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Socio-economic and Agroecology Impacts on Production Efficiencies of Small Farms in the Disadvantaged Black Communities of the Semi-arid Regions of South Africa

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ABSTRACT Smallholder agriculture is not fulfilling its pivotal role of attaining food security in developing countries such as South Africa. In rural areas, smallholder farmers' efficiencies are hindered mostly by factors beyond their control. This paper presents a scenario simulation of small farms' production efficiencies in the disadvantaged Black communities of the Eastern Cape province, South Africa, in the three major agroecological zones. Stochastic frontier analysis was used to model the technical efficiency of the small farms under different production scenarios. The analysis revealed that smallholder farmers' output is worse off under declining soil fertility and climate variability conditions. Overall, small farms in the study areas were inefficient in their production with congested household sizes and not optimized household labor. The study recommends the use of more intensive land-augmenting inputs and in the long run, output can rely on improvements in technical efficiency.

INTRODUCTION

Agriculture is the backbone of rural livelihoods, being both a primary source of household food and a means of generating income (Harvey et al. 2014). The rural livelihood pattern of South Africa is embedded in a complex involving various land-based and agrarian activities, small-scale, informal economic activities, both farm and non-farm, and a well-developed system of state cash transfers, and is characterized by culturally inscribed mutuality and social reciprocity (Neves and Du Toit 2013). Although livelihood activities are varied, farming-related activities are in the majority due to available endowment such as land. According to Statistics South Africa (Stats SA) (2015), agriculture in South Africa formally employs approximately 869,000 with an estimated 8.5 million people directly or indirectly dependent on agriculture for their employment and income. However, most farming households are still characterized by poverty, hunger, poor remuneration, underemployment as well as unemployment.

The South African government has initiated several programs such as the Integrated Food Security Strategy for South Africa and support mechanisms such as community food garden initiatives, land reform and farmer settlement, production loan schemes for small farmers, infrastructure grants for smallholder farmers and the tractor mechanization scheme (Koch 2012), which was implemented with the intention of significantly boosting food security, especially among the historically disadvantaged groups (Thornton 2008; Crush et al. 2011). One of the aims of the South African government is to create higher income opportunities for previously disadvantaged Black communities (Ngqangweni et al. 2001). Many studies have found that smallholder farmers can produce efficiently, even when subjected to opportunity cost assumptions that apply to their traditionally commercial counterparts, and at the same time can become the backbone of global food security in the developing world (Ngqangweni et al. 2001; Haji

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2007; Tscharntke et al 2012; Collier and Dercon 2014).

There has been a global focus in the last two decades on the realization of the contribution of smallholder agriculture to food security in the midst of scenarios of climate change and economic and energy crises, leading to the concepts of food security and agroecologically based production systems (Altieri et al. 2012; Collier and Dercon 2014). De Schutter (2010) states that in order to feed nine billion people in 2050, there is an urgent need to adopt the most efficient farming systems. He therefore recommends a fundamental shift towards agroecology as a way to boost food production and improve the situation of the poorest. Mudhara (2010) also contends that smallholder farmers can double food production within 10 years in critical regions by using agroecological methods already available. The food challenge will be met using environmentally friendly and socially equitable technologies and methods, in a world with a shrinking arable land base. The only agricultural system that will be able to confront future challenges is one that exhibits high levels of diversity, productivity and efficiency.

The agricultural sector in South Africa is dualistic, where large-scale commercial and smallholder sectors exist side by side. The former comprises of well-resourced large and operated farms, contributing a larger value of agricultural production in the country, whereas the latter are resource-poor smallholder farmers who mainly produce for subsistence and lack institutional support (Mudhara 2010). However, the smallholder sector is inflicted by the impacts of household's dynamics such as household size, labor, education, access to production assets, poverty, food insecurity, lack of employment and diseases. Importantly, smallholder farmers are influenced by their interaction with external factors such as agroecological and socioeconomic environments (Giller et al. 2006). The agroecological environment determines the potential agricultural activities in which households could engage. As a semi-arid region, rainfall has also become a major constraint of dry land cropping systems in most parts of the Eastern Cape province (Sibanda 2012). Dry land agricultural activities in the Eastern Cape province is therefore predominantly done during the summer period (October to April), with the exception of farmers who grow vegetables in the gardens near their homes with the intention of irrigating with water from their homes. Although smallholder farmers are efficient users of some productive resources, mostly labor, efforts needs to be geared towards issues of declining soil fertility, soil degradation and the negative effect of climate variations (Hosu 2012). These are the core hindrances to smallholder farm efficiencies.

