AgEcon SEARCH
RESEARCH IN AGRICULTURAL & APPLIED ECONOMICS

The World's Largest Open Access Agricultural & Applied Economics Digital Library

This document is discoverable and free to researchers across the globe due to the work of AgEcon Search.

Help ensure our sustainability.

Give to AgEcon Search

AgEcon Search
http://ageconsearch.umn.edu
aesearch@umn.edu

*Papers downloaded from **AgEcon Search** may be used for non-commercial purposes and personal study only. No other use, including posting to another Internet site, is permitted without permission from the copyright owner (not AgEcon Search), or as allowed under the provisions of Fair Use, U.S. Copyright Act, Title 17 U.S.C.*

4thICAAAE 2013 SEPTEMBER 22-25, Hammamet Tunisia
4th International Conference of the African Association of Agricultural Economists
icaaae.org
aaae-africa.org

Scenario simulation of small farms' production efficiencies in the Eastern Cape Province, South Africa

By:
Sunday Hosu, Melusi Sibanda, and Abbyssinia Mushunje

Invited paper presented at the 4th International Conference of the African Association of Agricultural Economists, September 22-25, 2013, Hammamet, Tunisia

Copyright 2013 by [authors]. All rights reserved. Readers may make verbatim copies of this document for non-commercial purposes by any means, provided that this copyright notice appears on all such copies.

192- Scenario simulation of small farms' production efficiencies in the Eastern Cape Province, South Africa

Sunday Hosu[1], Melusi Sibanda[1,2*] and Abbyssinia Mushunje[1]

[1]*Department of Agricultural Economics & Extension, University of Fort Hare, P Bag X1314, Alice, 5700*

[2]*Risk and Vulnerability Assessment Centre (RAVAC), University of Fort Hare, P Bag X1314, Alice, 5700*

[*]Corresponding Author Email: sibandamelusi@yahoo.co.uk Cell (+27) 72 647 3073

Abstract

Smallholder agriculture is not achieving its pivotal role of attaining food security in developing countries like South Africa. In rural areas, smallholder farmer's efficiencies have always been hindered mostly by some factors beyond their control such Agro-ecological factors. The challenge is how agriculture can be a key component of the drivers of rural economic development. This article presents a scenario simulation of small farms' production efficiencies in the Eastern Cape Province, South Africa in three major agro-ecological zones namely; Grassland, Savannah and Karoo. A combination of pedo-climatic and socio-economic data in the selected villages were collected from 223 respondents in the three major agro-ecological zones: 77 in the Grassland zone, 73 in the Savannah and Karoo zones respectively. The Stochastic Frontier Analysis (SFA) in the Cobb-Douglas functional form was used to model technical efficiency of the integrated small farms under different productive scenarios. The stochastic frontier analysis revealed a declining impact of soil fertility status but improved efficiency under climate variability. Overall, integrated small farms in the study areas are inefficient in their production exercise but comparatively, they are efficient under climate condition than other productive environments. There is potential for smallholder farmers to increase efficiency levels and thus total output by raising yields per hectare. In the short-term, the use of more intensive land-augmenting inputs such as fertiliser and irrigation in medium and low soil fertility agro-ecological zones can enhance productivity. In the long run, output can rely on improvements in technical efficiency.

Keywords: Technical efficiency, Agro-Ecological zones, Stochastic Frontier Analysis, Smallholder farmer.

1. Introduction

Most of South Africa's proportion of its population resides in rural areas and are, one way or the other, involved in some agriculture-related activity (Mudhara, 2010). According to Aliber (2009) agriculture in South Africa employs 4,75 million people, of whom 4 million are engaged in agriculture for own consumption purposes. Due to the fact that the nonagricultural sectors jointly employed 8 million employees, it implies that those who grow their own food, (smallholders) have the potential to employ approximately 33% of the total labor force in the country (Mudhara, 2010). However, most farming households are still characterized by poverty, hunger, poor remuneration, under employment as well as unemployment. Integrated Food Security Strategy for South Africa notes that government realizes the significance of food security and therefore prioritizes expenditure for the good of the of the historically disadvantaged groups (Department of Agriculture (DoA), 2002). Support mechanisms have been implemented and include community food garden initiatives, land reform and farmer settlement, production loans scheme for small farmers, infrastructure grant for smallholder farmers and the tractor mechanization scheme. One of the aims of the South African government is to create higher income opportunities for the previously disadvantaged black community (Ngqangweni, Kirsten and Delgado, 2001). In a study by Ngqangweni, Kirsten and Delgado (2001) they revealed that smallholder farmers can produce efficiently, even when subjected to opportunity cost assumptions that apply to their traditionally commercial counterparts.

