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The effect of climate change and livelihood strategies of smallholder farmers: the case of Chivi and Mwenezi Districts in Zimbabwe

Alexander Mapfumo *

Great Zimbabwe University, Masvingo, Zimbabwe

Abstract

This paper assessed the effect of climate change and examined how smallholder farmers adapted to weather changes in semi-arid regions. The smallholder farmers in Masvingo are vulnerable to the effects of climate change due to their marginal location, low levels of technology, and lack of other essential farming resources. The research utilised small grains and long grains smallholder in the research area. The study used a Multinomial Logit model to investigate the factors influencing a household's decision to choose different livelihood strategies as a result of climate warming experienced in Zimbabwe. In the model, the dependent variables included four livelihood strategies while the explanatory variables included various household social-economic and institutional factors. The results obtained from the multinomial logistic regression model established that four variables (education, climate warming, access to inputs and access to credit) were found to be significant in determining the adoption of small grains farming strategy in the study area up to less than 10% probability level. Smallholder farmers who did not adopt small grains farming indicated that limited land size, shortage of labour as well as access to small grains seeds inputs were the major impediments to adopt small grains farming. The majority of smallholder farmers pointed out high frequency of droughts, drying up of rivers, dams and wells, and changes in timing and pattern of seasons as evidence of climate change. The study recommends growing of small grains which are drought resistant and improving water management practices.

Keywords: Climate Change; Smallholder Farmers; Livelihood Strategies; Small Grains

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* Corresponding author. *E-mail address:* amapfumo@gzu.ac.zw

1. Introduction

Thakur and Bajagai (2019) noted that climate change is a global issue since 19th century by the scientists and its impacts are still currently being felt. Several developing countries such as Zimbabwe are sensitive to climate change and are already experiencing temperatures that negatively affect agricultural production (Kurukulasuriya et al., 2006; Da Cunha et al., 2015; Prince et al., 2018). The Intergovernmental Panel on Climate Change (IPCC)'s Fourth Assessment Report indicates that increases in warming and drying in Africa can negatively affect agriculture by reducing crop yields by almost half by 2020 (IPCC 2007). Consequently, the already vulnerable and poor communities that rely on climate-sensitive livelihood sources like agriculture and natural systems are most adversely affected. According to Saqib et al. (2019) small-scale farmers still play a significant role in agricultural production around the world but majority of them are suffering from poverty and food insecurity. Smallholder farmers in southern countries are also faced with challenges such as lack of access to new technology and developed markets, including insurance to mitigate the effects of climate change (Kurukulasuriya et al., 2006; Di Falco, 2014).

2. Background of the study

According to Government of Zimbabwe ministry of Environment, Water and Climate (2016). Climate Change in Zimbabwe has the potential to cause food insecurity and slowdown the country's development. The country's vulnerability to the adverse effects of climate change makes adaptation a national priority, demanding policy direction at the highest level (Nhemachena et al., 2014). In rain-fed and marginal regions in Zimbabwe such as Chibi district climate change greatly affect agricultural output as well as influencing decisions on the livelihood strategies which they will pursue (Moyo et al., 2012). According to Chitongo and Casadevall (2019), Zimbabwe is still getting more vulnerable to climate changes, and the country is likely to obtain reduced productivity of crop-livestock systems in the country’s marginal rural areas. With this background, this article sought to investigate the effect of climate change and livelihood strategies of smallholder farmers in Chivi and Mwenezi districts which are marginal rural areas in Zimbabwe. The paper therefore seeks to answer the question; what are the effect of climate change and livelihood strategies of smallholder farmers in Zimbabwe?

3. Research method and design

3.1. Description of the study setting

Chivi and Mwenezi districts are vulnerable to current and expected changes in climate, exacerbated by low adaptation capacity and climate change interaction with other stressors already being experienced in the region five of the study area, such as food insecurity, poverty and ecosystem degradation (Hassan & Nhemachena 2008).