Objectives

The objective of this paper was to examine the socio-economic characteristics and productive assets and determine the production efficiency of smallholder farmers in the Black communities of the Eastern Cape province of South Africa, which is regarded as one the poorest provinces where the poorest households of South Africa live. Specifically, the paper explored the socio-economic characteristics and production assets of smallholder farmers in the major agroecological (grassland, savannah and Karoo) zones and estimated different scenario production efficiencies under different conditions (unconditional farm production, soil fertility status and climate variability conditions). The information generated from the study will provide insight for policy intervention on improving smallholder farmers' production efficiencies in a semi-arid environment stressed with declining soil fertility and marginal rainfall.

METHODOLOGY

Study Area

The study was conducted in three major agroecological zones in the Eastern Cape province of South Africa to represent different climatic and soil conditions. The researchers employed a combination of secondary data on climate conditions in the selected villages as well as socio-economic surveys to build a model of a smallholder farming system for the Eastern Cape province based on various biophysical and economic variables. The specific study areas in the major ecological zones were two representative district municipalities of Amatole and Chris Hani, with seven local municipalities and fifteen locations. The locations in the grassland zones were Elliot, Engcobo, Seymour, Tsomo, Roxeni and Elliotdale, while the locations surveyed in the savannah zone were Lady Frere, Qamata, Cala,

Melani, Gqumashe and Middledrift. Surveyed locations under the Karoo (Nama) were Zola, Tarkastad and Hofmeyr. The study focused on cropping activities of the smallholder and emerging farming households.

Data Collection and Sampling Procedure

The researchers interviewed 223 respondents-77 in the grassland zone and 73 each in the savannah and Karoo zones. Data collection was stratified in line with the major ecological zones, after which a multistage sampling procedure was employed in the data collection in fifteen locations randomly selected within seven local municipalities of the two district municipalities (Amatole and Chris Hani). This involved the selection of the district municipality, local municipality and villages where there are smallholder farmers. The areas or villages in the ecological zones under different rainfall belts (rainfall being the paramount climate parameter) were randomly selected for the field survey through the use of a structured questionnaire and personal interviews with the farmers selected from the list of farmers identified by extension officers in the areas. Production data, including the crops grown, inputs used and their cost, outputs as well as the sales and revenues, generated during the production season were elicited from the respondents through personal interviews.

Data Analysis

Descriptive analysis was used to analyze the socio-economic characteristics of smallholder farmers in the study areas. The technical efficiency of the small farms was modeled through the stochastic frontier analysis (SFA). In order to gain further insight into the efficiency structure, the analysis was taken one step further by relating small farms' performance to 'exogenous' variables, which are not exclusively in the control of the farmer but nevertheless influence the outcome of the production process. These are climate indictors (mean precipitation and temperature in the study areas during the planting season) as well as soil fertility status. Four types of soil, namely luvisols, ferrasols, lithic luvisols and leptosols, were identified in the study areas. These were represented by dummies according to their nutrient supply to cropping activities. Luvisols are considered to be more fertile, ferrasols and lithic luvisols are medium fertile, while leptosols are low-fertile soils. These are represented by 3, 2 and 1 respectively, in the analysis. In general, leptosols are found most in the areas covered by this study. Although small farms are known for engaging in both crop and livestock activities, the SFA was determined for cropping activities only. The stochastic frontier for a cross-sectional analysis is stated in equation 1:

$$y_i = f(x_i; \beta).\exp(v_i).TEF_i \quad (1)$$

Where, y_i is the output of small farms represented in rand value, x_i is the vector of K inputs used by the farmers, $\hat{a}_i$ is a vector of input parameters to be estimated and $f(x_i; \hat{a})$ is the deterministic production frontier. Furthermore, $\exp(v_i)$ embodies the random shocks on each farmer, with $[f(x_i; \hat{a}).\exp(v_i)]$ the stochastic production frontier. TEF_i is the output-oriented technical efficiency of small $farm_i$, which is defined in equation 2 as:

$$TEF_i = \frac{y_i}{f(x_i; \beta).exp(v_i)}, \quad (2)$$

Which is the ratio of observed output and the maximum feasible output conditional on $\exp(v_i)$. Each farmer attains the maximum feasible output if, and only if, TEFi = 1, otherwise 0 <TEFi < 1 provides a measure of the shortfall of observed output from the maximum feasible in an environment characterized by $\exp(v_i)$ (Pereira and Moreira 2007). As it is a production function, the Cobb-Douglas functional form was used to estimate the SFA with Data Analysis and Statistical Software for Professionals (STATA). The estimated equation is presented in equation 3:

$$\ln y_i = \beta_0 + \Sigma_k \beta_k \ln x_{k,i} + v_i - u_i \quad (3)$$

Where, v_i is assumed to be independently and identically distributed symmetrically and independent of u_i. The error term in this equation, $\varepsilon_i = v_i - u_i$, is composed of a two-sided 'noise' term and a non-negative technical inefficiency term (Pereira and Moreira 2007). With the parameters estimates generated from equation 5 for the small farms, the efficiency is generated by the proposed formula by Battese and Coelli (1988) expressed in equation 4 as:

$$E[\exp(-u_i/\varepsilon_i)] \quad (4)$$

Empirically, the cross-sectional modeling equation is specified in equation 5 as:

$$\ln Y - \beta_0 + \beta_1 \ln FS + \beta_2 \ln HHAGE + \beta_3 \ln HHEdu + \beta_4 \ln HHSIZE + \beta_5 \ln HIRL + \beta_6 \ln HIRL + \beta_7 \ln FTY + \beta_8 \ln PREC + \beta_9 TEMP_t v_i - u_i \quad (5)$$

Where, FS stands for farm size, HHAge for household head's age, HHEdu for household head's education level, HHSize for household size, HHL for household labor, HIRL for hired labor, FTY for soil fertility status, PREC for mean precipitation of the area, TEMP for the average temperature of the area and ($v_{i,}$ u_i) the decomposed error term. A summary of the statistics used in the SFA is presented in Table 1.

Labor (both household and hired) was measured in the number of household members involved in farming activities as well as the number of hired labor utilized during cropping activities.

Three scenarios were determined in the efficiency analysis. The first one (unconditional production) was the efficiency of small farms with no constraints or hindrances. The second scenario was the efficiency of small farms' crop production when varied soil fertility conditions were imposed, that is, more fertile, medium fertility and low-fertility conditions. The third scenario was small farms' production efficiency under the imposition of adverse climatic variations. These scenarios were used to determine how productively efficient small farming households in the semi-arid regions of South Africa are.

RESULTS

The first part of the analysis was done to showcase the socio-economic characteristics and the productive assets of the small farming households, while the second part was done to determine the efficiency of the smallholder farmers under different conditions. Tables 2 and 3 illustrate the socio-economic characteristics and the productive assets of the respondents based on the agroecological zones and all-farm analysis. The technical efficiencies of the disadvantaged Black farmers are presented in Table 4.

Socio-economic Characteristics of the Farming Households

The information generated from the results in Table 2 shows that 51.5 percent of the farming households interviewed are headed by men. The results also show that there are variations in the headship of farming households in the three agroecological zones. The researchers observed that households in the grassland and in the Karoo zones are largely headed by women at 58.4 percent and 50.7 percent, respectively. However, the interviewed households in the savannah zone are largely headed by men. This further shows some improvement in men's engagement in farming activities, which is a departure from the past, where the majority of men in the Eastern Cape province engaged in other non-farm activities, most especially working in the mining sector in other provinces. Furthermore, the results indicate that the majority of the household heads are in their productive age in the savannah zone (89%), as compared to the grassland (83.1%) and the Karoo (69.85%) zones. In the general (all-farm) analysis, household heads that are in the productive age bracket (15–65) accounted for 80.7 percent in the study area. This is also an important rural household asset that will either be useful in farming activities or traded as economic good as labor. Either way, this will certainly lead to improvement of the rural households in the Eastern Cape if enhanced.