Worldwide there has been attention 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, economic and energy crisis leading to the concepts of food security and agro ecologically based production systems (Altieri, Funes-Monzote and Petersen, 2011). De Schutter (2010) state that in order to feed nine billion people in 2050, there is urgent need to adopt the most efficient farming systems and recommend for a fundamental shift towards agro-ecology as a way to boost food production and improve the situation of the poorest. Mudhara (2010) also contend that smallholder farmers can double food production within 10 years in critical regions by using agro-ecological 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 will exhibit 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). The sector is inflicted by all the impulses of poverty, food insecurity, lack of employment, HIV/AIDS, etc. Households are also influenced by their interaction with external factors such as agro-ecological and socioeconomic environments (Ruben *et al*., 1998). The agro-ecological environment determines the potential agricultural activities which households could engage in. Rainfall is also a major constraint of dry-land cropping system in most parts of the Eastern Cape Province (Sibanda, Mushunje and Mutengwa, 2012). Dry land agricultural activities in the Eastern Cape Province is rain-fed based, therefore planting is predominantly done during summer period (October to April) with exception of farmers who grow vegetables in the garden near their homes with the intention of irrigating with water from their homes. Although smallholder farmers are efficient users of some productive resources mostly labour, efforts needs to be geared towards issues about declining soil fertility, soil degradation and negative effect of climate variations (Hosu and Mushunje, 2013). These are the core hinderances to smallholder farms efficeincies.

This paper looks at a scenario simulation of small farms' production efficiencies in the Eastern Cape Province of South Africa under three major agro-ecological zones namely Grassland, Savannah and Karoo. In particular, it focuses on the estimation of different scenario specifications and production efficiency under different environments (unconditional farm production, soil fertility status and climate variability conditions). The insight generated from the study will provide information for policy intervention on improving smallholder farmers' production effeciencies in a semi-arid environment stressed with declining soil fertility and marginal rainfall.

2. Methodology

The study was conducted in three major agro-ecological zones in the Eastern Cape Province of South Africa. The study employed a combination of secondary data on climate conditions in the selected villages as well as socio-economic surveys to build a model of an integrated small-scale farming system for the Eastern Cape Province based on various bio-physical and economical variables. The specific study areas in the major ecological zones were namely; Grassland, Savannah and Karoo in two representative District Municipalities, Amatole and Chris Hani with seven local municipalities and fifteen locations. The locations in the Grassland zones are Elliot, Engcobo, Seymour, Tsomo, Roxeni and Elliotdale while locations surveyed in the savannah zone are: Lady Frere, Qamata, Cala, Melani, Gqumashe, and Middledrift. Surveyed locations under Karoo (Nama) are Zola, Takarstad and Hofmeyr. The study focused on smallholder and emerging farming households which keep livestock and those with some arable or home gardening of crops that could be used to feed the livestock or the residues used to supplement livestock feed.

2.1 Data collection and sampling procedure

The study interviewed 223 respondents; 77 in the Grassland zone, 73 in the Savannah and Karoo zones respectively. Data collection was stratified in line with the major ecological zones namely; Grassland, Savannah and Karoo and then fifteen locations were randomly selected within the seven local municipalities of the two District Municipalities (Amatole and Chris Hani). Here, areas/villages in the ecological zones under different rainfall belts (rainfall being the paramount climate parameter) were randomly selected for the survey. Multistage sampling procedure was employed in the collection of data. Primary data was sourced through the use of structured questionnaire and personal interviews of the farmers selected from the list of the farmers who combine both crops and livestock identified by extension officers in the areas.

