Effects of drought and animal diseases on smallholder farmers' participation in the South African livestock market

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Abstract

There is a global recognition that climate variability and its impacts are affecting most aspects of our lives frequently. Some of those impacts are observed with the regularity of drought and animal disease incidences. These occurrences affect the smallholder farmers and the vulnerable members of society. In this article, the effects of drought, animal diseases, and the combined impact of both drought and animal diseases on the smallholder farmers' market participation in South Africa are evaluated. The study used a multilevel logit model, and it conducted the best model test where the fixed effects model was selected. The study found that animal diseases negatively affect smallholder market participation. It was also noted that drought had an insignificant effect on smallholder market participation. It was revealed that animal diseases and drought combined have a negative effect on smallholder market participation. Their effect was found to be greater than the individual effect of animal diseases and drought. The results evidenced the government's need to enable smallholder farmers to access livestock vaccines and medicines to enhance their market participation. Compensation to the smallholder farmers should be commensurate to whether they are exposed to a single or combined effect of drought and animal diseases.

Keywords: Livestock market, market participation, drought, animal diseases, smallholder farmers, South Africa.

1. INTRODUCTION

The global livestock sector sustains approximately 1.3 billion people, and about 40% of the global agricultural output is contributed by the livestock sector (Matthews, 2006). However, the major challenges linked with livestock farming are deterioration of pastures, low technological adoption rates as well as drought and animal diseases (Matsaert, Kariuki and Mude, 2011; Hill, Hoddinott and Kumar, 2013; Bishu, O'Reilly, Lahiff and Steiner, 2018). Drought occurs when there is a persistent low amount of rainfall received relative to the mean rainfall in a specific area (Wilhite and Glantz, 1985). Reports show that 642 drought occurrences have happened between 1900-2013 worldwide (Masih, Maskey, Mussá and Trambauer, 2014). The drought occurrences have increased both in intensity and frequency over the recent past.

Effects of drought in Sub-Saharan Africa have increased over the years resulting in poor grazing lands, unavailability of water, and the death of animals (Muricho, Otieno, Oluoch-Kosura and Jirström, 2019). Drought deteriorates the livelihoods of the affected households by reducing both crop income and non-farm income (Fafchamps, Udry and Czukas, 1998). The reduction in the amount of rainfall in a region due to drought causes water scarcity which has direct implications on household food security. Southern Africa has experienced recurrent droughts with greater intensity affecting many countries including South Africa (Baudoin, Vogel, Nortje and Naik, 2017). Figure 1 below shows the amount of rainfall over the years from 1970 to 2017 in South Africa.

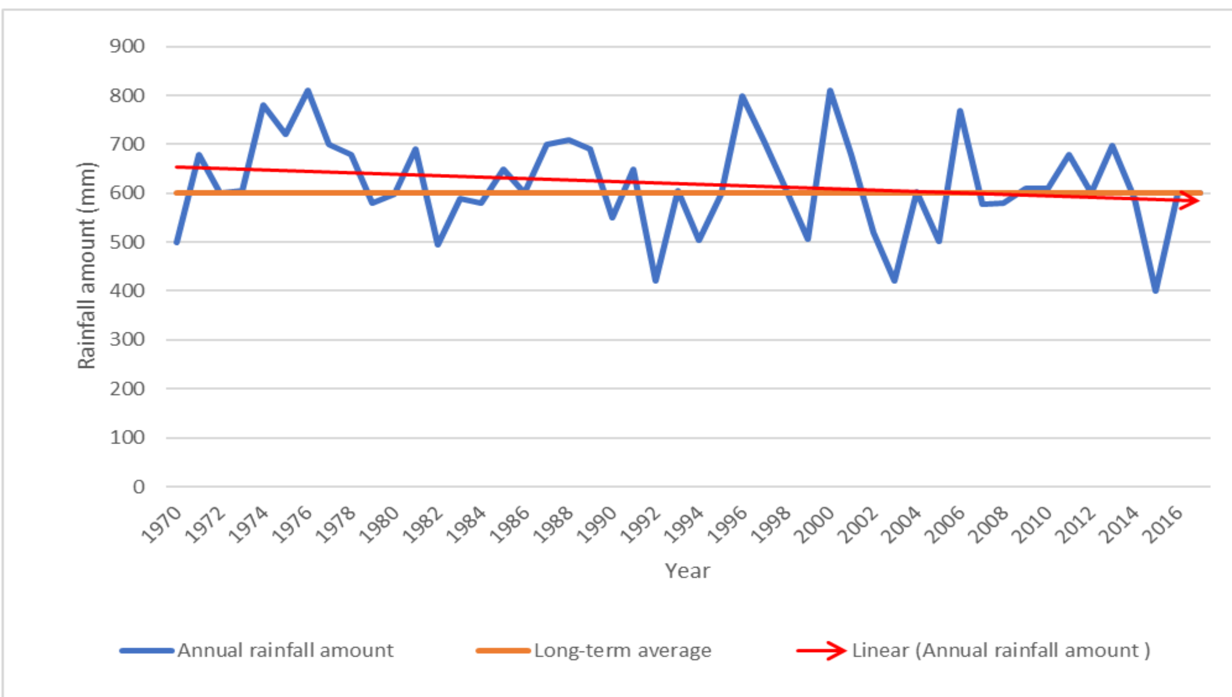

Figure 1: Annual Average rainfall

Source: Weather SA (2018)