Table 1: Statistics of the variables used in the SFA

Variables	*Description*	*Minimum*	*Maximum*	*Total (n=223) Mean (s.d.)*
Revenue From Cropping Activities	Revenue in rand	R1 080.03	R45.070	7498.03 (6959.97)
Precipitation	Average rainfall distribution in the Eastern Cape	319 mm	929 mm	564.1 mm (143.80)
Temperature	Average temperature	26 ^{0}C	29 $^\circ$C	27.65 $^\circ$C (1.42)
Farm Size	Farm size in ha	0.1 ha	10 ha	2.76 ha (1.82)
Fertiliser Use	In bags	0	15 bags	3 bags (2.93)
Household Labour	Available household labour	1	16	5 (2.97)
Hired Labour	Hired temporary/ permanent labour	0	40	5 (6.32)
Soil Fertility	Soil types and fertility status:3 is more fertile, 2 is medium fertile, 1 is low fertile	1	3	

In relation to the education status illustrated in Table 2, the all-farm analysis shows that approximately eighty-six percent of the interviewed farmers have been educated enough to positively influence their productivity and efficiency. Approximately eighty percent of the household heads in the Karoo zone have completed formal education up to secondary level, with 67.6 percent and 56.2 percent in the grassland and savannah zones, respectively. Similarly, the all-farm analysis shows that 26.5 percent of the respondents ended their education at primary level, while 41.3 percent had a secondary level education. However, the researchers observed that there is a higher percentage (16.9%) of respondents with no former education in the grassland zone compared to the other zones (12.3% for both the savannah and Karoo zones).

Furthermore, the results also show that 67.1 percent of the interviewed household heads in the savannah zone are married, compared to 66.2 percent and 61.6 percent married household heads in the grassland and the Karoo zones, respectively (Table 2). The all-farm results in Table 2 show that sixty-five percent of the interviewed household heads are married. The researchers also observed that 54.8 percent of the farming households in the Karoo zone have the largest household size of between 6 and 10 members compared to the respondents from the other two zones (49.31% and 44.2% for the savannah and grassland zones, respectively). The information on both marital status and household size also justifies a very important resource of smallholder farming systems. This shows that the interviewed farming households in the Eastern Cape can capitalize on household size to boost their productivity and enhance efficiency.

On the issue of farming being the main job, as it affects the efficiency of smallholder farming activities among the disadvantaged Black farmers in the Eastern Cape, the all-farm analysis (Table 2) indicates that approximately sixty percent engage in farming as the main occupation. Similarly, the researchers observed that 70.1 percent of the respondents in the grassland zone chose farming as their main job compared to other zones (57.5% and 47.9 % for the Karoo and savannah zones, respectively). As indicated in the results, other things being equal, the small-

Table 2: Socio-economic characteristic of the respondents according to the agro-ecological zones

Household head		*Grassland zone n=77*			*Savannah zonen=73*			*Karoo zonen=73*			*All-farm n=223*
Characteristic		*Freq.*	*Percen-tage*	*Cum.*	*Freq.*	*Percen-tage*	*Cum.*	*Freq.*	*Percen-tage*	*Cum.*	*Freq. (percen-tage)*
Household	Male	32	41.6	41.60	47	64.4	64.4	36	49.3	49.3	115 (51.5)
Head	Female	45	58.4	100	26	35.6	100	37	50.7	100	108 (48.43)
Age (Years)	15–35	1	1.3	1.30	3	4.10	4.1	3	4.1	4.1	7 (3.13)
	36–65	63	81.81	83.11	62	84.9	89.0	48	65.75	69.85	173 (77.57)
	66–100	13	16.8	100	8	11.00	100	22	30.15	100	43 (19.28)
Education Status	No formal education	13	16.9	16.9	9	12.3	12.3	9	12.3	12.3	31 (13.90)
(Years)	Primary	29	37.7	54.5	12	16.4	28.8	18	24.7	37.0	59 (26.46)
	Secondary	23	29.9	84.4	29	39.8	68.50	40	54.8	91.8	92 (41.26)
	Tertiary	12	15.6	100	23	31.5	100	6	8.2	100	41 (18.39)
Marital Status	Single	10	13.00	13.00	10	13.70	13.7	7	9.6	9.6	27 (12.11)
	Married	51	66.20	79.20	49	67.10	80.8	45	61.6	71.2	145 (65.02)
	Widow	14	18.20	97.40	8	11.00	91.8	11	15.1	86.3	33 (14.79)
	Widower	2	2.60	100	7	8.20	100	10	13.7	100	19 (8.52)
Household Size	0–5	26	33.76	33.76	34	46.57	46.57	18	24.7	24.7	78 (34.98)
(Number)	6–10	34	44.15	77.91	36	49.31	95.88	40	54.8	79.50	110 (49.33)
	10–15	17	22.09	100	3	4.12	100	15	20.50	100	35 (15.69)
Major	Farming	54	70.1	70.10	35	47.9	47.9	42	57.5	57.5	131 (58.74)
Occupation	Teaching	11	14.3	84.40	20	27.4	75.3	18	24.65	82.15	49 (21.97)
	Trading	6	7.8	92.20	3	4.1	79.5	6	8.22	90.37	28 (12.56)
	Security guard	6	7.80	100	15	21.50	100	7	9.63	100	28 (12.56)