2.2 Data Analysis

Descriptive analysis was used to analyze the socio-economic characteristics of the smallholder farmers in the study areas. Technical efficiency of the integrated small farms was modelled through Stochastic Frontier Analysis (SFA). In order to gain further insight on the efficiency structure, the analyses was taken one step further by relating small farms performance with "exogenous" variables, which are not exclusively at the control of the farmer but nevertheless influence the outcome of the production process. These are the climate indictors (mean precipitation and temperature) as well as the soil fertility status. Four types of soils: Luvisols, Ferrasols, Lithic-luvisols and Leptosols were identified in the study areas. These were represented by dummies according to their nutrient supply to farming activities. Luvisols is 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. Generally, there are more of Leptosols in the areas covered by this study. Stochastic Frontier Analysis was determined for cropping activities only because the inclusion of livestock revenue resulted to failure of the model. Also, free range grazing system is common among the farmers and the variables (inputs) considered mostly affect cropping activities.

The stochastic frontier for a cross-sectional analysis is stated in equation 1:

$$y_i = f(x_i; \beta).\exp(v_i).TEF_{i,} \tag{1}$$

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 and β_i is the is a vector of input parameters to be estimated and $f(x_i; \beta)$ is the deterministic production frontier. Further $\exp(v_i)$ embodies the random shocks on each farmer, being $[f(x_i; \beta).\exp(v_i)]$ the stochastic production frontier. TEF_i is the output-oriented technical efficiency of small integrated $farm_i$, is defined in equation 2 as:

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

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 & Moreira, 2007). Since it is a production function, Cobb-Douglas functional form was used to estimate stochastic frontier analysis with Data Analysis and Statistical Software for Professionals (STATA). The estimated equation is presented in equation 3:

$$\ln y_i = \beta_0 + \sum_k \beta_k \ln x_{k,i} + v_i - u_i \tag{3}$$

Where v_i is assumed to be independently and identically distributed symmetric and independent of u_i. The error term in this equation, $\varepsilon_i = v_i - u_i$, is composed by a two-sided "noise" term and a nonnegative technical inefficiency term (Pereira & 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:

$$E[\exp(-u_i / \varepsilon_i)] \tag{4}$$

Emprically, the cross-sectional modelling equation is specified in equation 5 as:

$$\ln y = \beta_0 + \beta_1 \ln LS + \beta_2 \ln HHL + \beta_3 \ln HIRL + \beta_4 \ln FTZ(Bags) + \beta_5 \ln FTY + \beta_6 \ln PREC$$
$$+ \beta_7 TEMP + v_i - u_i \tag{5}$$

Where LS stands for land size, HHL, Household labour, HIRL, hired labour, FTZ (Bags) fertilizer used in bags, FTY is soil fertility status, PREC stands for mean precipitation of the area, TEMP is the average temperature of the area and the decomposed error term (v_i, u_i). Summary of the statistic used in SFA is presented in Table 1.

Table 1: Statistics of the variable used in the Stochastic Frontier Analysis

Variables	**Description**	**Minimum**	**Maximum**	**Total (n=223) Mean (s.d)**
Revenue from cropping activities	Revenue in Rand	R1080.03	R45,070	7498.03 (6959.97)
Precipitation	Average rainfall distribution in the Eastern Cape	319mm	929mm	564.1mm (143.80)
Temperature	Average temperature	26^0C	29^0C	27.65^0C (1.42)
Farm size	Farm size in ha	0.1ha	10ha	2.76 (1.82)
Fertilizer use	In bags	0	15 bags	3bags (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, medium fertile, 1 is low fertile	1	3	

3. Results

3.1 The socio-economic characteristics of the farming households

The socio-economic characteristics of the farming households in the study areas illustrated in the Table 2 are presented in this section:The results in the Table 2 show some variations in the headship of farming households in the three Agro-ecological zones. The study observed that households in the Grassland and Karoo zones were largely headed by female with 58.4% and 50.7% respectively. However, male headed households accounted for 51.5% in all-farm analysis. This result shows an improvement in males' involvement in household agricultural activities with its positive impact on household's decision making and food security. However, the finding is in contrast to the past trend of women dominating agricultural activities in the Eastern Cape due to the fact that men always go outside the province to work in the mines (Ellis, 1993; Nhemachena & Hassan, 2007).