The average rainfall amount in South Africa is 600mm indicated by the long-term average plot in figure 1 above. Therefore, all the years in which the rainfall amount is less than 600mm are regarded as drought years. In the 47 years shown above, 20 years recorded below-average rainfall amounts. It was noted that the frequency of droughts increased for the years after 1990 compared to the previous years. The period between 1970 and 2017 shows that the slope of the linear plot of annual rainfall amounts is declining implying that if the line continues like that, then in the future, less rainfall will be expected. The droughts experienced in South Africa are associated with the variability in the climate which causes increased temperatures and changes in rainfall patterns. The year 2015 had the lowest amount of rainfall and this was because of the El Niño that prevailed due to the warming up of the Pacific and Indian Oceans (Botai, Botai, Dlamini, Zwane and Phaduli, 2016). The drought periods severely affected the agricultural sector at large and reduced the sustainability of the water reservoirs as such impacting water availability and food production. There has also been a decrease in fodder production and a disruption in some economic activities such as livestock rearing leading to a rise in the unemployment rates.

Sub-Saharan Africa also has high animal disease incidences which lead to low productivity (Mutibvu, Maburutse, Mbiriri and Kashangura, 2012). The climatic shocks have impacted the livestock sector in Africa causing the emergence of new animal diseases (Baylis and Githeko, 2006). The change in temperature and the rainfall patterns due to climate variability impacts the survival and occurrence of disease vectors, parasites, and pathogens (Thornton, van de Steeg, Notenbaert and Herrero, 2009; Kebede, Zinabu, Ferede and Dugassa, 2018). The depletion of the Ozone layer as a result of the greenhouse gasses also impacts disease distribution and occurrences (Baylis and Githeko, 2006). Therefore, the smallholder farmers who have a low adaptive capacity are led to suffering the effects of animal disease such as a rise in poverty and hunger levels as well as increased malnutrition as cattle mortalities increase (Noelle, Weru, Rodrigue and Karlin, 2018). South Africa is among the most susceptible regions to animal diseases associated with climate variability such as tick-borne diseases. Other common diseases include insect-transmitted diseases, viral diseases, and bacterial diseases. These animal diseases are caused by internal parasites (roundworms, tapeworms, flukes) and external parasites (ticks, lice, mites, flies, midges).

Animal diseases and drought have negatively impacted the livestock sector in most countries. The livestock sector in South Africa contributes to the sustenance of rural households as it creates jobs, and it contributes largely to the overall agricultural Gross Domestic Product (GDP). The South African beef industry is a major contributor to households' livelihoods, and the total beef herd of South Africa is 13.69 million (Makube, 2017). The gross value of beef production has shown significant growth increasing from R12 billion in 2007 to R33 billion in 2017 (DAFF, 2018). However, the beef industry in South Africa has a dual nature with commercial farmers being more developed than smallholder farmers (Department Of Agriculture Forestry And Fisheries (DAFF), 2018). South Africa has about 22 000 commercial producers and 3 million smallholder farmers (DAFF, 2018). The smallholder farmers trade their cattle in the formal and informal beef markets. The formal market channels are sales to abattoirs and auctions while the informal market channels occur mainly as sales to individual buyers (Togarepi, Thomas and Kankono, 2016). The market determines the prices, as such, there are no price settings, mandatory carcass auctioning, or restrictions in establishing abattoirs.

The smallholder farmers sell their cattle during festivals or religious occasions to remain food secure (DAFF, 2018). Food security rather than economic gain is the major reason why smallholder farmers rear their cattle (DAFF, 2018). Thus, there is higher market participation by commercial farmers who maximize their gains, unlike the smallholder farmers who engage sparingly in cattle markets (Department Of Agriculture Forestry And Fisheries (DAFF), 2017). The cattle offtake rate is a ratio of the cattle sold in a given region to the herd size in that region expressed as a percentage (Musemwa, Mushunje, Chimonyo and Mapiye, 2010). The offtake rate is about 25% for commercial farmers while it is only about 5% among the smallholder farmers (Sotsha, Fakudze, Myeki, Ngqangweni, Nyhodo, Ngetu, Mazibuko, Lubinga, Khoza and Ntshangase, 2017). Therefore, there is a low offtake rate among the smallholder farmers which translates to low market participation in livestock markets

The objective of the article is to evaluate the impacts of droughts and diseases on the market participation of smallholder livestock owners. Droughts and animal diseases affect and cause a variation in regional offtake rates. However, empirically, it is not known whether drought and animal diseases contribute to the low market participation of smallholder farmers in South Africa.

The next section provides an overview of the links that exist between the livestock markets and the effects of drought and animal diseases. Section 3 discusses the methods, conceptual framework, and procedures used to evaluate the effects of drought and animal diseases on the smallholder farmers' participation in the South African livestock markets. Lastly, the results and conclusions are presented in section 4.

