Vol. 74 | No. 5/1 | May 2018
DOI: 10.21506/j.ponte.2018.5.19

PONTE
Florence, Italy
International Journal of Sciences and Research

SOCIO-ECONOMIC FACTORS INFLUENCING NETT FARM REVENUE OF SMALLHOLDER FARMERS UNDER EXTREME CLIMATIC CONDITIONS IN THE EASTERN CAPE PROVINCE, SOUTH AFRICA

Melusi Sibanda, *Department of Agriculture, University of Zululand, South Africa, Tel.: +27 (0) 35 902 6068, email: SibandaM@unizulu.ac.za;*

Lovemore Musemwa, *Department of Agricultural Economics, Education and Extension, Bindura University of Science Education, Zimbabwe.*

Abyssinia Mushunje, *Department of Agricultural Economics and Extension, University of Fort Hare, South Africa.*

Charles S. Mutengwa, *Department of Agronomy, University of Fort Hare, South Africa.*

Leocadia Zhou, *Risk & Vulnerability Science Centre (RVSC), University of Fort Hare, South Africa.*

ABSTRACT

The Eastern Cape is one of the poorest provinces in South Africa. Agriculture remains an important sector in the province, and most smallholder farmers largely depend on it for both income and sustaining their livelihoods. Smallholder farming is usually constrained by numerous bio-physical and socio-economic challenges, resulting in low productivity and low income levels. This situation is worsened by the emerging global threat of extreme climatic events. This paper sought to determine the socio-economic factors that influence the nett farm revenue of smallholder farmers under extreme climatic conditions in the Eastern Cape province. Smallholder farmers were stratified into dry-land and irrigation farmers. Primary data was collected from 250 smallholder farmers (both crop and livestock) through structured questionnaires by means of convenience sampling from the Chris Hani and OR Tambo Districts. Data was analysed on Stata software. Descriptive statistics were employed to describe farmer characteristics and the Ordinary Least Squares (OLS) multiple regressions were employed to determine the socio-economic factors influencing nett farm revenue of smallholder farmers. Results show that on average, the nett farm revenue of irrigation farmers was higher (ZAR11 868.06) than that of the dry-land farmers (ZAR7 904.85) per annum. Socio-economic factors such as gender, highest educational level, household size, farming experience and access to formal markets positively influenced nett farm revenue while distance to output markets negatively influenced nett farm revenue. It is recommended that smallholder farmers be supported and empowered, especially under extreme climatic conditions, through educational programmes and market development to enhance their production and boost their nett farm revenues.

Keywords: Eastern Cape Province; Extreme Climatic Conditions; OLS Regression; Nett Farm Revenue, Smallholder Farmers.

INTRODUCTION

Due to increased greenhouse gas emissions, there is now a consensus that the climate of the earth has gradually become warmer (Harris & Roach 2016). Projections are that towards

the end of the next century, mean temperatures would have risen by about 1.5 to 5.8 ºC (Gao et al. 2017); which would result in increased frequency of droughts; a rise in sea levels; occurrence of floods and heavy rains, and changes in wind directions (Intergovernmental Panel on Climate Change (IPCC) 2001; IPCC 2014; Climate Council 2017).

Battisti and Naylor (2009) predict that in the tropics and subtropics, temperatures will exceed the greatest (>90%) seasonal growing temperatures recorded during the last century. It is evident from the World Economic Forum (2018) report that environmental risks associated with global warming and climate change such as high-impact hurricanes, extreme temperatures and rising carbon dioxide emissions is one of the biggest challenges mankind has ever faced. Climate change is anticipated to worsen the present challenges faced by society such as food insecurity and other developmental stresses, particularly on the African continent where difficulties posed by the emerging climatic change and variability are prevalent (Slingo et al. 2005; Misra 2014).

Production in agriculture has more than trebled between 1960 and 2015, owing to productivity-enhancing green revolution technologies, substantial increases in land use, water and other natural resources (Food and Agriculture Organization of the United Nations (FAO) 2017). Nevertheless, the majority of the African populace still live in abject poverty, with those in the sub-Saharan Africa (about 70%) depending on subsistence farming (Hellmuth et al. 2007; Bastos Lima 2014). Climate change in low to middle income countries is therefore most likely to lower agriculture's contribution to gross domestic product (GDP) (Mendelsohn et al. 2000) and also consistently and negatively affect the food production in all aspects (FAO 2017). As a result of increasing temperatures and drying, Jones and Thornton (2003) predict that the productivity of crops in Africa would be significantly affected, with yields for example maize declining by 10 to 20 percent by the year 2055. Recent estimates by Adhikari, Nejadhashemi and Woznicki (2015) for the major grain crops, including maize, rice and soybean, project about 45 percent loss in yield by the end of the current century.

African societies are highly dependent on agriculture, with most smallholder farming households in sub-Saharan Africa being the most vulnerable due to limited ability to respond to the impacts of climate change (Shiferaw et al. 2014). Agricultural activity is highly sensitive to climatic variability and smallholder farmers rely directly on farming as a livelihood (Harvey et al. 2014). Therefore, any changes in temperatures, coupled with a decrease in precipitation levels, would have detrimental effects for crop production as well as agricultural welfare (Stevanović et al. 2016), thus declining agricultural productivity that will significantly have an impact on food security, nutrition, income and the well-being of smallholder farmers (Harvey et al. 2014). Generally, in South Africa, resource-poor smallholder farmers mostly produce for household consumption with limited institutional support (Mudhara 2010). As a result, they are subjected to the stresses of poverty, food insecurity, unemployment and diseases such as HIV/AIDS. Smallholder farmers tend to succumb to exogenous factors, for example the environmental and socio-economic conditions they operate under (Ruben et al. 1998; Ochieng et al. 2016). The Eastern Cape province is semi-arid and is among the worst poverty-stricken regions in the country. Rainfall becomes a major challenge, particularly for dry-land farmers. Irrigation in the Eastern Cape is reported by the Department of Agriculture, Fisheries and Forestry (DAFF) (2018:3) "to be at critical levels, with no irrigation at all in some areas."