holder farmer focusing on farming activities will enhance productivity as well as efficiency.

Productive Assets of the Respondents

The ownership of some household productive assets by the interviewed farmers is illustrated in Table 3. The information generated on farming experience among the interviewed farming households shows that approximately eighty-eight percent have been engaged in farming activities for more than 20 years. Similarly, approximately ninety-one percent of the respondents in the savannah zone have been engaged in farming activities for more than 20 years, while 71.42 percent and 87.7 percent of the respondents in the grassland and Karoo zones respectively, have more than 20 years of experience in farming. This is supposed to boost farm productivity, as the majority of the farmers are familiar with farming operations.

Similarly, the information from the results shows that the majority (72%) of the interviewed farming households cultivated less than two hectares of land. On an agroecological basis, approximately seventy-one percent of the respondents in the Karoo zone cultivated less than two hectares, compared to 44.2 percent in the grassland zone and 38.3 percent in the savannah zone. The all-farm analysis shows that more than half of the respondents (55.61%) have access to land through inheritance. Land ownership through inheritance was pronounced among the respondents in the Karoo zone (72.6%), compared to 57.6 percent in the grassland and 37 percent in the savannah zones, respectively. The issues of size of land cultivated as well as land ownership indicate a serious issue of land fragmentation as a crucial hindrance to the performance of smallholder farmers in the Eastern Cape and developing nations in general. Land fragmentation and land through inheritance have always denied smallholder farmers some level of mechanization and collateral for capital.

Stochastic Frontier Modeling for Small Farms in the Eastern Cape Province

The stochastic frontier modeling for the determination of the technical efficiency of small farms in the Eastern Cape province is illustrated in Table 4. The results in Table 4 show how the smallholder farmers performed under different scenarios. All models were estimated by maximum likelihood using STATA version 12. The estimation shows elasticity of the inputs and production efficiency under unconditional production, soil fertility condition and climate variability conditions. Using the principles of constant return to scale used in Cobb-Douglas function, all the independent variables in the frontier analysis will have a unit effect on small farm revenue, as indicated in Table 4. The significant variables of farm size (0.789, 0.753 and 0.719), hired labor (0.184, 0.203 and 0.263) and rainfall (0.548) will increase small farms' productivity by the units indicated in brackets in the order of unconditional production environment, soil fertility condition and rainfall variability. The coefficients show that size of land holds the most important influence on smallholder farmers' efficiency in the Eastern Cape province. The results show that small farms' revenue will increase

Table 3: **The productive assets of the respondents according to the agro-ecological zones**