2. RELATED LITERATURE

Livestock marketing in developing nations is a vital element in eradicating poverty in rural areas, improving household resilience as well as food security and productivity (Girma and Abebaw, 2012; Herrero, Havlik, McIntire, Palazzo and Valin, 2014). The most vital form of livestock reared by the smallholder farmers is cattle. There several reasons for rearing cattle among the smallholder farmers including prestige, security against emergencies, a store of wealth, and mere satisfaction that is derived from keeping cattle (Motiang, 2017). Cattle is also used to pay the bride price and as a form of compensation when disputes arise (Chimonyo, Kusina, Hamudikuwanda and Nyoni, 1999). In other instances, cattle are used for festivals like circumcision and wedding ceremonies, and funerals (Musemwa, Mushunje, Chimonyo, Fraser, Mapiye and Muchenje, 2008). Cattle rearing is viewed as a better hedge against extreme weather conditions than growing crops by most rural agricultural households (Rötter and Van de Geijn, 1999). As such, some of the farmers only rear cattle as a hedge against extreme climate variability.

Therefore, drought and animal disease occurrences are associated with the marketing of cattle. Smallholder farmers may sell off more cattle in periods of drought and animal diseases as a coping strategy (Motiang, 2017). In this case, the smallholder farmers use their cattle to serve as insurance against climatic risks and are sold in periods of drought and animal disease to close consumption gaps (Stroebel, Swanepoel and Pell, 2011). Therefore, the prevalence of drought and animal diseases affects cattle offtake rates or the ratio of the number of cattle sold relative to the herd size among the smallholder farmers (Düvel and Stephanus, 2000). Cattle sales rise in drought periods causing an increase in offtake rates (Kinsey, Burger and Gunning, 1998). However, other studies that evaluated the effect of the drought conditions in West Africa and Kenya indicated that drought did not affect the cattle offtake rates (Barrett, McPeak, Luseno, Little, Osterloh, Mahmoud and Gebru, 2004b; Fafchamps et al., 1998). Droughts in Sub-Saharan Africa (SSA) have also caused a decline in the quality of the cattle produced. (Shiferaw, Tesfaye, Kassie, Abate, Prasanna and Menkir, 2014). The declined quality leads to a reduction in the social, economic, and environmental gains that were initially realized in the SSA in the last few decades.

In Kenyan arid and semi-arid lands, it was observed that more than 25% of cattle deaths occurred during droughts due to lack of pasture and unavailability of water (Ogutu, Piepho, Said, Ojwang, Njino, Kifugo and Wargute, 2016). Droughts have more often than not led to indiscriminately high cattle mortality rates especially among the smallholder farmers (Stroebel, Swanepoel, Nthakheni, Nesamvuni and Taylor, 2008). The forecasted increase in temperatures and reduction in rainfall amounts in Southern Africa implies an increase in cattle mortality rates due to droughts in the future. According to a case study in Kenya which was conducted to evaluate beef marketing efficiency, it was found that cattle marketing was constrained by high cattle mortality rates attributed to drought (Mbogoh, Munei, Komen and Mohammed, 2016). As such, prolonged droughts also impact cattle marketing negatively due to a significant increase in cattle mortality rates.

However, cattle are reared for various reasons in different cultural settings, and in some instances, farmers are only forced to sell their cattle during droughts in fear that their will cattle die. This causes a sharp rise in offtake rates as drought conditions begin to intensify (Mbogoh et al., 2016). An increase in cattle mortality was shown to raise market participation in South Africa (Montshwe, 2006). Apart from causing a rise in cattle mortality, droughts also lead to a decline in cattle birth rates which impacts cattle offtake rates in successive periods. The number of cattle births reduces significantly in prolonged drought periods due to the long cattle calving interval (Stroebel et al., 2011). Bellemare and Barrett (2006) conducted studies in Kenya and Ethiopia which showed that cattle births influenced market participation. The same effect was also observed in South Africa (Bahta and Bauer, 2007).

Therefore, the number of cattle that are marketed during droughts increases initially and then declines as droughts persist and in the post-drought period as farmers may still be trying to rebuild their stock (Barrett, Bellemare and Osterloh, 2004a). Drought causes poor body condition of the animal, as such, this affects market prices received by the farmers (Makhura, 2002; Baluka, Mugisha and Ocaido, 2014). The cattle that survive the droughts regain and have better body conditions due to reduced pressure on pasture as other cattle die during droughts. The improved body condition or quality increases the income gains from cattle sales after the drought (Fafchamps et al., 1998). Therefore, this highlights associations that exist between drought and the affected farmers' participation in livestock markets.

On the other hand, animal diseases also affect cattle marketing due to the various restrictions that are put in place because of the disease outbreaks. There is usually no cross-border trade allowed and inland trade is subject to restrictions due to animal disease outbreaks (Baluka et al., 2014). Sometimes the cattle may be required to go through an inspection process before reaching the market. As such, cattle are kept under quarantine for a given period, which substantially raises the transaction costs. Quarantine conditions and the use of cattle as a buffer for animal disease shocks affect the market participation of the farmers (Shiimi, Taljaard and Jordaan, 2012). A study of the constraining factors to the efficiency of cattle marketing in Kenya showed that disease occurrence is among the major cattle marketing constraints (Onono, Amimo and Rushton, 2015). Therefore, an increase in cattle disease outbreaks reduces the number of cattle supplies on the market.

Drought and animal diseases affect the cattle herd-size owned by the farmers which in-turn impacts their participation in markets (Seleka, 2011). Smallholder farmers suffer the effects of drought and animal diseases due to their low adaptive capacity to climatic shocks (Sotsha et al., 2017). Therefore, drought and animal diseases are among the major constraints to livestock marketing (Togarepi et al., 2016). However, a study by Barrett et al. (2004a) reviewed that households that have more livestock participate more in markets post the climatic shock. The less wealthy households may only participate in the livestock markets after the shock to cover their consumption gaps. Therefore, there is a clear link that exists between the effects of climate variability and the farmer's decisions to participate in livestock activities (Kabubo‐Mariara, 2008). A study of the effect of drought and animal disease on market participation is vital and this study endeavored to do so.