The Eastern Cape province is bordered by KwaZulu-Natal (KZN) and the Western Cape provinces and its climate is largely influenced by these provinces. The province is characterised by both a subtropical and Mediterranean climate. The coastal climate of the province is humid and windy (South Africa Channel Information 2018). Humidity rises close to KZN and declines nearer to the Western Cape. Inland areas are typically dry and hot with lesser rainfall levels than at the coast (Jordaan 2017). According to the Department of Water and Sanitation (2014), there has been some evidence of extreme climatic events occurrence in the Eastern Cape province for example with warnings of a large part of the province remaining in an icy grip in 2014 due to temperature drops and weather predictions that indicated very rough seas, with waves in excess of 6m for the coastal areas. According to the Department of Environmental Affairs (DEA) (2011), although there is limited research with regard to possible fluctuations in extreme climatic events for Africa, regional modelling over southern Africa projects continued climatic changes and/or variability to long-term temperature and rainfall trends, with a rise in extreme climatic events such as drought spells, including flooding in some areas. The impacts of extreme weather events to society and economies, especially to the agricultural sector and rural livelihoods, are presently being experienced in South Africa and are predicted to increase in magnitude in the coming decades (DEA 2011). A study by Hosu et al. (2016) indicates the Eastern Cape to be more vulnerable to climatic shocks and climate change across the major agro-ecological zones due to the smallholder farmers in the province having limited adaptive capacity. Hosu et al. (2016) further predicted future climate patterns' impact on smallholder farmers' revenue in the Eastern Cape and their findings revealed that maize production will be positively affected by climate change and variability for both resource-poor and irrigated management farming systems, while they expected the yield of potatoes to decline. However, most climatic impact projections are that farming will be negatively affected. Given that most smallholder farmers in the Eastern Cape are resource-poor and rely on rain-fed (dry land) farming systems, and that the province is already drought prone, and the projected rise in extreme climatic conditions such as heat waves, frequency of droughts and uncertainty in rainfall patterns, dry-land smallholder farmers are most likely to be affected.

In most cases conventional subsistence farming in the rural areas is not profitable, or it results in very low nett farm incomes. Studies have been carried out to indicate the factors that influence farm profitability of large-scale farms but little research has been done on the factors that influence the nett farm revenue of smallholder farmers in South Africa. There are less studies that have focused on the socio-economic influence on the nett farm revenue of smallholder farmers, especially under extreme climatic events in South Africa specifically in the Eastern Cape province. The Eastern Cape is most likely to be adversely impacted by extreme climatic events because of its poverty state and much reliance on rain-fed farming by the vast number of smallholder farmers, with fluctuations in both temperature and rainfall directly affecting crop and livestock production. Empirical evidence from other countries have shown that socio-economic attributes such as farmer demographics like age, gender, educational levels and socio-economic factors are some attributes that influence the nett income from smallholder farming activities. However, the direction of the influence and magnitude of these factors on farm income under different land-use options and geographical location vary. With the Eastern Cape being hypothesized to be among the most vulnerable provinces to climate change and climate variability due to inadequate economic and institutional ability to respond to climatic shocks, it is in this regard that a better understanding of how extreme climatic conditions will impact the agricultural welfare and thus the income of smallholder farmers is crucial to inform policies that may help reduce the severity of the impact or take advantage of the situation. The

aim of this paper therefore is to determine the influence of socio-economic attributes on nett farm income of smallholder farmers for both crop and livestock farmers under both dry-land and irrigation farms in the drought-prone province of the Eastern Cape in South Africa where extreme climatic events are already assumed to be happening.

METHODOLOGY

Description of the Study Area

Two district municipalities in the Eastern Cape province were selected, namely Chris Hani and O.R. Tambo districts. These districts were purposively selected given their agricultural potentials and geo-climatic aspects. Four villages were randomly selected from these districts, namely Cofimvaba and Qamata Irrigation Scheme (QIS) both in Chris Hani district and Mqanduli (Goodhope and Lower Nhenga) near Coffee Bay in the O.R. Tambo district. Cofimvaba is a town about 79km east of Queenstown on the road to Butterworth. Qamata Irrigation Scheme is found in the Qamata Basin on the banks of the Indwe River near its confluence with the Great White Kei River (Kodua-Agyekum 2009). Both Cofimvaba and QIS fall under the Intsika Yethu Municipality of the Chris Hani District. Goodhope and Lower Nhenga are villages in Ward 24 and 25 respectively of Mqanduli in King Sabata Dalindyebo Municipality of the O.R. Tambo district.

Research Design

The study employed a quantitative research approach that made use of a cross-sectional research design to determine the socio-economic factors influencing the nett farm revenue of smallholder farmers. Data was collected at a single point in time, and proved to be cost effective but covered several aspects of data such as household livelihoods, including crop yields, livestock production and revenues where possible using interviewer-administered questionnaires. The unit of analysis in a study refers to the major entity that was analysed (Trochim 2006). For this study, smallholder farmers for both crops and livestock provided primary data. The sample excluded large commercial farms. In most instances, the study measured crop production as the value of yields per hectare harvested per farm household the previous year. Most small-holder farmers do not keep records and also practice mixed crop systems in one plot, creating difficulties in precisely getting accurate yield records of specific farm enterprises which thus explains the use of nett farm revenues in this paper.

Description and Selection of Participants

Bless and Smith (2000) define a sampling frame as a list of all units from which a sample is to be drawn. It was, however, not possible to access a complete sampling frame for all smallholder farmers in the study areas. Due to time and financial constraints, a total of 250 (145 dry-land and 105 irrigation) smallholder farmers from the two selected districts in the Eastern Cape province were selected by means of a convenience sampling strategy.

Data Collection

Primary data was collected in 2013 during the farming period and included the socio-economic data, production costs and income data for the computation of nett farm revenue. The relevant authorities (local *Indunas* or councilors) were approached with the help of the extension officer(s) in the study areas, for approval to conduct the study. Face-to-face interviewer-administered questionnaires were used to gather data.

