, (ii) dispersion of the small scale farmers, time and cost could not allow covering all those 132 farmers.

To create well-grounded relationship among the variables influencing farm productivity; at first Ordinary Least Square was tested. However, due to the presentence of heteroscedasticity and multicollinearity problems, the Weighted Least Square (WLS) model was found to be the right estimator. The model is specified as follows:

$$TFINCOME = AGE + GENDER + LSIZE + FEQPT + DISMKT + LOWN + C \quad (1)$$

$$\log TFINCOME = \log AGE + \text{GENDER} + \log LSIZE + FEQPT + \log DISMKT + LOWN + C \quad (2)$$

where TFICOME denoted the total farm income; AGE represents age of the farmer; GENDER is a dummy variable for gender that is one for a male farmer and zero for a female farmer; LSIZE is the irrigation plot size; FEQPT represents a dummy variable for ownership of farm equipment; DISMKT is the distance to the local market; LOWN is land ownership; and C represents the constant in the equation.

Furthermore, to examine the weight and magnitude of influence

Table 1. Characteristics of the participants**.**

Characteristic		Etunda Government (%)	Epalela community (%)	Total (%)
Gender	Male	61.80	84.80	70.80
	Female	38.20	15.20	29.20
	Total	100	100	100
Education level	No formal education	5.90	3.00	11.30
	Elementary education	41.20	18.20	35.80
	Secondary school	41.20	54.50	40.60
	Post-secondary education	11.80	24.20	12.30
	Total	100	100	100

Table 2. Analysis of variance (ANOVA).

Scheme		Sum of squares	df	Mean square	F	Sig.
Government support project	Regression	0.120	5	0.024	6.16	0.001
	Residual	0.109	28	0.004	-	-
	Total	0.228	33	-	-	-
Community project Epalela	Regression	0.101	6	0.017	2.63	0.040
	Residual	0.167	26	0.006	-	-
	Total	0.268	32	-	-	-

(that is, to measure elasticity), model was transformed to log form (Assaf and Sima, 2005). Weighted least squares regression is used to describe the relationship between the process variables factors influencing farm productivity. The model reflects the behavior of the random errors and it can be used with functions that are either linear or non-linear in the parameter characterization (Koenker, 2000). It is important to note that the weight for each observation is given relative to the weights of the other observations; so that different sets of absolute weights can have identical effects. The advantage of WLS is (i) it is an efficient method that makes good use of small data sets; (ii) it also shares the ability to provide different types of easily interpretable statistical intervals for estimation, prediction, calibration, and optimization; and (iii) WLS enjoys its ability to handle regression situations in which the data points vary in quality (Dalén, 2005; Elisson and Elvers, 2001; Eurostat, 2006; Haan et al., 1999; Kadilar and Cingi, 2006).

RESULTS AND DISCUSSION

In terms of gender of the respondents from Etunda, 62% were male and 38% being female and at Epalela 85% were male with 15% being female (Table 1). What can be deduced is that the small scale irrigation projects are dominated by male headed households. The Namibian Government's four major development objectives in the First National Development Plan (NPC, 2012) were to reduce poverty and to enhance women participation in farming sector as the most effective way to reduce poverty. In this light, it seems that at Etunda, there is significant participation of female household heads in irrigation farming, though at Epalela a lot is still to be done to address gender imbalance in the irrigation sector. Thus, the results have serious implications on policy to improve the low participation of women in irrigation farming system. This is despite government efforts and policy pronouncements that seek to promote gender equity in the agricultural sector. Therefore, government should proactively seek to support more female households' participation in the sector. In terms of education level of the respondents at Etunda, 53% of the respondents had at least secondary level education with only 5.9% having no formal education. At Epalela on the other hand, 78.9% had at least attained secondary education with only 3% having no formal education. What can be deduced from the results is that the majority of the participants have a reasonable level of education needed to manage and make informed decisions on farming. However, these statistics will not say much about factors influencing household income levels from the schemes. For that reason further analysis was performed.

With regards to factors influencing total farm income, have a linear relationship, that is, each and every explanatory variable has its own impact for productivity, that is significant at P-value less than 1% (Table 2).

Factors affecting total farm income are reported in Table 3. The overall explanatory power is quite high at 73

Table 3. Model summary.