Statistics South Africa (SSA) (2012) report also confirms men's recent increase involvement in agriculture labour force in the Eastern Cape Pronvince. The report states men's agricultural involvement increased by 2.5% and 12.2% quarterly and annually respectively. This might be as a result of recent agricultural development program such as CASP envisaged in Phuhlisani (2008) report. However, SSA (2012) indicates that women's involvement in agricultural labour increased by 7.6% quarterly and 2.4% annually. However, study by Musemwa *et al.* *(*2010) posit that men's dominance in agricultural activities could be linked with African societies' customary status of men as traditional heads of households in rural communities. But Kaliba *et al.* (2000) and Quisumbing *et al.* (1994) conclude that it does not appear that gender differences affect farming households but the control and inequality in ownership of productive resources.

The study (Table 2) also observed that larger percentage of the respondents was in the productive age in Savannah zone (89%) compared to Grassland (81.81%) and Karoo (69.85%). In general analysis (all-farm), respondents who are in the productive age bracket (15-65) accounted for 77.57% in the study area. Age is very important factor to agricultural productivity. The study indicated that many of the farmers are in the productive age which is good for farming activities in the study area. This is supported by national quarterly and annual increase agricultural labour employment by 4.1% and 8.8% respectively (SSA, 2012). Several studies have attributed positive impact of age to sustainable agricultural practices. Abdulai and Huffman (2005) and Lapar and Pandey (1999) state that older farmers have the higher possibility to adopt a technology because of their accumulated knowledge, capital and experience. But Featherstone and Goodwin (1993) and Sidibe (2005) have a contrary opinion that young farmers are lower risk averse and can capitalised on the youthful age to adopt new technologies that have long lags between investments and yield of benefits.

Analysis of the household head's education status showed that 79.5% of respondents in the Karoo zone have secondary level education compared to grassland zone (67.6%) and savannah zone (56.2%). All-farm analysis showed that respondents who have primary education are 59% while those who have secondary education are 41.26%. The percentage education level attained is expected to have positive influence on farm's productivity and adoption of crop-livestock integration technology in the study area.

Comparatively, the study observed that there is higher percentage (16.9%) of illiterate respondents in the Grassland zone compared with other zones. Overall, the study showed that majority of the farmers have got education up to the secondary level which is expected to serve as a positive link to agricultural technology such as the adoption of integrated crop-livestock system. In a similar study, Abdulai and Huffman (2005) finds that education enables farmers to identify feasible technologies whose adoption provides an opportunity for net economic gain from those that do not. Musemwa *et al*. (2010) also states 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 comprehend agricultural experts advices.

The study observed (Table 2) that 67.10% of the household heads were married in the Savannah zone compared to 66.20% and 61.6% married household heads in the Grassland and Karoo zones respectively. All-farm analysis showed that 65.02% of the household heads were married. The study also observed that 54.8% of the farming households in the Karoo zone have household size of 6-10 members. This is the largest group compared with 44.15% in Grassland and 49.31% in the Savannah zones. However, all-farm results showed that farming households with members of 6-10 accounted for 49.33% in the study area. Household size is an important factor in smallholder farming system because it ensures availability of labour to agricultural activities which is labour intensive, most especially integrated crop-livestock system where labour is needed in transporting and spreading manure.

Smallholder agricultural system is labour intensive. This was indicated by large household size observed among the respondents in the study area. This showed that household size can have positive influence on farming activities and the intensification of integrated crop-livestock system among farmers in the study area by the provision of family labour. Odendo *et al.* (2011) state that a higher ratio of household members who contribute to farm work is generally linked with a greater labour force available to the household for timely operation of farm activities including soil management.