Data Analysis

Collected data was entered and coded in Microsoft Excel spreadsheets and exported to STATA software version 11 for analysis. Descriptive statistics and the ordinary least square (OLS) technique multiple regressions were used in analysing data. The OLS regression was employed to determine the socio-economic attributes that influence nett-farm revenue of smallholder farmers in the Eastern Cape Province. The dependent variable in the model is the nett farm revenue, otherwise known as nett farm income which is computed as follows:

$$NFI = Gross\ \ Margin\ \ (GM)\ -\ \ Total\ \ Fixed\ \ Cost\ \ (TFC) \qquad (1)$$

Where,

$$Gross\ \ Margin\ \ (GM) = \ Total\ \ Income\ \ (TI)\ -\ \ Total\ \ Variable\ \ Costs\ \ (TVC) \qquad (2)$$

Descriptive Analysis

Descriptive statistics (analysis) was used to describe the socio-economic profile (characteristics) of the sample. Descriptive statistics expressed as percentages are reported for dummy variables and the minimum, maximum values and means and standard deviations are reported for continuous variables on the socio-economic characteristics of participating smallholder farmers.

Multiple Regression Models

Multiple regression, involving the use of OLS technique was employed to determine the magnitude and direction of independent variables (socio-economic characteristics) on the nett farm revenue (dependent variable) of smallholder farmers. The Multiple Regression Model was employed to identify socio-economic factors that influence the nett farm revenue of smallholder farmers in the study areas. Multiple Regression Analysis permits one to discriminate between the effects of the independent variables, making allowances for the fact that they may be correlated. The Multiple Regression Model was adapted from Safa (2005) who conducted a similar study on "socio-economic factors affecting the income of smallholder agroforestry farms in Hill Country areas in Yemen." The Multiple Regression Models are specified as follows:

$$Y = \ \beta 0\ +\ \beta 1X1\ +\ \beta 2X2\ +\ \beta 3X3{+}\ldots.\beta nXn\ +\ \mu i \qquad (3)$$

Where the functional forms to be fitted are specified as follows:

Y = The dependent variable measured by the nett farm revenue (South African Rand (ZAR))
X1 =Age
X2 = Gender

X3 = Highest educational level
X4 = Household size (proxy for labour)
X5 = Farming experience (years)
X6 = Access to a tractor (yes/no)
X7 = Access to extension (yes/no)
X8 = Access to formal markets (yes/no)
X9 = Access to credit (yes/no)
X10 = Distance to input markets (km)
X11 = Distance to output (km)
μi = random error term.
β1, β2.... βn are coefficients of independent variables;
X1, X2,...,Xn are the independent variables and
μi is the error term.

Guided by literature, the factors that may affect nett farm revenue were regressed against the independent variables that included the demographics of the smallholder farmers such as age, gender, education level, household size (proxy for labour), and socio-economic factors such as farming experience (years); access to a tractor (yes/no); access to extension (yes/no); access to formal markets (yes/no); access to credit (yes/no); distance to input markets (km); and distance to output markets (km). Table 1 provides a brief explanation of the independent variables inputted in the Multiple Regression Models, and the assumed relationship or expected outcomes with nett farm revenue.

The explanatory variable age was inputted in the model as a continuous variable. Numerous studies use age as a proxy for farming experience. It was hypothesized that age would have a positive influence on nett farm revenue. Gender was taken as a dichotomous (dummy) variable and was coded with 1 if the respondent was female and 0 if otherwise (male). The effect of gender on the nett farm revenue cannot be predetermined as its influence may be positive or negative on either sex. The education variable was categorized into four categories coded as follows: if the respondent did not have formal education (1); had attained primary education (2); secondary education (3); and college/tertiary education (4). The assumption was that an improvement in the level of education can equip a smallholder farmer with new ideas and information that will in turn impact on his or her farming productivity and thus ultimately positively influence their nett revenues. The household size variable represented the number of household members in a farm and was used to reflect labour availability for farming activities. The expectation here was that households with a greater number of members would positively influence the nett farm revenue. Years of experience in farming were recorded to reflect the respondent's farming knowledge that they might have acquired over the period they have been involved in farming. It was postulated here that more experience in farming would be associated with improved farming methods and thus to be positively correlated to nett farm revenue. The variable access to a tractor (if yes coded with (1) and/or otherwise coded with (0)) was used as a proxy for farm machinery. Farm machinery embraces the use of improved technology to improve productivity and thus nett farm revenue. The variable access to extension was measured to determine contact with extension and advisory services. It was expected that better access to extension and advisory services such as training and more information from the extension services would boost farmers' nett farm revenue.

Table 1. Explanatory variables, description, and the expected outcome.

Variable	Description and Measurement Type	Variable Type	Expected Outcome (+/−)
Age	Actual age in years of the smallholder farmer	Continuous	+/-
Gender	The sex of the smallholder farmer (male (1)/female (0))	Categorical (Dummy)	+/-
Educational level	The highest educational level attained by the smallholder farmer. (no formal education (1); primary (2); secondary (3) and tertiary (4)	Categorical	+
Household size (proxy for labour)	Actual number of household members	Continuous	+
Farming experience (years)	Actual number of farming experience in years	Continuous	+
Access to a tractor (yes/no)	Whether the smallholder farmer has access to a tractor (yes (1)/no (0))	Categorical (Dummy)	+
Access to extension	Whether the smallholder farmer has access to extension services (yes (1)/no (0))	Categorical (Dummy)	+
Access to formal markets	Whether the smallholder farmer has access to formal markets (both input & output) (yes (1)/no (0))	Categorical (Dummy)	+
Access to credit	Whether the smallholder farmer has access to formal credit (yes (1)/no (0))	Categorical (Dummy)	+
Distance to input markets (km)	Actual distance (km)	Continuous	-
Distance to output markets (km)	Actual distance (km)	Continuous	-