Etunda Government funded irrigation scheme	Multiple R	0.724
	R square	0.524
	Adjusted R square	0.439
	Standard error of the estimate	0.062
	Log-likelihood function value	-28.250
Epalela community initiated irrigation scheme	Multiple R	0.614
	R square	0.377
	Adjusted R square	0.234
	Standarde error of the estimate	0.080
	Log-likelihood function value	-36.845

and 61% for government support project and community support project, respectively.

Studies elsewhere have indicated that farm productivity and income levels are influenced by multitudinous factors which can be summarized into five categories, that are economic growth and the overall development level of a country, macroeconomic factors, demographic factors, political factors, and historical, cultural, and natural factors (Eicher and Garcia, 2000; Kaasa, 2003; Sarel, 2015; Stiglitz, 2012; Stiglitz et al., 2009). In this paper, the constant is shown to be significant, at one percent with an estimated coefficient of 9.51 and 9.75 for government project and community project, respectively. This implies that the unexplained factors have a bigger influence for farm productivity and resultant income levels (Table 4).

Age was found to be critical in influencing income levels derived from the irrigation activities for both schemes. This concurs with what has been established in the development literature specifically from policy discussions. For example, the World Bank recommends fostering participation of young people in economic development as a strategy to achieve sustainable development (World Bank, 2013). As shown in Table 4, age has relatively smaller negative estimated coefficients at 0.04 and 0.03, respectively for government and community initiated schemes, respectively. The implication is that as the participant gets older the overall productivity will eventually decline (IFAD, 2013). The explanation is also very clear because farming activities at the schemes are not highly mechanized, thus requires human physical effort. So, as one gets older then the energy to perform demanding tasks at the farm becomes less hence may end up producing less demanding crops which will not bring in higher income. However, it is very inelastic, that is one percent increase in age will only increase productivity by 0.04 and 0.03%, respectively (Table 4). For example, the average age of the participants was around 48 and 45 years old for government and community project, respectively, with the mode being 43 years in both schemes. The implication is that there is limited participation by young farmers at the two schemes. As has been articulated in NDP4, its government policy to redress income inequality, accelerate high economic growth, increase employment, and the eradication of poverty (NPC, 2012). However, policy implication of the paper's findings is that it seems that irrigation initiatives have failed to enhance participation by youth in irrigation projects at the two irrigation schemes. For this reason such interventions have not succeed to narrow down the income inequality gap and also high unemployment levels particularly for the youth.

As indicated in Table 4, land size and access to farm equipment were found to be positive and significant at 1% to influence household incomes from irrigation activities in both Etunda and Epalela irrigation schemes. Land size's influence on income operates by way of the fact that those with larger plots can have diverse cropping systems which will in the end result in them earning more from the sale of the produce. Irrigation systems demand that the participants should have operational irrigation equipment like pumps and tractors and related machinery. Those with such equipment can take advantage of cropping opportunities that will result in their harnessing marketing opportunities. This is particularly true for Epalela irrigation scheme where community members have to finance their own operations. Even for Etunda inefficient management of the irrigation equipment particularly irrigation pumps have been blamed for poor cropping systems and missing of market opportunities. However, distance to the market was found to be insignificant. Despite the fact that the research by IFAD (2013) shows that distance to the market is crucial in the study, it was not the case. The explanation could be that at Etunda government, products are collected through AMTA agents from the farmers and transport them to the market.

Land ownership was also found to be significant at 10% in community initiated irrigation scheme. The explanation was that community members own their land and can invest in its development that will lead to the unlocking of

Table 4. Factors affecting respondents' farm income.

Scheme		Unstandardized coefficients		Standardized coefficients		t	Sig.
		Beta	Std. Error	Beta	Std. Error		
Government funded Etunda irrigation scheme	Constant	9.51	0.83			11.40	0.00
	Age	-0.04	0.01	-0.41	0.15	-2.73	0.01
	Gender	0.21	0.25	0.13	0.15	0.85	0.40
	LSIZE	0.32	0.09	0.49	0.14	3.44	0.00
	FEQPT	0.67	0.23	0.42	0.15	2.86	0.00
	DISMKT	0.07	0.05	0.22	0.14	1.59	0.10
Epalela community initiated irrigation scheme	Constant	9.75	1.21			8.03	0.000
	Age	-0.03	0.02	-0.33	0.17	-2.00	0.05
	Gender	-0.40	0.40	-0.16	0.16	-1.00	0.32
	LSIZE	0.09	0.03	0.52	0.19	2.93	0.00
	FEQPT	-0.27	0.43	-0.13	0.20	-0.62	0.54
	DISMKT	-0.02	0.02	-0.24	0.17	-1.47	0.15
	LOWN	1.08	0.58	0.37	0.20	1.87	0.07