3. METHODS, CONCEPTUAL FRAMEWORK, AND PROCEDURES

The main objective of this study was to evaluate the effect of drought and animal diseases on smallholder farmers' participation in livestock markets. The data used was collected in the five-wave National Income Dynamics Study (NIDS) covering the years 2008, 2010, 2012, 2014, and 2017 in South Africa (Southern Africa Labour and Development Research Unit (SALDRU), 2018). The NIDS followed a two-stage cluster sampling design where the first stage led to a sample of 400 Primary Sampling Units (PSUs) from a total of 3000 PSUs in the master sample Stats SA in 2003 (Woolard, Leibbrandt and Villiers, 2010). A nation-wide representative sample of 28,000 individuals in 7,300 households was obtained in 2008 and the survey was repeated every two years with the same individuals making a panel of individuals called Continuing Sample Member (CSMs). The individuals added in the succeeding waves called Temporary Sample Members (TSMs) are not tracked in the waves that follow.

The panel survey is carried out by the Southern Africa Labour and Development Research Unit at the University of Cape Town's School of Economics. The survey is on individual and household livelihoods such as household shocks, vulnerability, education, labor market participation, and economic activities (Brophy, 2018). The survey has information on several economic activities carried out, however, to evaluate the effects of drought and animal diseases on market participation this study focused on individuals who were specifically engaged in cattle rearing and only CSMs. Selecting the appropriate variables and individuals applying for this study produced an unbalanced panel dataset. Therefore, the Multiple Imputation (MI) technique was used for missing observations due to attrition and nonresponse. MI produced a balanced panel with a sample of 2,534 individuals used in the analysis. Several authors have recommended the use of multiple imputations over the traditional methods of handling missing data such as listwise or pairwise deletion which lead to biased results (Enders, 2010; Newman, 2014). The South African long-term annual average rainfall data was sourced from Weather South Africa (Weather SA). The annual rainfall amount below 600mm was considered a drought period. Therefore, a drought dummy variable (*Drought (=1, 0 otherwise))* was generated from the rainfall data.

3.1 Conceptual Framework

The market environment affects the decision to engage in the market or not. Some farmers may decide to maximize their utility by rearing their cattle for other reasons, and not merely through participating in markets to maximize profit. Therefore, various factors affect the farmers' decisions to engage in markets. Figure 2 shows an illustration of how these factors are conceptualized to affect market participation and how they relate to each other.