Source: By Authors (2013) (+/−) Denotes a positive or negative relation with the dependent variable

Access to formal markets is also a critical factor. This variable was measured as a dummy (if respondent answered in the affirmative "yes" coded with (1) and/or otherwise coded with (0)). The assumption here was that ready access to formal markets would directly inject income to the farm business with less losses due to produce lost as a result of no access to markets or less retains from informal markets. Access to credit represents the availability of working capital which in most cases a stumbling block for smallholder farming. Access to credit was inputted in the model as a dummy variable were farmers indicated whether they were able to get credit loans (if the respondent answered in the affirmative "yes" coded with (1) and/or otherwise coded with (0)). Both distance to and from the formal market were measured as continuous variables and were hypothesized to negatively influence nett farm revenues of smallholder farmers. The nett farm revenue (income) (the dependent variable used in this paper)

was recorded as a continuous variable. The estimated nett farm revenue was measured in South African Rand (ZAR).

RESULTS

Summary of Socio-Economic Characteristics of Respondents

Table 2 shows that the mean nett farm revenue per annum for smallholder farmers is ZAR7 904.85 for dry-land farms; ZAR11 868.06 for irrigation farms and ZAR9 569.40 for all farm analysis. The maximum nett farm revenue per annum for all farm analysis was ZAR111 490 and the minimum was ZAR20. This finding reveals that irrigation farms on average perform better than dry-land farms. The average age of the interviewed smallholder farmers was about 58 years across all farms, suggesting farming activities were largely undertaken by the elderly (Table 2). In terms of gender, the results generally show that there were more female farmers (54%) than male farmers (46%) for dry-land and irrigation farms and all farms analysis respectively in the study areas. Education is an important strategy to prepare communities to cope with extreme climatic conditions (Striessnig et al. 2013). The majority of the smallholder farmers (about 78%; 60% and 71%) for dry-land farms, irrigation farms and all farms' analysis respectively had no education or had attained primary education, with a few having attained secondary or tertiary education (Table 2). The size of each household was taken as the number of persons who lived in the respondent's household. Labour, mainly casual, is an essential factor of production for smallholder farmers. In most cases, smallholder agriculture is labour-intensive rather than capital-intensive (Kirsten & van Zyl 1998). The mean household size was 7 and 8 members per household for dry-land and irrigation farms, and all farms analysis respectively and a maximum of 13 and 20 members per household for dry-land and irrigation farms, and all farms analysis respectively in the study areas (Table 2). Farming experience can be associated with the age of a household head (Hofferth 2004). Table 2 reveals that farmers have been involved in agricultural activities for more than 10 years with an average of about 22, 21 and 22 years for dry-land farmers, irrigation farmers and all farmers analysis respectively (Table 2). This is in agreement with prior findings on the age of the farmers which showed that the dominant age group of the interviewed farmers across all farms were in the elderly bracket, implying that they could be experienced farmers. Another important factor that influences the performance of farmers under extreme climate conditions is ownership of implements and asset endowment. Examples of implements include access to farm machinery such as tractors. The majority (about 22% and 33%) of dry-land farmers and all farmers analysis respectively had no farm machinery such as a tractor. On the other hand, approximately 50% of the irrigation farmers reported that they had access to a tractor (Table 2). Indeed, Nhemachena (2009) citing Kurukulasuriya and Mendelsohn suggested that access to farm machinery such as a tractor can positively increase nett farm revenue. The results show that the majority (82%, 65% and 75%) of dry-land farmers, irrigation farmers and all farmers analysis respectively revealed limited access to formal credit. Extension services represent human capital and equip farmers with climate change information and technical know-how that can reinforce their capacity to better cope under extreme climatic conditions (Coulibaly et al. 2015). The majority (about 83%, 98% and 90%) for dry-land farmers, irrigation farmers and all farmers analysis respectively in the study areas shows that respondents had access to extension services. It is evident from Table 2 that a greater part of the respondents (about 85% dry-land farmers, 86% of irrigation farmers and 85% all farmers analysis) had no access to formal markets. Results in Table 2 show that across all farms, the maximum distance travelled by farmers to their input market was about 100km. For output markets, farmers reported that they had to travel a maximum distance of

about 400km and 70km for dry-land farms and irrigation farms respectively in the study areas. Generally, these results show that farmers had to travel long distances to both input and output formal markets and have difficulty in gaining entry to both these formal markets.

Table 2. Descriptive results (socio-economic characteristics of the smallholder farmers)

Variable	ß (Dry-land farms) n=145	ß (Irrigation farms) n=105	ß (All farms) n=250
Age	Max-86, Min - 23, Mean- 58.65, SD - 13.045	Max-80, Min - 30, Mean- 58.37, SD - 11.245	Max-86, Min - 23, Mean- 58.53, SD - 12.298
Gender	Male (42.1%), Female (57.9%)	Male (45.7%), Female (54.3%)	Male (46%), Female (54%)
Education	Never (33.8%), Primary (44.8%), Secondary (21.4%)	Never (35.2%), Primary (25.7%), Secondary (38.1%) , Tertiary (1.0)	Never (34.4%), Primary (36.8%), Secondary (28.4%), Tertiary (0.4)
Household size	Max - 13, Min - 1, Mean - 7.87, SD - 3.019	Max - 20, Min - 1, Mean - 6.81, SD - 3.768	Max - 20, Min - 1, Mean - 7.42, SD - 3.387
Farming experience	Max - 45, Min - 1, Mean -21.68	Max - 60, Min - 1, Mean -21.36	Max - 60, Min - 1, Mean -21.54
Access to a tractor	Yes (22.1%), No (77.9%)	Yes (49.5%), No (50.5%)	Yes (33.6%), No (66.4%)
Access to extension services	Yes (83.4%), No (16.6%)	Yes (98.1%), No (1.9%)	Yes (89.6%), No (10.4%)
Access to credit	Yes (17.9%), No (82.1%)	Yes (35.2%), No (64.8%)	Yes (25.2%), No (74.8%)
Access to formal markets	Yes (15.2%), No (84.8%)	Yes (14.3%), No (85.7%)	Yes (14.8%), No (85.2%)
Distance to input markets	Max - 100, Min - 0, Mean -81.66	Max – 100, Min – 0, Mean - 40.76	Max – 100, Min – 0, Mean - 64.48
Distance to output markets	Max – 400, Min – 0, Mean - 13.99	Max – 70, Min – 0, Mean – 7.81	Max – 400, Min – 0, Mean – 11.40
Nett Farm Revenue	Max – ZAR67 760, Min – R20, Mean - ZAR7 904.85	Max – ZAR111 490, Min – R30, Mean - ZAR11 868.06	Max – ZAR111 490, Min – R20, Mean - ZAR9 569.40