The study also observed that 70.1% of respondents in the grassland zone chose farming as main job whereas 47.9% and 57.5% of the respondents chose farming as main job in Savannah and Karoo zones respectively. This by implication shows that majority of the respondents in the grassland zone will have more time devoted to their farming activities which is expected to impact positively on farm turnovers. All-farm analysis showed that 58.74% of the respondents engaged in farming as the main job.

The study also observed that majority of the respondents have been engaged in farming activities up to 20 years. About 91% of respondents in the Savannah zone have been in farming activities for 20 years while 71.42% and 87.67% of the respondents in Grassland and Karoo respectively have got 20 years experience in farming. All-farm results showed that 87.95% of the respondents have been engaged in farming activities for 20 years. This is supposed to boost farm productivity since majority of the farmers are familiar to farming operations.

The analyses of land size cultivated showed that 71.23% of the respondents in the Karoo zone cultivated land size between 0-2 hectares compared to 44.16% in the Grassland zone and 38.3% in the Savannah zone for the same land size cultivated. This result showed that smallholder land access is more fragmented in the Karoo zone compared to others. However, all farm analysis also showed that about 72% of the respondents cultivated land size between 0-2 hectares. All-farm analysis showed that the majority of the respondents (55.61%) have access to land through inheritance. Land ownership through inheritance was pronounced among the respondents in Karoo zone (72.6%) compared with 57.6% in the Grassland and 37% in the Savannah zone. Land ownership through rentage was also prominent among respondents in the Karoo zone. However, communal ownership was prominent among respondents in Grassland compared to other zones.

Land size cultivated is believed to have positive influence on the efficiency and development of smallholder farming system (Norris and Batie, 1987). This study observed that higher percentage of the respondents cultivated between 2 to 5 hectares. This, harnessed with other factors efficiently is expected to boost agricultural production in the study area. A study by Norris and Batie, (1987) states that larger farm size is associated with greater wealth, increased availability of capital, and high risk bearing ability which makes investment in conservation more feasible. This is supported by Rahm and Huffman (1984) that farmers who cultivate larger farms can afford to apportion part of their fields to try out the improved technology such as integrated crop-livestock systems.

Table 2: socio-economic characteristic 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
Characteristic Household Head		Freq	percent	cum	Freq	percent	cum	Freq	percent	cum	Freq (percent)
	Male	32	41.6	41.60	47	64.4	64.4	36	49.3	49.3	115 (51.5)
	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 (years)											
	No formal education	13	16.9	16.9	9	12.3	12.3	9	12.3	12.3	31 (13.90)
	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 (numbers)											
	0-5	26	33.76	33.76	34	46.57	46.57	18	24.7	24.7	78 (34.98)
	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 occupation											
	Farming	54	70.1	70.10	35	47.9	47.9	42	57.5	57.5	131 (58.74)
	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)

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)
Land 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)
	Rentage	4	5.3	63.2	8	11.00	48.00	13	17.8	90.4	25 (11.21)
	Land Redistribution	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)

Source: Field Survey; March-May, 2012

3.2 Results of the stochastic frontier modelling for small farms in the Eastern Cape

The estimation of different scenario specifications is shown in Table 3. All models were estimated by Maximum Likelihood using STATA version 12. The estimation shows elasticity of the inputs and production efficiency under different environments**.** The results show decline in the productive elasticity of land under different scenarios. An increase in average land size by 1% will influence small farms' revenue by 0.56%, 0.54% and 0.44% respectively under unconditional farm production, soil fertility status and climate variability conditions. The results also showed that land size is significant at 1% under all the production environments. Although household labour was not significant, it has highest magnitude of impact under climate change condition. Similarly, increasing hired labour by 1% will significantly increase small farms' revenue by 0.18%, 0.18% and 0.22% respectively under unconditional production, soil fertility status and climate conditions. Fertilizer use by small farms significantly influence production frontiers under unconditional production and soil fertility status. The results showed that fertilizer's use has high impact on production frontier under soil fertility status condition. The results further showed that precipitation has the highest significant impact on the small farms production frontier and revenue generation in Eastern Cape Province. Lastly, the results show that integrated small farms in the study area are inefficient in their production exercise given that the higher technical efficiency is 43%. But comparatively, they are efficient under climate condition than other productive environments.