Household head		*Grassland zone n=77*			*Savannah zone n=73*			*Karoo zone n=73*			*All-farm n=223*
Farming Experience (years)	1–20	55	71.42	71.42	66	90.4	90.40	64	87.67	87.67	185 (82.95)
	21–40	22	28.58	100	7	9.60	100	9	12.33	100	38 (17.04)
Farm Size (ha)	0–0.99	8	10.4	10.4	12	16.4	16.4	23	31.51	31.51	43 (19.28)
	1–2	26	33.76	44.16	16	21.9	38.3	29	39.72	71.23	71 (31.84)
	2.1–5	23	29.87	74.03	30	54.8	93.10	20	27.40	98.63	73 (32.74)
	5.1–10	20	25.97	100	5	6.90	100	1	1.37	100	26 (11.66)
Forms of Land Ownership	Inheritance	44	57.9	57.9	27	37.00	37.00	53	72.6	72.6	124 (55.61)
	Renting	4	5.3	63.2	8	11.00	48.00	13	17.8	90.4	25 (11.21)
	Landredistribution	13	17.1	80.3	13	17.8	65.8	1	1.4	91.8	27 (12.11)
	Land restitution	5	6.6	86.8	16	21.9	87.7	5	6.8	98.6	26 (11.66)
	Communal land	10	13.2	100	9	12.3	100	1	1.4	100	20 (8.97)

by a unit increase in cultivated land. However, the researchers found that the contribution of the land to farmers' revenue shrank under soil fertility and climate variability scenarios.

The results also indicate that hired labor has a positive and significant influence on small farmers' revenue in the Eastern Cape, whereas household labor influences negatively, albeit not significantly. The researchers are of the view that this situation can be explained by the optimal use of hired laborers who are paid for work done satisfactorily. The reverse is the case of household labor, because small farms hardly measure or optimize the use of household labor. Similarly, the negative impact of household size further shows the issue of not optimized household labor among small farms in the Eastern Cape.

The study revealed an interesting case of farming experience relating to the efficiency and productivity of small farms in the Eastern Cape province. Although, farming experience is not significant, the researchers found that farmers' lack of experience will negatively influence their revenue. The implication of this is that there is the need for improved knowledge of soil fertility management and rainfall variability for improved farm revenue. Furthermore, the results show that water (rainfall) is positively related to the improvement of farm revenue. In other words, increasing the available water through irrigation by half will also lead to small farms' revenue increasing by fifty percent. Overall, the results show that small farms are more efficient under unhindered conditions, as the analysis showed thirty-nine percent efficiency compared to thirty-eight percent and thirty-seven percent efficiency under declined soil conditions and climate variability conditions, respectively. The results also show that small farms in the Eastern Cape are presently not technically efficient.

DISCUSSION

The information generated from the results is indicative of some emerging dynamics. This result show improvement in men's involvement in household agricultural activities, which is in contrast to the past trend of women dominating agricultural activities in the Eastern Cape province as a result of men's preference for jobs at the mines outside the province (Nhemachena and Hassan 2007; Aliber and Hart 2009; Crush et

Table 4: Stochastic frontier modelling for small farms in the Eastern Cape province

		Unconditional production		*Under different soil fertility status*		*Under varied climate condition*	
	Variable	*Co-efficient*	*P>|z|*	*Co-efficient*	*P>|z|*	*Co-efficient*	*P>|z|*
Production Frontier	Ln Farm size	0.789	0.000***	0.753	0.000***	0.719	0.000***
	Ln HH Age	0.073	0.793	0.141	0.571	0.149	0.550
	Ln Edu (years)	-0.002	0.984	0.013	0.898	0.014	0.887
	Ln HH Size	-0.304	0.274	-0.273	0.308	-0.277	0.302
	Ln Farming experience (years)	0.038	0.743	-0.027	0.821	-0.008	0.948
	Ln HH Labour	-0.095	0.633	-0.076	0.689	-0.098	0.59
	Ln HIR Labour	0.184	0.103*	0.203	0.063*	0.263	0.020**
	Ln Soil fertility status			0.317	0.114	0.374	0.229
	Ln Precipitation					0.548	0.106*
	Ln Temperature					2.122	0.488
	Constant	8.465	0.000***	8.152	0.000***	-2.456	0.839
Distribution of v and u	$Sigma^2$	1.061		1.075		1.087	
	Sigma_v	0.419		0.388		0.354	
	Sigma_u	0.941		0.961		0.980	
	Lambda(ë)	2.241		2.478		2.762	
Efficiency Scores		0.39		0.38		0.37	

Log likelihoods: -151.62, -150.43 and -148.84 for unconditional, soil fertility status and climate conditions frontier respectively

***= 1% significance level

**= 5% significance level

*= 10% significance level

al. 2011). Stats SA's (2012) report confirmed men's recent increased involvement in the agriculture labor force in the Eastern Cape province. The report states that men's agricultural involvement increased by 2.5 percent and 12.2 percent quarterly and annually, respectively. Similarly, a study by Musemwa et al. (2010) states that men's dominance in agricultural activities could be linked to African societies' customary status of men as traditional heads of households in rural communities. However, Place (2009) and Jayne et al. (2010) observed that access to productive assets and control of productive resources are gender sensitive, with women on the vulnerable side.