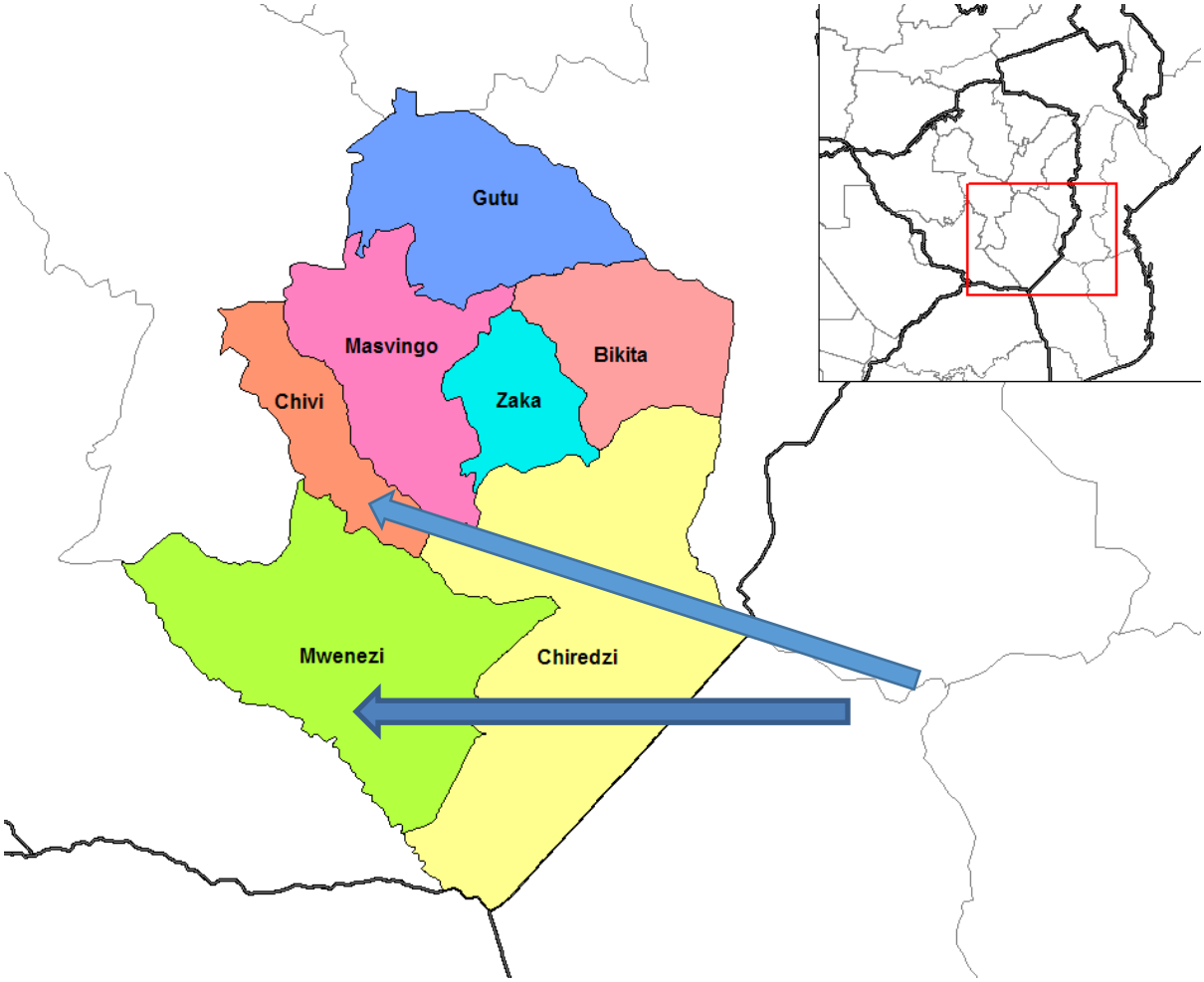

Figure 1. Districts in the Masvingo Province, Zimbabwe

3.2. Data collection and analysis

The study focused on impact of climate change and livelihood strategies of rural communities of Chivi and Mwenezi in Masvingo from which a sample was randomly selected. The study collected information on livelihood activities as well as community responses. The south-eastern Masvingo Province was purposively selected because it is a predominantly dry arid region from the 10 provinces in Zimbabwe. The Province has seven districts, namely Chivi, Bikita, Zaka, Masvingo, Gutu, Mwenezi, and Chiredzi. The two districts of Mwenezi and Chivi were purposively chosen because they fall into the medium drought risk zone. A total of one hundred and eighty respondents were interviewed using a researcher administered structured questionnaire composed of 109 women and 71 men (household heads). The majority of household heads were women because the majority of men left for towns and cities in search of formal employment.

3.3. Mathematical representation of the multinomial logit regression model

A multinomial logit regression model was used in the study which depicts key household attributes such as age, gender of household head, family size, farming skills, access to credit, land size, income and constraints that differentiate households pursuing different livelihood strategies. The assumption is that, to identify the determinants behind rural household decision to pursue various livelihood strategies in a given period, a rational household head choose among the two mutually exclusive livelihood strategy alternatives that will make the household to derive maximum utility. Following Greene (2003), suppose for the *i*th respondent faced with j choices, the utility choice j is specified as:

$$U_{ij} = Z_{ij}\beta + \varepsilon_{ij} \quad \text{..... (1)}$$

If the respondent makes choice *j* in particular, then we assume that U*ij* is the maximum utility the *i*th respondent could obtain among the *j* utilities. So the statistical model is derived by the probability that choice j is made, which is:

$$\Pr(U_{ij} > U_{ik}) \text{ for all other K} \neq \text{j} \quad \text{..... (2)}$$