Source: Own Survey (2013)

Empirical results of the OLS multiple regression on factors influencing the nett farm revenue of smallholder farmers

A model fit statistics was computed in the OLS multiple regression analysis to determine how well the model fitted the data using the R-Square and Adjusted R-Square coefficients

(Table 3). R-Square and Adjusted R-Square measure the percentage of the results variance that is explained by the model. An adjusted R-Square that is closer to one (1), shows a better fit of the estimated regression line. With regard to this data set, the adjusted R-Squares of 0.6349 (dry-land farms), 0.5106 (irrigation farms) and 0.5374 (all farms analysis) suggests that the model was appropriate to explain the variations to the dependent variable. Therefore, about 63%, 51% and 53% variations of the nett farm revenue for dry-land farms, irrigation farms and all farms (combined) respectively was triggered by the variables inputted in the model. Another test, the F-statistic elucidates the association of the dependent and the explanatory variables. According to Table 3, the nett farm revenue is statistically significant since the p-value (0.000) of the F statistic, significant at 1 percent level is less than the significance p-value levels. Therefore, the null-hypothesis is rejected and it can be affirmed that the model provides a better fit than the intercept-only model. This implies that there is a significant relationship between nett farm revenue and the independent (explanatory) variables.

The variable of gender is found to be an important factor that influences the nett farm revenue at a 1% significance level (p=0.000) and at a 5% (p=0.001) significance level for dry-land farms and all farms analysis respectively (Table 3). The variable gender is positively related to the nett farm revenue for dry-land farms and all farms analysis. The model predicts that the "effect" of being a male smallholder farmer (male coded with 1) is greater than being a female smallholder farmer (female coded with 0) on the nett farm revenue.

Education determines the level of human capital and the capacity to interpret information (Kuzilwa et al. 2017). The results reveal that a higher formal educational level of a household head is linked with higher nett farm revenue. The highest education level parameter, tertiary level, is significant at 1% level (p= 0.000) for irrigation farms and all farms analysis respectively (Table 3). The positive coefficients on the education level tertiary parameter suggest that households that are headed by those that are functionally literate are more likely to realise more nett farm revenue. The model predicts that a smallholder farmer with a tertiary education is likely to generate more nett farm revenue per annum of about ZAR60 768.41 and ZAR59 907.99 for irrigation and all farms analysis respectively compared to a smallholder farmer with no education (Table 3). The coefficient of education parameter tertiary level is greater for irrigation farms than all farm analysis. The result of this study is in line with other studies for example Panda (2015) that a higher educational level may significantly increase nett farm revenue.

Table 3. Estimates of the multiple regression model on factors influencing the nett farm revenue of smallholder farmers under extreme climatic conditions in the Eastern Cape province

Variable	**Dry-land farms**		**Irrigation farms**		**All farms (Combined)**	
	Coef. *(ß)*	**P>|t|**	**Coef. *(ß)***	**P>|t|**	**Coef. *(ß)***	**P>|t|**
Constant	11086.84	0.027	-3587.362	0.836	6256.153	0.266
Age	-104.8179	0.092	-139.098	0.489	-150.6391	0.045
Gender (*male*)	5586.471***	0.000	595.5835	0.862	4933.425**	0.001

Highest educational level						
Primary	-5242.095**	0.002	-888.0115	0.823	-4529.633**	0.015
Secondary	-620.7519	0.746	855.9798	0.834	-944.7704	0.639
Tertiary	-	-	60768.41***	0.000	59907.99***	0.000
Household size (proxy for labour)	-110.1532	0.640	1453.374***	0.000	580.3208**	0.008
Farming experience	96.79514	0.229	260.816**	0.029	148.3769	0.016
Access to a tractor	500.1633	0.835	3884.311	0.210	1849.525	0.303
Access to extension	309.1853	0.875	4593.113	0.657	2007.153	0.409
Access to credit	-325.2189	0.873	-1771.298	0.589	262.5143	0.870
Access to formal markets	25002***	0.000	28294.61***	0.000	25569.44***	0.000
Distance to input markets (km)	-19.14207	0.422	-59.27105	0.250	21.16731	0.276
Distance to output Markets (km)	-48.16006***	0.000	-35.02044	0.762	-64.5211***	0.000
Number of observations	145		105		250	
R-square (Adjusted R-Square)	0.6653 (0.6349)		0.5718 (0.5106)		0.5615 (0.5374)	
F-Statistics (Prob > F)	21.87 (0.0000)		9.35 (0.0000)		23.25 (0.0000)	

Source: Own Survey (2013) Computed from STATA 14 ***; ** denotes statistical significance at 1%; 5% levels

The variable household size was used as a proxy for household labour. This variable is significant at 1% level (p=0.000) and (p=0.008) for irrigation farms and all farms analysis (Table 3). The household size is positively related to the nett farm revenue and agrees with the prior expectation. The model predicts that a unit increase in the household size of a farming household would increase the nett farm revenue per annum by about ZAR1 453.37 (irrigation farms) and ZAR 580.32 (all farms analysis) (Table 3). The results further show that the coefficient of this variable is greater for irrigation farms than all farm analysis. The study's

finding is in harmony with the findings of Talukder (2014) and Kuzilwa et al. (2017) that household size is a positive contributor to farm household income.