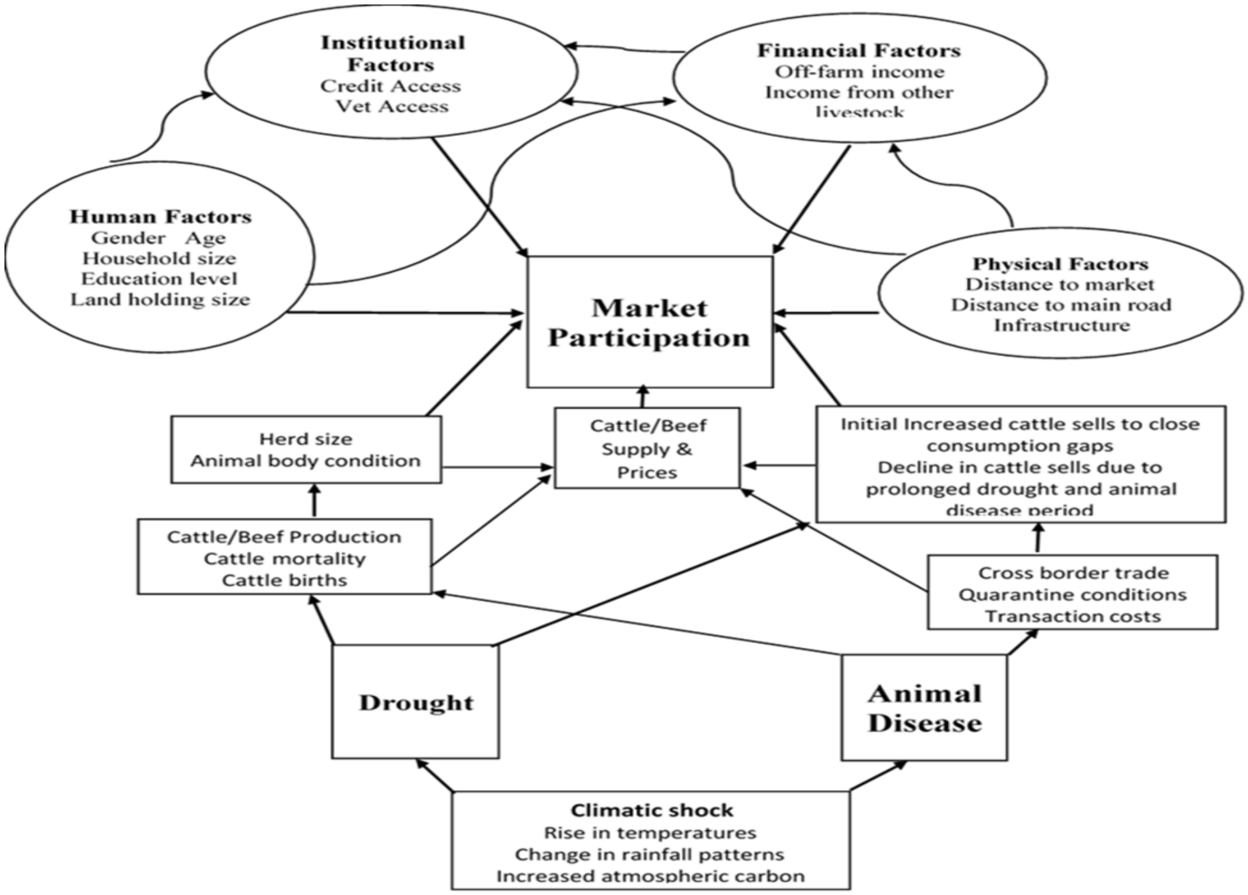

Figure 2: Conceptual Framework

Source: Author's analysis

Figure 2 above shows that market participation, a dichotomous response variable, is affected by several factors including Human factors, Institutional Factors, Financial factors, and physical factors. However, of particular interest is the effect of drought and animal disease on market participation. Figure 2 above shows that drought and animals result from climate shocks that cause changes in temperatures, rainfall patterns, and increase atmospheric carbon. Drought causes cattle mortality and decreases cattle births which affect the supply of cattle. The resulting low cattle supply and changes in market prices which could also be due to the effects of drought on the herd size and the body condition of animals ultimately affects market participation. On the other hand, animal diseases lead to restrictions in cross-border trade, quarantine conditions, and high transaction costs. Thus, animal diseases also eventually impact the supply of cattle and market prices thereby affecting market participation. Therefore, the dynamic effect of both drought and animal diseases on market participation is an initial increase in cattle sales to close consumption. However, as the period of drought and animal disease occurrence prolongs and intensifies, there is a decline in cattle sales due to high mortality.

3.2 Modeling the Effects of Drought and Animal Diseases on Market Participation

Qualitative response models are usually used to evaluate many behavioral responses such as decisions related to labor force participation (Maddala and Flores-Lagunes, 2001). To evaluate the farmer's choice of whether to participate in the market or not, one must consider the relative level of utility derived by taking either of the two courses of action. The equations below show the utility maximization.

$$y*_{ijt} = \beta_0 + \beta i x i j t + \varepsilon_{ijt} \quad (1)$$

where

$$\varepsilon_{ijt} = \alpha_{ij} + v_{ijt} \quad (2)$$

$y*_{ijt}$ is a latent variable representing the behavior demonstrated by the ith individual in the jth (j=1, 2, …,9) province of South Africa in period t. The vector of independent factors that affect market participation is denoted by $Xijt$. The error term, ε_{ijt}, is made up of two parts as indicated in equation two (2). The term α_{ij} denotes the individual-specific effects while the term v_{ijt} is the idiosyncratic error. Therefore, equation one (1) could be rewritten in a manner that decomposes the error term in its two components as shown in equation three (3) below;

$$y*_{ijt} = \beta_0 + \beta i x i j t + \alpha i j + v_{ijt} \quad (3)$$

The latent $y*_{ijt}$ affects the observed outcome variable (y), such that, y is one if $y* > 0$, and y is zero if $y* \leq 0$. However, the probability of taking one course of action over another is influenced by independent factors. The standard model used to understand the relationship between independent factors and a binary dependent variable is the logit model (Garforth, Angell, Archer and Green, 2003). The discrete choice logit model is characterized by a binary dependent variable that assumes only the values of zero and one.

The specification of the logit model is as follows;

$$P(y = 1|x) = f(\beta 1 itx1ijt + \beta 2itx2ijt + \ldots + \beta nijtx1ijt + \mu_{ij} + \varepsilon_{ijt)} \quad (4)$$

where $$f(z) = \exp exp\,(z)\,/(1 + exp(z)) \quad (5)$$

$$P(y = 1|x) = \{1\; if\; i\; particpates\; in\; the\; market \quad 0\; otherwise$$

Where the parameter p represents the response probability, where $p \in (0,1)$), implying that it only takes values of zero and one. Y is the outcome variable, market participation indicator, which is 1 when an individual participates in the market and zero otherwise. f represents the function which also assumes values between zero and one for all real numbers with the notation: $0 < f(z)$

< 1, for all real numbers z. The function f has a logistic distribution or probability density function.

3.3 Model for Determining the Effects of Drought and Animals on Market Participation

The study used the logit model to evaluate the effect of drought and animal disease on the market participation of the smallholder farmers. A qualitative response model is used because of the dichotomous nature of the farmer's decision. The empirical model includes the factors that are hypothesized to influence the participation of smallholder farmers in the market as explanatory variables. This model relates to the evaluation of the response probability parameter expressed in equation four (4). To account for the variables attributed to an individual as well as account for the provincial characteristic differences such as the rainfall amount (drought variable), the study used a multilevel model as applied by (Zulvia, Kurnia and Soleh, 2017). The model used is shown below;

$$Y_{ijt}=\Upsilon_{00}+\sum_{q=1}^{r}\Upsilon qRqj+\sum_{p=1}^{K}\beta pXijt+T_t+u_{oj}+\varepsilon_{ijt} \quad (6)$$

$$Y = \{1 \; if \; the \; farmer \; particpates \; in \; the \; market \quad 0 \; if \; the \; farmer \; has \; not \; participa$$

X = (gender, age, education, death of HH member, cattle income, number of cattle owned, drought, disease, & drought-disease)

where Y_{ijt} is the dependent variable, Υ_{00} is the intercept, Υq (q=1,2,…,r) is parameters model for the province, Rqja independent variable from province j, βp is parameter model for individual,

$Xijt$ an independent variable from individual in province j in time-t, T_t is fixed effect of time, u_{oj} is an error from the province (u_{oj}~$N(0,\sigma_u^2)$ and ε_{ijt} an error (ε_{ijt} ~$N(0,\sigma_e^2)$).