Table 3: Stochastic Frontier modelling for small farms in the Eastern Cape

		Without any condition		Under different soil nutrient status		Under Climate Conditions	
		Co-efficient	P>|z|	Co-efficient	P>|z|	Co-efficient	P>|z|
Production frontier	ln Land size	0.56	0.000***	0.54	0.000***	0.44	0.000***
	ln HH Labour	0.05	0.706	0.043	0.742	0.083	0.513
	ln HIRLabour	0.18	0.006***	0.18	0.003***	0.22	0.002***
	ln Fertilizer used	0.30	0.003***	0.25	0.010***	0.11	0.363
	ln Soil fertility			0.23	0.184	0.44	0.163
	ln precipitation					1.12	0.007***
	ln Temperature					3.07	0.249
	Constant	8.30	0.000***	8.35	0.000***	-8.96	0.395
Distribution of v & u							
	Sigma ^{2}	1.77		1.81		1.56	

	Sigma_ v	0.22	0.18	0.23
	Sigma_ u	1.31	1.33	1.23
	Lambda(λ)	5.93	7.30	5.31
Efficiency scores	Av. TEF_i	0.42	0.41	0.43

*** indicates 1% significant level

Log likelihoods: -102.00, -101.10 and -97.54 for unconditional, soil fertility status and climate conditions frontier respectively.

4. Conclusions and Recommendations

This paper attempted to explore the efficiency level of smallholders intergrated farmers in the Eastern Cape Province under different agro-ecological zones. Smallholder farmers when subjected to different levels of land, labour, soil status and climate variability, the general observation is that they can produce relatively efficient under climate variability condition compared to other scenarios. The stochastic frontier analysis revealed declining impact of soil fertility status but improved under climate variability on small farms production frontier in the Eastern Cape Province because the farmers with time have adjusted to climate variation by by shifting planting dates or by selection of crops favourable to their agro-ecological conditions. As stated in the study, most of the soil in the study areas are low in soil fertility in Eastern Cape Province. The impact of the soil fertility on small farms production was further justified by the magnitude of the fertilizer utilisation under soil fertility scenario.

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

Although household labour was not significant in this study, low efficiency can be accounted to labour congestion. The problem of labour congestion is more acute in provinces with a higher demographic pressure, highlighting the need to create more off-farm employment opportunities. Therefore higher levels of production and productivity can be attained by improving the income level of farm households thorough govenments transfers and remittances. Many conditions that can be conducive for high levels of efficiency and production such as economic incentives, liquidity availability, education, and nutrition are all closely related to income.

A new challenge, particularly for smallholder, farmers is emerging from climate change. 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, e.g., cropping and planting practices and grain storage, land management including erosion control, and soil protection. The natural calamity such as climate change can have long term negative impact on particularly on smallholder farmer productivity. Necessary policy actions should be taken to encourage more public investment in agricultural infrastructure and the provision of a more effective weather forecast and early warning networks.

References

Abdulai, A., & Huffman, W. E. 2005. The diffusion of new agricultural technologies: the case of crossbred-cow technology in Tanzania. *Am. J. Agric. Econ*., 87: 645-659.

Aliber, M., 2009. Exploring Statistics South Africa's national household surveys as sources of information about food security an subsistence agriculture. Unpublished report, Centre for poverty Employment and Growth, Human Sciences Research Council, Pretoria.

Altieri, M.A., Funes-Monzote, F.R. & Petersen, P., 2011. Agro-ecologically efficient agricultural systems for smallholder farmers: contributions to food sovereignty. Agron. Sustain. Dev. DOI 10.1007/s13593-011-0065-6. Review article.

Battese, G, & Coelli, T.1988. Prediction of .rm-level technical e¢ ciencies with a generalized frontier production function and panel data. Journal of Econometrics (38), 387.399.

DoA (Department of Agriculture), 2002. The intergrated food security strategy for South Africa. Pretoria: Department of Agriculture.