The results show that many of the interviewed farmers are in the productive age, which is good for farming activities. This is supported by both national quarterly and annual increases in agricultural labor employment by 4.1 percent and 8.8 percent, respectively (Stats SA 2012). Several studies have attributed the positive impact of age to sustainable agricultural practices. For instance, older farmers have a higher possibility to adopt a technology because of their accumulated knowledge, capital and experience and increase in yields (Abdulai and Huffman 2005; Fischer and Qaim 2012).

The percentage of education level attained is expected to have a positive influence on farms' productivity and the efficiency of crop production in the study area. Overall, the study showed that the majority of the farmers have an education up to the secondary level, which is expected to serve as a positive link to agricultural productivity and efficiency. In a similar study, Abdulai and Huffman (2005) found that education enables farmers to identify feasible technologies, whose adoption provides an opportunity for net economic gain over those that do not. Musemwa et al. (2010) also state that educated farmers have better access to information, as they can read farming periodicals that may boost their knowledge base on farming, which will enable them to comprehend agricultural experts' advice.

Household size is an important factor in smallholder farming systems, because it ensures the availability of labor for agricultural activities that are labor intensive, most especially as it affects efficiency in low-input and resource-poor households. This was indicated by the large household sizes observed among the respondents. Household size can have a positive influence on farming activities and production efficiency through the provision of family labor. Odendo et al. (2011) observed that a higher ratio of household members who contribute to farm work is generally linked to a greater labor force available to the household for the timely operation of farm activities, including soil management.

Farm size cultivated is believed to have a positive influence on the efficiency and development of smallholder farming systems (Giller et al. 2011). This study observed that a higher percentage of respondents cultivated less than two hectares. This, if efficiently harnessed with other factors, is expected to boost agricultural production in the study area. A similar study by Chand et al. (2011) on smallholder faming households in India showed that smallholdings in Indian agriculture exhibit higher productivity than large holdings.

The efficiency results show declined productive elasticity of land under different scenarios. However, the study revealed a declining effect of farm size on small farmers' production output under unconditional farm production, soil fertility status and climate variability conditions. This revealed that intensification of technologies rather than extensification of land will produce production efficiency under varied climatic conditions in the Eastern Cape province. This is very important, as farm size was significant at a one percent alpha level under all the production environments. Similarly, household labor was insignificant, as it also had an inverse relationship with small farms' productivity. The implication of this is that household labor among the interviewed farms in the Eastern Cape province is underutilized. This is opposite to the theory of well-supervised household labor and labor efficiency known with small farms (Hazell et al. 2010).

CONCLUSION

This paper explored the socio-economic characteristics and the different agroecological zones and also determined the efficiency levels of smallholder crop producing farmers in the Eastern Cape province under three scenarios. Descriptive analysis was used to present the socio-economic characteristics and productive assets of the smallholder farmers in the Eastern Cape. SFA was employed to determine the production efficiencies of the interviewed small farm-

ers under unhindered production environment, soil fertility condition and climate variability conditions.

The researchers found similar but striking socio-economic characteristics among small farms in the different agroecological zones of the Eastern Cape, just as is the case in all parts of developing nations. However, the researchers also found glutted household size and not optimized household labor, fragmented land and land without collateral as some of the hindrances to the productivity of smallholder farmers. The study also revealed that access to land and technology intensification are vital policy interventions required for small farms in the disadvantaged Black communities in the Eastern Cape for enhanced food production.