The variable farming experience is significant at a 5% level (p=0.029) for irrigation farms and is positively related to the nett farm revenue (Table 3). The model predicts that a one-unit increase in farming experience by years would increase the nett farm revenue per annum of the smallholder farmer by about ZAR260.81 (Table 3).

The variable access to formal markets is found to be significant at a 1% significance level (p=0.000) and positively related nett farm revenue for dry-land farms; irrigation farms and all farms analysis (Table 3). The regression model suggests that access to formal market (coded with 1) would result in an increase in nett farm revenue per annum for both dry-land farms and irrigation farms. This is in agreement with the prior expectation.

The variable distance to output markets showed a negative relationship with nett farm revenue. The variable is significant at 1% (p=0.000) for both dry-land farms and all farms analysis respectively (Table 3). The model predicts that a unit increase in the distance travelled to output markets would result in a decrease in the nett farm revenue per annum by about ZAR48.16 for dry-land farms and ZAR64.52 for all farms analysis (Table 3). This is in agreement with the prior expectations and descriptive statistics that showed that the majority of the farmers travelled long distances to formal markets.

DISCUSSION

Overall, the nett farm revenue by irrigation farmers appears to be better off than for dry-land farmers under extreme climatic conditions. The finding suggests that irrigation farmers have the advantage of increased crop yield and production, and thus increased nett farm revenue. This may be due to that irrigation offers a buffering mechanism during periods of drought. However socio-economic characteristics of both irrigation farmers and dry-land farmers were found to be more or less similar in the study area. In terms of factor endowment, generally most of the farmers, particularly dry-land farmers, had limited access to farm mechanisation such as a tractor. According to Smith et al. (2015), age influences socio-economic vulnerability. Therefore, the elderly is more likely to perform less in terms of nett farm revenue under the effects of extreme climatic conditions. This is confirmed by the inferential statistics (negative sign) of the coefficient of the age variable across all farm types, however this variable is not significant for this dataset.

Results on gender showed that there were more females than male farmers. This finding suggests that males prefer looking for paid employment outside the agricultural sector, probably in urban areas or nearby mines, leaving farming activities to females. This is, however, problematic as the empirical results suggest that male smallholder farmers are more likely to receive greater nett farm revenue per annum as compared to their female counterparts. This finding is understandable given that in most communities, men usually have more access to production resources such as infrastructure, land and access to credit than women and therefore their performance may be higher than for women. Generally, the majority of the smallholder farmers across all farm types had low education levels. The finding may imply that the low levels of education of smallholder farmers means that they cannot easily compete in other job markets to complement farm income.

Generally, smallholder agricultural systems are labour intensive (Hosu et al. 2013). For example, weed infestation is one of the major constraints in the Eastern Cape Province and weeding in particular, is very demanding of labour. Labor availability generally remains an issue in most smallholder farming with the farming activities largely being undertaken by the elderly and women. The able-bodied men and the youth in many instances migrate to urban areas in pursuit of what they perceive to be more rewarding job opportunities. Although this can be helpful by providing a source of income back to people on the farms, it makes it harder to perform laborious agricultural activities. Taken as a proxy for labour availability, the study's finding suggests that family labour can positively influence the smallholder farming activities and the reinforcement of integrated crop livestock systems.

In terms of farm experience, it can be inferred that most of the farmers were experienced. Experienced farmers tend to be better off in terms of knowledge and information, especially in areas such as climate change and agronomic practices (Maddison et al. 2007). Experienced farmers are therefore expected to use their knowledge to enhance their nett farm revenues in response to climate challenges. This is further confirmed by the empirical analysis that the more experienced the farmer is, the more nett farm revenue they are likely to gain from their farming enterprise. This is true because with more experience in farming, the more the farmer is generally likely to apply adaptive measures in his farming and take informed decisions based on his/her experience. This will result in improved productivity and thus increased nett farm income.

Diagne et al. (2000), attest to the notion that the availability of credit eases the cash constraints and improves the ability of a farmer with less or no savings to acquire the necessary agricultural inputs such as fertiliser, improved planting materials and other inputs. Access to credit improves the financial resources of farmers and their capability to meet transaction costs associated with the various adaptation options available to them under extreme climatic conditions. Results showed that across all farm types, access to credit was a stumbling block. Limited access to credit undermines the farmers' capacity for capital investment and means that they are unable to expand their productive activities as a result of their lack of access to inputs such as seed, fertiliser and insecticides. However, this variable was not significant for this dataset.

It is possible for smallholder farmers to realise greater returns from land, labour and capital; however, smallholder farmers do not partake in market-oriented production because of limited access to formal markets (Mkhabela 2007). Descriptive results confirmed that smallholder farmers across all farm types struggled with gaining entry to both input and output formal markets. In most cases, smallholder farmers may not know where the opportunities for markets are because they may not be educated, not exposed and they may not have the facilities for marketing. The empirical analysis suggests that improved access to formal markets by smallholder farmers under extreme climatic conditions will enhance their nett farm revenue. Access to input markets will boost productivity and access to output markets are expected to boost sales and thus the nett farm revenue. Again, better access to markets enables farmers to buy new inputs and adaptation technologies that they may need if they are to change their practices to cope with extreme climatic conditions and improve their nett farm revenue. Another problem faced by smallholder farmers across all farm types was travelling long distance to both input and output markets. The empirical analysis confirms that being far from markets is likely to have a negative influence on the nett farm revenues of smallholder farmers. The greater the

distance travelled to output market, the more cost the farmer incurs in terms of money and time and this negatively impacts on their nett farm revenue.