De Schutter, O., 2010. Report submitted by the Special Rapporteur on the right to food. UN General Assembly. Human Rights Council Sixteenth Session, Agenda item 3 A/HRC/16/49.

Ellis, F. 1993. *Peasant economics. Farm households and agrarian development*. Second edition, Cambridge, University Press.

Featherstone, A., & Goodwin, B. 1993. Factors influencing farmers' decision to invest in long term conservation in improvements. *Land Econ*., 69: 277-292.

Hosu, Y.S. & Mushunje, A., 2012. Agro-ecological condition and constraints to optimal productivity of smallholder intergrate crop-livestock farmers in the Easern Cape Province, South Africa.

Kaliba, A, R. M., Verkuijl, H., & Mwangi, W. 2000. Factors Affecting Adoption of Improved Maize Seeds and Use of Inorganic Fertilizer for Maize Production in the Intermediate and Lowland Zones of Tanzania.

Lapar, M., & Pandey, S. 1999. Adoption of soil conservation: the case of the Philippine Uplands. *J. Agric. Econ*., 21: 241-256.

Mudhara, M., 2010. Agrarian transformation in smallholder agriculture in South Africa: A diagnosis of bottlenecks and public policy options. Conference paper presented at 'Overcoming inequality and structural poverty in South Africa: Towards inclusive growth and development, Johannesburg, 20-22 September 2010.

Musemwa, L., Mushunje, A., Chimonyo, M., & Mapiye, C. 2010. Low cattle market off-take rate in the communal areas of Eastern Cape Province of South Africa: Causes and mitigation strategies. *Journal of Sustainable Development* 12 (5): 209-226.

Nhemachena, C., & Hassan, R. 2007. Micro-Level Analysis of Farmers' Adaptation to Climate Change in Southern Africa, *IFPRI Discussion Paper* No. 714. IFPRI: Washington, DC.

Ngqangweni, S.S., Kirsten, J.F. & Degado, C.L. (2001). How efficient are African smallholders? A case study in the Eastern Cape Province of South Africa. Agrekon. Vol 40 (1). 58-64.

Norris, P. E, & Batie, S. S 1987. Virginia farmers' soil conservation decisions: Application of Tobit analysis. *S. J. Agric. Econ*., 19: 79-90.

Odendo, M., Obare, G. & Salasya, B., 2011. What factors influence the speed o adoption of soil fertility management technologies? Evidence from Western Kenya. Journal ofDev and Agric. Econs. Vol 3 (13). 627-637.

Pereira, M. C, and Moreira, S. 2007. A Stochastic Frontier Analysis of Secondary Education Output in Portugal, Banco de Portugal:1-34.

Phuhlisani, 2008. *Extension and small holder agriculture: Key issues from a review of the literature* (eds) First draft: 16th June 2008.
Quisumbing, A. 1994. Improving women's agricultural productivity as farmers and workers. *ESP Discussion Paper Series 37*. World Bank,Washington DC, USA.

Rahm, M. R., & Huffman, W. E 1984. The Adoption of Reduced Tillage: The Role of Human Capital and Other Variables. *Am. J. Agric. Econ*., 66: 405-413.

Ruben, R., Moll, H., & Kuyvenhoven, A., 1998. Intergrating agricultural research and policy analyisis: Analytical framework and policy applications for Bio-economic modelling. Agricultural systems. 58:3 (331-349).

Sibanda, M., Mushunje, A. & Mutengwa, C.S., 2012. An assessment of factors influencing the demand for Open Pollinated Varieties (OPVs) of maize as an adaptation strategy to Climate change by smallholder farmers in the Eastern Cape, South Africa. Paper presented at the 1st National Conference on Global Change, 26 – 28 November 2012, Birchwood Hotel, Boksburg.

Sidibe, A. 2005. Farm-level Adoption of Soil and Water Conservation Techniques in Northern Burkina Faso. *Agric. Water Mgt*., 71: 211-224.

SSA, (Statistic South Africa) 2012. Quarterly labour force survey: Stastistic release P0211, quarter 1, May, 2012.