Furthermore, the researchers found that smallholder farmers, when subjected to different levels of land, age, household size, years of formal education, years of farming experience, labor (both household and hired), soil status and climate variability, produced relatively efficiently under unhindered (unconditional) environments compared to the scenarios. The SFA revealed a declining impact of soil fertility status and climate variability on small farms' production frontier in the Eastern Cape province, a semi-arid region of South Africa. As stated in the study, most of the soils in the study areas are low in soil fertility. Furthermore, the researchers found that apart from the size of land cultivated, climate variability was the second impact in magnitude on small production frontiers in the Eastern Cape province.

In relation to the results and inferential analysis, the researchers therefore conclude that smallholder farmers in the Eastern Cape are currently inefficient and their production frontier can worsen under conditions of declining soil fertility and climate variability and change.

RECOMMENDATIONS

This paper has exhaustively analyzed socio-economic and production frontiers of disadvantaged Black smallholder farmers in the semi-arid Eastern Cape province of South Africa. The information generated requires policy realignment to tap into unused or not optimized socio-economic and productive assets of the small farms, and the researchers therefore make the following recommendations.

Land issues are not new in South Africa, most especially in the former homelands where the disadvantaged Black people live. However, the land issues need to be adequately addressed, not necessarily as it is currently done, but in terms of the present demographic reality and the issue of land title documents. Overburdened household sizes and household labor can be put into productive use by different farming arrangements such as contract farming and equity farming systems for the improvement of food security, reduction of poverty and hunger and increased smallholder production frontiers, which will have a positive effect on national economic growth.

Although household labor was not found to be significant in this study, low efficiency can be accounted to labor congestion. The problem of labor congestion is more acute in provinces with a higher demographic pressure, highlighting the need to create more agro-allied employment opportunities. Therefore, higher levels of production and productivity can be attained by improving the income levels of farm households through revamping current governmental transfer and remittance systems by targeting those farmers who engage in full-time farming activities. Many conditions that can be conducive to high levels of efficiency and production, such as economic incentives, liquidity availability, education and nutrition, are all closely related to income.

The declining soil fertility status of the smallholder farming systems in the Eastern Cape province of South Africa calls for a multifaceted approach to improve production efficiencies. There is a vast potential for smallholder farmers to increase their efficiency levels and subsequently their total output by raising yields per hectare and also per capita. The short-term solution may be the use of more intensive land-augmenting inputs such as fertilizer and irrigation in medium and low soil fertility agroecological zones. In the long run, output can rely on improvements in technical efficiency. Government investment in research and development can have a positive impact on efficiency. Such research and development should place more emphasis on areas such as water control (irrigation) and chemicals (fertilizer, pesticides, insecticides) and scientific advances in modern agriculture, such as improved seeds and breeding new varieties.

A new challenge, particularly for smallholder farmers, is emerging from climate change in the long run. Climate change is expected to have damaging effects such as an increased year-to-year variability in rainfall, resulting in increases in both droughts and heavy precipitation events. Households will need to adapt to the changes, for example through cropping and planting practices, grain storage, land management, including erosion control, and soil protection. The natural calamity of climate change can have a long-term negative impact on particularly smallholder farmers' productivity. Necessary policy actions such as public investment in agricultural infrastructure and the provision of more effective weather forecasting and early-warning networks should be taken to encourage more small farms' engagement in agricultural activities.

LIMITATIONS

Although this paper is based on a study in the three major agroecological zones of the Eastern Cape, the researchers acknowledge the limitation of not covering other agroecological zones and recommend such further studies. The researchers also acknowledge that this paper is based on smallholder farmers' revenues from different crops, hence a study of production frontiers on specific crops is also recommended. Finally, this paper modeled with the current climate situation by using the average temperature and rainfall. The researchers therefore recommend a longitudinal study or projection into the future on the impact of climate change on smallholder production frontiers among disadvantaged Black farmers in the Eastern Cape province.

NOTE

[1] This paper was extracted and revised from a draft copy presented at the 4th International Conference of the African Association of Agricultural Economists (AAAE) on September 22-25, 2013; Hammamet, Tunisia. The conference contribution paper titled Scenario simulation of small farms' production efficiencies in the Eastern Cape Province, South Africa was authored by Sunday Hosu, Melusi Sibanda and Abbyssinia Mushunje and hosted on AgEcon search.

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