Where, U_{ij} is the utility to the *i*th respondent form livelihood strategy *j*

U_{ik} the utility to the *i*th respondent from livelihood strategy *k*

According to Brown et al. (2006), the household's choice is the optimal allocation of its asset endowment if the *i*th respondent's utility is maximised as a result of the selected livelihood strategy. As a result, the *i*th household's decision can ultimately be modelled as maximizing the expected utility by selecting the *j*th livelihood strategy among *J* discrete livelihood strategies, i.e,

$$\max_j = E(U_{ij}) = f_j(x_i) + \varepsilon_{ij}; j = 0...J \quad \text{..... (3)}$$

For an outcome variable with J categories the jth livelihood strategy that the ith household chooses to maximize its utility could take the value 1 if the ith household choose jth livelihood strategy and 0 otherwise. Consequently, the probability that a household with characteristics x chooses livelihood strategy j, P_{ij} can be modelled as:

$$P_{ij} = \frac{\exp(X_i^{'}\beta_j)}{\sum_{j=0}^{J}\exp(X_i^{'}\beta_j)}, \quad J=0...3 \quad \text{..... (4)}$$

Applying the requirement that $\sum_{j=0}^{J} P_{ij} = 1$ for any *i*

Where: P_{ij} = probability representing the *ith* respondent's chance of falling into category *j*

X = Predictors of response probabilities

β_j = Covariate effects specific to j[th] response category with the first category as the reference.

To remove an indeterminacy in the model, appropriate normalization which is to be carried out should assume that $\beta_1 = 0$ (this arise because probabilities sum to 1, so only J parameter vectors are needed to determine the J + 1 probabilities), so that $\exp(X_i\beta_j) = 1$, (Greene, 2003) implying that the generalized equation (4) above is equivalent to

$$\Pr(y_i = j / X_i) = P_{ij} = \frac{\exp(X_i\beta_j)}{1 + \sum_{j=1}^{J} \exp(X_i'\beta_j)}, \quad \text{for } j = 0, 2...J \text{ and}$$

$$\Pr(Y_i = j) = \frac{e^{\beta_j x_i}}{\sum_{k=0}^{j} e^{\beta_k x_i}}, \; j = 0,1....J \qquad \text{..... (5)}$$

Where

β_i= a vector of coefficients on each of the household attributes *i x;*

β_k = the vector of coefficients of the base alternative;

j denotes the specific one of the *j* +1 possible livelihood choices.

4. Results

The estimation of factors affecting livelihood strategies was carried out using the multinomial logistic regression model. The results of the multinomial logistic regression model are shown in Table 1 below. In the multinomial logistic regression model the dependent variable is ordered where 1=small grains farming household; 2= long grains farming household (crops and livestock); 3= household active in off farm activities and 4=wage-earner household (formal employment). Examination of literature shows that the category which is redundant should be taken as the reference category hence formal employment was considered to be the reference category in the model. Consequently, a positive sign for the variable in the multinomial model reflects the higher the likelihood of participating in the main livelihood strategy (small grains farming) indicated. However, a negative sign for the variable in the multinomial model reflects a lower likelihood of participating in the main livelihood strategy indicated.

The chi-square value is significant at one percent implying that the explanatory variables taken together influence the livelihood strategies adopted by smallholder farmers in Masvingo. The Pseudo-R^2 refers to the Nagelkerke's Pseudo-R^2. Verbeek (2008) suggests that the interpretation of the pseudo R^2 (Nagelkerke) be

done with great caution since it does not have the same interpretation as the R^2 in the ordinary least square regression. A positive value means that the explanatory variable increases the chances of pursuing the livelihood strategy with an increase in its magnitude.

Table 1. Results of the Multinomial Logistic Regression in the Model (Model included only significant variables at 0.1 level)

Variable	Small grains farming			Long grains farming			Off- farm activities		
	Estimate	SE	P(Sig)	Estimate	SE	P(Sig)	Estimate	SE	P(Sig)
Intercept	-16.25	3.645	.000	-5.692	9.669	.000	-65.352	4.984	.000
Education	12.902	.651	.000***	17.014	.594	.256	0.293	1.6730	0.020**
Climate warming	0.675	.185	0.03**	-.0600	.625	.125	1.117	.621	0.074*
Access to credit	4.581	1.401	.012**	3.051	1.411	.000***	0.351	0.622	0.31
Access to inputs	1.010	.923	.024**	1.584	.902	0.081*	1.452	.991	.142

*N= 180 (small grains farming household = 119; long grains farming household = 32; household active in off farm activities = 20 and wage-earner household = 9), Model chi-square =123.526; p<0.0001, –2 log likelihood =326.562 Pseudo R^2 (Nagelkerke) =0.756, Significance levels: *** p<0.01: ** p<0.05: * p<0.1 .The reference category is: 4 (Formal employment), (Source: Field Data)*