The independent variables were selected based on the literature reviewed and a priori expectations of the factors that affect market participation. The variables used in the study are summarized in Table 1 below;

Table 1 Description of explanatory variables in the logit model

Variable	Description
Market participation	Dummy, 1=yes if the farmer participates in the market
Gender	Dummy, 1=yes if the individual is male
Age	Age of an individual in Years
Education	Level of education of an individual (categorical)
Death of HH Member	Dummy, 1= yes if the individual face a mortality shock
Cattle Income	Income obtained from the sale of cattle in Rands
Cattle Owned	Number of cattle owned by the individual
Disease	Dummy, 1=yes if the individual if his livestock were affected by a disease outbreak
Drought	Dummy, 1=yes if the annual rainfall amount was below 600mm
Disease-Drought	Dummy, 1=yes if an individual affected by drought and an animal disease outbreak in the same period

Source: Author's analysis

Market participation is the dependent variable while the independent variables are gender, age, education, death of a household member, cattle income, number of cattle owned, disease, drought, and an interaction term between drought and disease. The variables gender, death of a household member, disease, and drought were dummy variables. Gender was coded as 0 for females and 1 for males while the death of a household member was coded 0 if the smallholder farmer did not have a mortality shock and 1 if he or she had a mortality shock. The disease variable was coded 0 if the smallholder farmers' cattle had not been attacked by a disease in the previous 12 months and 1 if there was a disease occurrence. The drought variable was coded 0 for the year in which the province in which the farmer resides received normal rainfall and 1 when there was below annual average rainfall (600mm) received.

The interaction term between disease and drought indicated the points at which the smallholder farmer was affected by both disease and drought at the same time and those he or she was not. The age of the smallholder was measured in years while the variable cattle income signifying the income obtained from the sale of cattle was measured in Rands. The variable number of cattle owned signifies the herd size of the smallholder farmer. This study defined market participation as the sale of cattle in the market by smallholder farmers. The market participation variable was coded 0 if the smallholder farmer does not participate in the market (does not sell any cattle in the market) and 1 if the smallholder farmer participates in the market.

4. RESULTS

This study hypothesized that; Drought negatively affects the market participation of smallholder farmers, animal diseases have a negative effect on the market participation of smallholder farmers, and the combined impact of drought and animal diseases on market participation is higher than the individual effects.

The analysis was done on panel data using the pooled model, the random-effects model, and the fixed-effects models. However, the likelihood ratio test evaluated the validity of the random effect parameter; and the Hausman test indicated the more appropriate model between the fixed-effects model and the random-effects model. The linear dependence that existed between the variables was determined using the VIF test for multicollinearity.

4.1 Estimating the Logit Model

The logit model was used in the study because the dependent variable, market participation, is binary. The variable indicates whether the smallholder farmer participated in the livestock market or not. The pooled, the fixed effects, and the random-effects models were estimated. The pooled model that does not consider the panel structure of the data by assuming a constant slope and intercept was the first model used. This model does not account for the individual-specific effects in determining the dependent variable, market participation in this case (Baltagi, 2008). The panel data models used were the fixed effects model and the random-effects model, the basic distinction between the two models lies in the assumptions they make.

The fixed-effects model assumes a correlation between the individual-specific effects and the independent variables while the random effects model assumes independence between the individual-specific effects and the independent variables (Baltagi, 2008). The likelihood ratio test was used to select between the pooled and random-effects model. The Hausman test was used to select the appropriate model between the fixed model and the random-effects model.

The LRT compares two distinct models to choose which one is a superior model by offering a better fit to the data. LRTs are most generally used to choose if a specific random effect ought to be included in the model by assessing whether that improves the fit of the model, ceteris paribus (Luke, 2017). The null hypothesis for the likelihood ratio test is that there is no significant difference between the pooled and the random-effects models. If Prob>chi2<0.05, then the null hypothesis is rejected, and the conclusion made is that there is a statistically significant difference between the models.

Hausman test determines if there is a correlation between the unique errors and the regressors in the model. The null hypothesis is that there is no correlation between the unique errors and the regressors. Essentially, the Hausman test determines the better fit model between the fixed effects (correlated errors) and the random effects (uncorrelated errors) for panel data. Interpreting the result from a Hausman test is such that when the p-value is less than 0.05, the null hypothesis is rejected. In this case, it would imply that the model has correlated errors and as such, we fail to reject the alternative hypothesis that the fixed effects model is more consistent. The table below shows the results of the likelihood ratio test and the Hausman test.