CONCLUSIONS AND RECOMMENDATIONS

The study sought to elicit the factors that influence the nett farm revenue of smallholder farmers (that is for both dry-land and irrigation farms) under extreme climatic conditions in the Eastern Cape province of South Africa. An OLS Multiple Regression Model that regressed nett farm revenue against a number of socio-economic factors such as age, gender, education level, household size (proxy for labour), farming experience, access to a tractor, access to extension, access to formal markets, access to credit, and distance to input and output markets was employed. The results show that the variables (gender, education, household size, farming experience, access to formal markets and distance to output markets) were found to significantly influence the nett farm revenue of smallholder farmers in the study areas. The OLS Multiple Regression Model results show that being male, having a higher educational level, a large household size, more experience in farming and better access to formal markets all had a significant positive influence on the nett farm revenues across all farm types. However, the influence of these variables in irrigation farms was found to be greater than that of dry-land farms. This suggests that education, farming experience, household size and access to formal markets serve as important production factors in agriculture, especially under extreme climatic events.

The study findings have a number of policy implications. The findings provide guidance on appropriate socio-economic factors to be targeted for policymakers to design the necessary support measures to increase the nett farm income of smallholder farmers under extreme climatic conditions and improve the livelihoods of people residing in the study areas. Climate change related policies need to invest more on these factors in order to improve farm performance of smallholder farmers under extreme climatic conditions. The increased distance to output markets seems to be a limiting factor and is negatively influencing nett farm revenue of smallholder farmers. Improving access to formal markets will ensure that farmers become competitive and thus improve their production activities. Policies aimed at improving farm-level performance need to highlight the critical role of market entry for smallholder farmers. Thus, it is recommended that improving access to markets is crucial for smallholder farmers. This should also be coupled with paying attention to the gender balance in agricultural activities and empowering them (especially women farmers) with the necessary resources and educational programmes (capacity building) through extension services that can enhance climate change knowledge among smallholder farmers. Education, coupled with agricultural skills training, is likely to enhance the nett farm revenue of smallholder farmers under extreme climatic conditions.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the University of Fort Hare Risk and Vulnerability Science Centre (RVSC), the Department of Science and Technology (DST) and the National Research Fund (NRF) for financing this study.

Author Contributions: Melusi Sibanda conceptualised and developed a framework for the study, Lovemore Musemwa assisted with the collection of data. Melusi Sibanda compiled the draft manuscript. Abyssinia Mushunje, Charles S. Mutengwa and Leocadia Zhou supervised

the study. The discussion and final manuscript is the outcome of the contributions from all the authors.

Conflicts of Interest: No conflict of interest has been declared by the authors.

REFERENCES

Adhikari, U., Nejadhashemi, A. P. & Woznicki, S.A. 2015. Climate change and eastern Africa: A review of impact on major crops. *Food and Energy Security*, 4(2): 110-132.

Bastos Lima, M.G. 2014. Policies and Practices for Climate-Smart Agriculture in Sub-Saharan Africa: A Comparative Assessment of Challenges and Opportunities across 15 Countries. Pretoria, Food, Agriculture and Natural Resource Policy Analysis Network (FANRPAN).

Battisti, D.S. & Naylor, R.L. 2009. Historical warnings of future food insecurity with unprecedented seasonal heat. *Science*, 323: 240 – 244.

Bless C. & Smith S.C. 2000. Fundamentals of social research methods: An African perspective. Kenwyn, South Africa: Juta.

Climate Council 2017. Cranking up the intensity: Climate change and extreme weather events. *Report by the Climate Council of Australia Ltd 2017*. ISBN: 978-1-925573-14-5 (print) 978-1-925573-15-2 (web).

Coulibaly, J.Y., Gbetibouo, G.A., Kundhlande, G., Sileshi, G.W. & Beedy, T.L. 2015. Responding to crop failure: Understanding farmers' coping strategies in Southern Malawi. *Sustainability*, 7: 1620-1636.

Department of Agriculture, Fisheries and Forestry (DAFF) 2018. National Agro-meteorological Committee (NAC) Advisory on the 2017/18 summer season Statement from Climate Change and Disaster Management 05 DAFF 2017. At http://www.daff.gov.za/doaDev/topMenu/doc/05Ad17%20for%20Jan2018.pdf [Accessed 03 April 2018].

Department of Environmental Affairs (DEA) 2011. Chapter 11 Climate change. At https://www.environment.gov.za/sites/default/files/reports/environmentoutlook_chapter11.pdf [Accessed 03 March 2018].

Department of Water and Sanitation 2014. The national state of water resources quarterly report July to September 2014. At http://www.dwa.gov.za/groundwater/documents/4th%20Quarter%202013-14%20State%20of%20Water%20Resources%20Report.pdf [Accessed 03 April 2018].

Diagne, A., Zeller, M. & Sharma, M. 2000. Empirical measurements of households' access to credit and credit constraints in developing countries: Methodological issues and evidence. Food Consumption and Nutrition Division Paper No. 90. International Food Policy Research Institute, Washington D.C.

Food and Agriculture Organization of the United Nations (FAO) 2017. The future of food and agriculture: Trends and challenges. Rome.

Gao, Y., Gao, X. & Zhang, X. 2017. The 2°C Global Temperature Target and the Evolution of the Long-Term Goal of Addressing Climate Change—From the United Nations Framework Convention on Climate Change to the Paris Agreement. *Engineering*, Volume 3, Issue 2, April 2017, Pages 272-278.

Harris J.M. & Roach B. 2016. Environmental and natural resource economics: A contemporary approach. Advance chapters for fourth edition: Fourth edition chapter 12: Global climate change: science and economics replaces third edition chapter 18. At http://ase.tufts.edu/gdae/Pubs/te/ENRE/4/Ch12_ClimateScience_4E.pdf [Accessed 03 April 2018].

Harvey, C.A., Rakotobe, Z.L., Rao, N.S., Dave, R., Razafimahatratra, H., Rabarijohn, R.H., Rajaofara, H. & MacKinnon, J.L. 2014. Extreme vulnerability of smallholder farmers to agricultural risks and climate change in Madagascar. *Philos Trans R Soc Lond B Biol Sci*., 5; 369(1639): 20130089.