its potential unlike at Etunda where the members have short term contracts with government as was also established by Nekwaya (2008). Due to short contracts farmers may not invest on the land as they will not be assured that their contracts will be renewed. It is thus little wonder why at Epalela participants indicated that they have invested more on their plots as they have long term user rights to their land hence they invested more on irrigation equipment which would result in realizing more income from the irrigation scheme. The implication is that government should revisit its irrigation policy and give the beneficiaries longer term leasehold interest to encourage the farmers to invest more on the land and hence earn higher income.

During the interviews, some of the farmers raised the following concerns: (i) although government provides agricultural extension services across the country, there are no feedback mechanism to assess the level of satisfaction with the quality of extension services they have received; (ii) there is no inclusiveness during policy formulation as beneficiaries of small scale irrigation farmers feel left out during designing of the projects and that (iii) there is a lack of coordination in the administration, preparation, and design of strategic sustainable solutions for their multitude challenges in their irrigation system. The respondents also feel there is lack of transparency in project preparation and choice and inadequate monitoring of performance of the irrigation projects

Within the aforementioned backdrop, one would suggest that strengthening of the small scale irrigation farmers' social capital is an important policy strategy. The farmers can use their social capital to gather requisite information they cannot get from the extension services, to create local savings schemes that can be useful financial 'stores' to be drawn from during times of stress. Another important policy implication is that there is need for government and stakeholders to design an economical viable model of small scale irrigation projects that is more focused on commercialization of the sector than small scale so as to achieve the objectives of food increased production, income generation, and job creation.

Conclusions

The small scale irrigation schemes are dominated by male headed households. This is despite government's efforts to redress the gender imbalances in the economic space. For that reason it is suggested that government implements affirmative policies that will give preference to female headed households in future irrigation schemes allocation. The study also established that age of the farmers, land size, land ownership and access to farming equipment which were the main factors influencing household income from the farming activities at the two irrigation schemes.

While gender and age at Etunda irrigation scheme and access to farm equipment at Epalela community irrigation scheme were found to be significant, these are inelastic implying that heavy intervention on these factors would make small contributions on the changes in income. What this means is that at the small scale irrigation farming schemes, there are other factors other than these which have greater influence on income levels. However, it is interesting to note that at Etunda age has a negative estimated coefficient implying that as age increases the productivity will be reduced. In such case, a policy option will be to promote youth to venture to irrigation farming even for Epalela. However, there is also need for policy that will address the gender imbalance at both just like at Etunda government policy instrument needs to focus on addressing gender balance.

RECOMMENDATIONS

It is therefore recommended that government and its stakeholders should strengthen capacity and organizational institutions of the farmers like farmers' associations, commodity groups, and cooperatives of the small scale irrigation farmers. To increase income levels of the irrigation farmers, it is also recommended for strengthening producers' understanding of socio-economic aspects like business plans, record keeping, and related business management systems for small irrigation. It is also recommended that government revisit the land size and tenure policy for the small scale irrigation scheme beneficiaries and to provide small scale irrigation farmers with appropriate technology and infrastructure required by them to increase their income levels.

Women play a major role in society, especially in terms of food security and it is therefore important for the government to encourage the participation of women in decision-making and training programs designed innovatively to improve small scale irrigation projects. Women empowerment is important, especially in terms of access to credit, land ownership, and income generating opportunities such as small scale irrigation projects. Given marketing challenges faced by small holder farmers, small scale irrigation farmers included the government and other stakeholders involved should develop policies to enhance market information dissemination and infrastructure development for irrigation products. The formation of small scale irrigation schemes cooperatives and/or association can enable the farmers to pool their resources for production intensification. It is therefore suggested that government and other stakeholders should come up with innovative ways to support the farmers with technical training, access to loans and credit lines.

Conflict of Interests

The authors have not declared any conflict of interests.

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