4.1. Interpretation of econometric results

The multinomial logit regression model successfully estimated the significant variables which influenced livelihood strategies used by smallholder farmers in Masvingo. The results showed that the model had strong explanatory power since the p value was obtained to be less than 0.0001. Furthermore, Pseudo R^2 (Nagelkerke) of 0.756 revealed that the explanatory variables managed to predict about 76 percent of variations in livelihood strategies for the respondents indicating that the model was well specified. The following variables were found to be significant determinants for small grains farming adoption decision by smallholder farmers in the study area: education, climate warming, access inputs and access to credit challenges. The results of the estimated equations of the final multinomial logistic regression model were discussed in terms of the significance and signs on the parameters. Table 1shows that the set of significant explanatory variables varies across the groups in terms of the levels of significance for all livelihood choice categories.

The variable *climate warming* was obtained to significantly affect the adoption of small grains farming and off farm activities at 5% and 10% levels respectively. Prolonged hot and dry weather were reported to be experienced and have become more frequent and devastating in recent years during the rainy season in Chivi and Mwenezi districts. Since farming is mainly rain fed in Masvingo, this has led to fall in agricultural production causing food insecurity. This is in line with the findings of Mutekwa (2009) which stressed that dry weather conditions can force smallholder farmers to sale assets, indebtedness and depend on food relief. As a

result adoption of better livelihood strategies such as small grains farming and off farm activities became imperative

The level of education of the household head *(Education)* proves that it is one of the key factors which positively influence the likelihood of choosing the livelihood strategies of small grains farming and off-farm activities. Educational attainment is crucial for understanding and adopting better livelihood strategies such as small grains farming as well as understanding the need for diversifying into other non-farm activities so as to reduce farming risks such as low output prices and bad weather conditions. These results are in line with the findings of Ayuya et al. (2012) which established that farmers who have attained higher education are able to analyse and respond to new and better livelihood strategies. However, the results contradict with the findings of Destaw (2003) who established that education has no effect on livelihood strategies.

The variable *access to inputs* has a positive and statistically significant at 5% and 10% level of probability for small grains and long grains smallholder farmers respectively. This shows that access to inputs is a key component for both small grains and long grains smallholder farmers in Masvingo. These results were in agreement with findings of the survey carried out by ZimVac (2013) which established that the major reasons for reduction in the area planted by smallholder farmers was due unavailability and late availability of agricultural inputs. Moreover, these findings are also in line with the findings of the report by Poverty Reduction Forum Trust (2013) which reiterated that generally the downward trend in agricultural output by farmers in Zimbabwe is attributed to insufficient agricultural inputs.

As expected, *access to credit* for farming activities was found to have a positive and significant at 5% and 1% level on the likelihood of choosing small grains farming and long grains farming respectively. It also explains why most of the households were diversified since the majority of the smallholder farmers in the study area lacked access to credit lines. These results of the study suggest that farmers' access to credit would play important role in promoting better livelihood strategies which will lead to agricultural development in Zimbabwe. These results are in agreement with the findings of the report by Poverty Reduction Forum Trust (2013) which noted that agricultural production in rural Zimbabwe generally is on a decline as a result of lack of credit lines for farmers.

5. Conclusion

The study used a Multinomial Logit model to investigate the factors influencing a household's decision to choose different livelihood strategies. In the model, the dependent variables included four livelihood strategies while the explanatory variables included various household social-economic and institutional factors. The results obtained from the multinomial logistic regression model established that four variables (education, climate warming, access to inputs and access to credit) were found to be significant in determining the adoption of small grains farming strategy in the study area up to less than 10% probability level. Smallholder farmers who did not adopt small grains farming indicated limited access to inputs and credit lines as the major impediments to adopt small grains farming.

6. Recommendations

The results of the multinomial logistic regression model established that climate warming was a major challenge affecting livelihood strategies undertaken by smallholder farmers in the study area. The government should support the efforts by smallholder farmers to improve their livelihood strategies, food security as well as the contribution of agriculture towards GDP through unveiling credit lines for farming activities. This will go a long way in enabling smallholder farmers to engage in better livelihood strategies which are suitable for the climate such as small grains farming. Consequently, Agribank needs to be capacitated so that it will be able to effectively extend financial support to smallholder farmers in the country. Moreover, it is not entirely up to the government alone to fund agriculture other players such as private companies and Non-Governmental Organisations (NGOs) should also chip in to help the cause and also systems should be put in place for the bulk of agricultural production to be self-financing.

Access to inputs for small grains should be made a priority by the government through provision and fair distribution of adequate inputs to smallholder farmers. This can be done through allocating adequate funds to the Ministry of Agriculture as well as supporting the Presidential Input Scheme. Private players also should play their role to ensure adequate supply of small grains inputs to smallholder farmers.

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