Hellmuth, M.E., Moorhead, A., Thomson, M.C. & Williams, J. 2007. Climate risk management in Africa: learning from practice. New York, USA: International Research Institute for Climate and Society, Columbia University.

Hofferth, S.L. 2004. Persistence and change in the food security of families with children, 1997-1999. At http://naldc.nal.usda.gov/download/45674/PDF [Accessed 19 January 2018].

Hosu, S.Y., Cishe E.N. & Luswazi, P.N. 2016. Vulnerability to climate change in the Eastern Cape province of South Africa: what does the future holds for smallholder crop farmers? *Agrekon*, 55(1): 133-167.

Hosu, S., Sibanda, M. & Mushunje, A. 2013. Scenario simulation of small farms' production efficiencies in the

Eastern Cape Province, South Africa. Invited paper presented at the 4th International Conference of the African Association of Agricultural Economists, September 22-25, 2013, Hammamet, Tunisia.

Intergovernmental Panel on Climate Change (IPCC) 2014. Climate Change 2014 Synthesis Report Summary for Policymakers. At https://www.ipcc.ch/pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_SPM.pdf [Accessed 03 April 2018].

Intergovernmental Panel on Climate Change (IPCC) 2001. Climate change: The scientific basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change. J. T. Houghton and Ding Yihui, (Eds), Cambridge, UK: Cambridge University Press.

Jordaan, A.J. 2017. Vulnerability, Adaptation to and Coping with Drought: The Case of Commercial and Subsistence Rain Fed Farming in the Eastern Cape. Volume I Report to the Water Research Commission and Department of Agriculture, Forestry and Fisheries, *WRC Report number: TT 716/1/17*, Gezina: Water Research Commission.

Jones, P.G. & Thornton, P.K. 2003. The potential impacts of climate change and maize production in Africa and Latin America in 2055. *Global Environmental Change*, 13: 51-59.

Kirsten, J.F. & van Zyl, J. 1998. Defining small-scale farmers in the South African context. *Agrekon*, 37 (4): 560-571.

Kodua-Agyekum, C. 2009. The transfer of technology to the rural poor: The case of Qamata Irrigation Scheme in the Eastern Cape province of South Africa. PhD dissertation submitted for examination at University of KwaZulu-Natal, Pietermaritzburg.

Kuzilwa, J.A., Fold, N., Henningsen, A. & Larsen, M.N. 2017. Contract Farming and the Development of Smallholder Agricultural Businesses: Improving Markets and Value Chains in Tanzania. Routledge (Taylor and Francis Group), London.

Maddison, D. 2007. The perception of and adaptation to climate change in Africa, Policy Research Working Paper 4308, Development Research Group, Sustainable Rural and Urban Development Team, Washington DC: The World Bank.

Mendelsohn, R., Morrison, W., Schlesinger, M.E. & Andronova, N.G. 2000. Country-specific market impacts from climate change. *Climatic Change*, 45: 553-569.

Misra, A.K. 2014. Climate change and challenges of water and food security. *International Journal of Sustainable Built Environment*, 3(1): 153-165.

Mkhabela, T. 2007. Linking farmers with markets in rural South Africa: rural development and poverty alleviation through supply chain management. At http://www.namc.co.za/upload/per_category/Linking%20farmers%20to%20markets%20in%20Rural%20SA.pdf. [Accessed 19 January 2018].

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.

Nhemachena, C. 2009. Agriculture and future climate dynamics in Africa: Impacts and adaptation options. PhD Thesis, University of Pretoria, South Africa.

Ochieng, J., Kirimi, L., Mathenge, M. 2016. Effects of climate variability and change on agricultural production: The case of small scale farmers in Kenya. *NJAS - Wageningen Journal of Life Sciences*, 77: 71-78.

Panda, S. 2015. Farmer education and household agricultural income in rural India. *International Journal of Social Economics*, 42(6): 514-529.

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

Safa, M.S. 2005. Socio-economic factors affecting the income of smallholder agroforestry farms in Hill Country areas in Yemen: A comparison of OLS and WLS determinants. *Smallholder Forest Economics, Management and Policy*, 4(1): 117-134.

Shiferaw, B., Tesfaye, K., Kassie, M., Abate, T., Prasanna, B.M. & Menkir A. 2014. Managing vulnerability to drought and enhancing livelihood resilience in sub-Saharan Africa: Technological, institutional and policy options. *Weather and Climate Extremes*, 3: 67-79.

Slingo, J.M., Challinor, A.J., Hoskins, B.J. & Wheeler, T.R. 2005. Introduction: food crops in a changing climate.

Philosophical Transactions of the Royal Society B., 360: 1983 – 1989.

Smith, E.F., Keys, N., Lieske, S.N. & Smith, T.F. 2015. Assessing socio-economic vulnerability to climate change impacts and environmental hazards in New South Wales and Queensland, Australia. *Geographical Research*, 53(4): 451-465.

South Africa Channel Information 2018. Climate of the Eastern Cape. At http://www.southafrica.com/eastern-cape/climate/ [Accessed 03 March 2018].

Stevanović, M., Popp, A., Lotze-Campen, H., Dietrich, J.P., Müller, C., Bonsch, M., Schmitz, C., Bodirsky, B.L., Humpenöder, F. & Weindl, I. (2016). The impact of high-end climate change on agricultural welfare. *Science Advances*, 2(8), e1501452.

Striessnig, E., Lutz, W. & Patt, A.G. 2013. Effects of educational attainment on climate risk vulnerability. *Ecology and Society*, 18(1): 16.

Talukder, D. 2014. Assessing Determinants of Income of Rural Households in Bangladesh: A regression analysis. *Journal of Applied Economics and Business Research (JAEBR)*, 4(2): 80 – 106.

Trochim, W.M.K. 2006. Unit of Analysis. Research Methods Knowledge Base (2nd ed). Wadsworth Publishing, California.

World Economic Forum 2018. The Global Risks Report 2018 13th Edition, Geneva: World Economic Forum.