Table 2 Likelihood Ratio Test (LRT) and the Hausman test results

Test	Statistic	P-value
Likelihood ratio test	121.56	0.000 ***
Hausman test	24.06	0.002 ***

*Note: *** denotes 1% significance, ** denotes 5% significance, * denotes 10% significance*

Source: Author's computations

The Likelihood ratio test result as tabulated in Table 2 shows that the likelihood-ratio test result (121.56) is statistically significant at a one percent significance level. Therefore, the null hypothesis is rejected, and the conclusion is that the random effects parameter was valid. As such, the random-effects model has a better fit for the data and was more appropriate compared to the pooled model which did not consider the panel structure of the data. The random-effects model accounted for the disaggregation of the smallholder farmers by province. The results from the random-effects model showed that the provincial random-effects compose approximately 17.03% of the total residual variance. This result indicates that market participation is slightly correlated within the same province.

The Hausman test (24.06) as indicated in Table 2 was statistically significant at a one percent significance level. Therefore, the null hypothesis of the Hausman test that there is no statistical difference between the random effects and the fixed effects models was rejected. As such, the fixed effects model was more appropriate than the random-effects model.

The fixed effects model included a number of variables hypothesized to affect the market participation of the smallholder farmers. However, a high linear dependence among the predictors increases their standard errors and thereby their variance. The extent to which the variance has been inflated is measured using the Variance Inflation Factor (VIF). If the VIF is greater than five, the predictors are highly correlated or multicollinearity exists (Daoud, 2017). Table 3 below shows the VIFs for the predictors used in the study.

Variable	Variance inflation factor
Male (=1, 0 otherwise)	3.27
Age (Years)	2.82
Education	2.23
Death of HH Member (=1,0 otherwise)	2.18
Cattle Income (Rands)	1.93
Number of Cattle Owned	1.76
Disease (=1, 0 otherwise)	1.71
Drought (=1, 0 otherwise)	1.70
Disease-Drought (=1, 0 otherwise)	1.63

Table 3: Variance Inflation Factors (VIF)

Source: Author's computations

Table 3 above shows that all the predictors used for the study had a variance inflation factor of less than five. As such, it shows that the predictors are not highly correlated, or multicollinearity did not exist.

4.2 Results from The Fixed Effects Model

This subsection presents results that were obtained from an estimation of the fixed effects model as tabulated below.

Table 4: Results for the fixed effects model

Variable	Marginal Effect	P-value
Male (=1, 0 otherwise)	0.0229	0.083 *
Age (Years)	0.00410	0.000 ***
Education	0.0473	0.000 ***
Death of HH Member (=1,0 otherwise)	-0.0859	0.000 ***
Cattle Income (Rands)	9.84e-06	0.000 ***
Number of Cattle Owned	0.0105	0.000 ***
Disease (=1, 0 otherwise)	-0.0348	0.034 **
Drought (=1, 0 otherwise)	-0.0118	0.393
Disease-Drought (=1, 0 otherwise)	-0.0915	0.000 ***
Number of groups Number of observations		9 10, 136

*Note: *** denotes 1% significance, ** denotes 5% significance, * denotes 10% significance*

Source: Author's computations

The results show that gender was statistically significant at a 10% significance level and it positively affected market participation. This result is consistent with what was observed in Uganda where males had a higher market participation rate than females among cattle keepers (Ruhangawebare, 2010). On the contrary, a study by Lubungu, Chapoto and Tembo (2012) showed that gender did not matter in livestock market participation.

The age variable was also statistically significant at a 10% level of significance and had a positive relationship with market participation. The result is consistent with the expectation that the responsibilities and financial demands of individuals increase as they age. As such, the smallholder farmers increase their participation in the cattle markets as they get older to meet their financial demands. Likewise, education was statistically significant and was positively associated with market participation. An increase in the education level of an individual leads to an increase in one's ability to access market information (Lubungu et al., 2012).

However, the variable indicating the household mortality shocks, *Death of a Household Member*, was statistically significant but had a negative effect on market participation. Lubungu et al. (2012) on the contrary stated that mortality shocks increase participation in livestock markets. The effect of cattle income on market participation was statistically significant at a 10% significance level. The cattle income was positively related to market participation which implies that higher incomes lead to higher market participation rates. Likewise, the *number of cattle owned* also had a statistically significant positive effect on the market participation of smallholder farmers. The likelihood of selling cattle increases as the herd size owned by the smallholder farmers increases (Lubungu et al, 2012).

4.2.1 The Effect of Animal Diseases on the Smallholder Farmers' Participation in the Market

The coefficient on the *Disease* variable was negative and its effect was statistically significant at a one percent level of significance. Therefore, the prevalence of animal disease reduces the likelihood of smallholder farmers participating in livestock markets. As such, the result is consistent with the initial study hypothesis which stated that animal diseases have a negative effect on the market participation of smallholder farmers.

Animal diseases cause an increase in the mortality levels of cattle which ultimately reduces the number of cattle available to sell in the market. A decrease in the cattle herd size owned by the smallholder farmers reduces the probability of participating in livestock markets. Animal disease outbreaks also reduce the birth rates which ultimately impacts cattle herd size in the long run. Low birth rates hinder participation in livestock markets as the smallholder farmers endeavor to preserve their current stock and invest in restocking their cattle herd rather than selling. Some disease outbreaks may also require that the government intervenes by destroying the entire cattle herd to avoid widespread disease. Therefore, disease outbreaks greatly impact the market participation of the smallholder farmers due to the reduced supply of cattle to be marketed. However, animal diseases do not always result in mortality, but the sickness of the animals may lead to poor body conditions. As such, the sick animals are not appealing to the buyers which implies a demand reduction, hence, low market participation by the smallholder farmers.

Animal disease outbreaks also cause a reduction in the engagement of smallholder farmers in livestock markets due to some restrictions imposed on the movement of animals in the affected regions. The inland and cross-border animal movement restrictions instituted prevent the widespread of disease across regions. The strict movement of animals allowed during such periods usually requires cattle quarantining for a specific period. However, the farmers may be unwilling to endure waiting in quarantine camps leading to a decrease in market participation. The indirect effect of restricted movement across regional borders is a rise in cattle supply within the regions. The high supply leads to a lowering of the prevailing market prices in that specific region which may discourage the participation of smallholder farmers in livestock markets.

4.2.2 The Effect of Drought on Market Participation by Smallholder Farmers

The study hypothesized that drought negatively affects the market participation of smallholder farmers. On the contrary, the results in Table 4 show that drought did not significantly impact market participation. This result is consistent with the findings by Fafchamps et al. (1998) who evaluated the use of livestock as a buffer stock in West Africa and found that the change in the cattle offtake rates due to drought conditions was insignificant. Similar results were observed in northern Kenya and southern Ethiopia where it was observed that cattle offtake rates among pastoralists remained constant despite the grazing lands' carrying capacities being reduced by drought (Barrett et al., 2004a).

Smallholder farmers rear cattle for many reasons including using cattle for draught power, for feasts and festivities, for paying the bride price, for compensation in case of breaking a law, for prestige, and other reasons which may not directly relate to rearing cattle as a source of income (Motiang, 2017). Therefore, smallholder farmers will always endeavor to maintain a certain level of stock to allow them to meet other needs that may not be monitory in form. The smallholder farmers may also maximize the number of cattle owned to serve as insurance against very critical climatic risks and sold to close consumption gaps in such periods (Stroebel, Swanepoel and Pell, 2011). Therefore, depending on how farmers perceive the severity of drought, the cattle offtake rates may remain constant. Smallholder farmers mostly sell off cattle only in severe periods of drought as a coping strategy.

4.2.3 The Combined Impact of Drought and Animal Diseases on the Participation of Smallholder Farmers in Livestock Markets

In Table 4 above, the combined impact of drought and animal disease is given by the interaction term between drought and animal disease. The combined marginal effect of drought and animal disease on market participation is a reduction in the likelihood of the smallholder farmer's participation in cattle markets by 9.15%. The value is statistically significant at a one percent significance level. However, the marginal effect of disease outbreaks alone is a 3.48% reduction in the probability of participation in livestock markets by smallholder farmers. As discussed in the previous subsection, the effect of drought on market participation is not significant. Therefore, the findings are consistent with the third hypothesis which stated that the combined impact of drought and animal diseases on market participation is higher than the individual effects.

The impact on the smallholder farmers is greater when they are affected by both drought and animal disease outbreaks at the same time. Such periods effectively lead to even higher cattle mortality rates. Mbogoh et al. (2016) evaluated the beef marketing efficiency in Kenya and found that cattle mortality that occurred in drought periods constrained cattle marketing. Smallholder farmers are dependent on the use of extensive grazing rather than the use of feedlots. However, droughts lead to poor pasture which causes a poor state of the animals and reduces their marketable quality. The poor-quality results in farmers not receiving premium prices for the animals sold. The prevailing low market prices discourage smallholder farmers from participating in livestock markets. Therefore, this results in a combined impact of both drought and animal diseases than their individual effects.

5 CONCLUSIONS

The global effects of climate variability have impacted several economic activities. The adverse effects of climate variability are more noticeable with the occurrences of animal diseases and droughts, which result from changes in temperature, rainfall patterns and atmospheric carbon. Livestock rearing is a prime economic activity among smallholder farmers which enhances their food security and income gains. However, like most other economic activities, its full potential to sustain the smallholder farmers' livelihoods is hindered by drought and animal diseases occurrences. Animal diseases and drought impact livestock marketing by causing regional variation in livestock supply and raising livestock mortality. It also decreases birth rates and leads to restrictions in cross-border and land trade of animals and quarantine conditions that increase transaction costs, thereby affecting livestock marketing.

The livestock market in South Africa is characterized by low participation of smallholder farmers. Therefore, this study evaluated the effects of animal diseases and drought on smallholder farmers' participation in livestock markets. It also looked at the combined effects of drought and animal diseases on the market participation of smallholder farmers. The article found that the prevalence of animal diseases reduces smallholder farmers' probability of participating in the market. Therefore, smallholder farmers' low participation in the South African livestock market is partly attributed to the prevalence of animal diseases. The article also concluded that the smallholder farmers' market participation does not depend on whether or not there is drought unless it occurs in a period in which there is also a disease outbreak. Participation in the livestock market by the smallholder farmers is more highly constrained in periods in which droughts and animal diseases co-occur than when a single shock hits farmers.

Therefore, the study recommends that the government enable smallholder farmers to access livestock vaccines and medicines to enhance their market participation. The effect of drought and animal diseases on smallholder farmers' participation in the livestock market depends on whether they are exposed to a single or combined effect of drought and animal diseases. As such, the smallholder farmers' compensation should be commensurate to the animal disease and drought effects they have been exposed to.

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