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160- A Micro-Level Analysis of Vulnerability to Climate Change by Smallholder Farmers in Semi-Arid Areas of Zimbabwe

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Abstract

Using household survey data from a random sample of 180 households in Gweru and Lupane district, we found the distribution of vulnerability among households was skewed with mean 0.76. On average 89% of the households had a probability of more than 0.5 making them vulnerable to food insecurity and 11% were not vulnerable to food insecurity. The gender of household head, farming experience, household income, and livestock ownership had strong influence on household cereal production and hence their vulnerability to climate changes. In addition, social networks and use of hired labour positively influences crop productivity. Overall, development policies that increase household income, boost livestock ownership and enhance social capital improve crop production, which is critical to boost household adaptive capacity to climate change. There is need to link climate change policies to broader rural development policies especially in developing nations.

Keywords: *Climate change, household, vulnerability*

1. Introduction

Agriculture is a key sector of the Zimbabwean economy contributing about 17% to the country's Gross Domestic Product (GDP) in 2011 (World Bank, 2012). Agriculture provides employment and livelihoods for about 70% of the population, including 30% of formal employment, and accounts for about 40 to 50% of the country's total export revenues (ZIMFA, 2012). About three-quarters of Zimbabwe's population live in the rural smallholder farming sector and depend on agriculture for their livelihoods. The agricultural sector is dominated by smallholder crop-livestock production systems characterised by low productivity (Mupangwa, et al., 2008; Masikati, 2011). The major factors responsible for this low productivity include: soil degradation caused by overgrazing and deforestation; poor complementary services such as credit, markets and infrastructure services; and climatic factors such as drought, unpredictable and erratic rains (Jama and Pizzaro, 2008; Masikati, 2011). These factors increase farmers vulnerability to future changes and weakening the the performance of the already depressed agricultural sector.

In Zimbabwe, the majority of smallholder farming in the country is rain-fed and agricultural is strongly influenced by fluctuations in rainfall (Boko et al, 2007) with Gross Domestic Product positively correlated to annual rainfall (UNEP/GRID, 2012). Agricultural production is

heavily dependent on climatic conditions. This makes agricultural activities extremely vulnerable to climatic changes. Droughts in most parts of the country especially the low lying areas have become recurrent over the last two decades and farmers have been experiencing droughts every two to three years (Mazvimavi et al, 2007). More frequent and prolonged droughts and increases in temperature can seriously reduce crop yield, especially maize, which is a staple crop in Zimbabwe (Tadross et al, 2009, Crespo et al, 2011). Meanwhile, climate change is expected to pose a particular challenge for agriculture and for instance food production.

Few studies have analyzed the perceptions and adaptation of Zimbabwean farmers to climatic and non-climatic shocks (Mubaya, et al 2010; Hoddinot 2006; Tawodzera 2011; Eriksen et al 2008; Hassan and Nhemachena 2008; Kurukulasuriya and Mendelson 2008a; Kurukulasuriya and Mendelson 2008b). The study by Hoddinott (2006) found that 1993-1994 rainfall shock in rural Zimbabwe resulted in increased mortality rates and morbidity levels and resulted in adverse forms of coping. Tawodzera (2011) study analyzed the urban household vulnerability to food insecurity. Eriksen et al, (2008); Hassan and Nhemachena (2008); Kurukulasuriya and Mendelson, (2008a) noted that livelihood activities key for climate risk management in Zimbabwe include: diversifying crops, planting drought resistant crops, planting different crops and varieties, exchange of labour for food, replacing farm with off farm activities, use of soil and water conservation, irrigation, changing planting and harvest dates, conservation of fodder for livestock and rearing drought tolerant livestock.

Most of the above studies, have focussed on quantifying perceptions, identifying climatic adaptation strategies. However, little research has been done to quantify how households are vulnerable to these climatic shocks in semi-arid areas of Zimbabwe. In line with Chaudhuri (2003) we should be concerned about vulnerability assessment because (i) it highlights the distinction between ex-ante poverty prevention interventions and ex-post poverty alleviation interventions, and (ii) it helps to investigate sources and forms of risks households face. This helps to design appropriate safety net programs to reduce or mitigate risk, hence vulnerability. Our study contributes to this debate and addresses the knowledge gap by using a cross-sectional dataset collected from 180 randomly selected smallholder farmers in semi-arid areas of Gweru and Lupane districts of Zimbabwe. The study area has diverse socio-economic settings. The objectives of this paper are to (1) to assess household vulnerability to climate change using food insecurity probability estimates, (2) assess the determinants of household vulnerability to climate change, and (3) suggest policy options to enhance farmer's adaptation to climate change in order to reduce their vulnerability.

The paper is organized as follows. Section 2 reviews the literature on approaches to vulnerability assessment. Section 3 describes the empirical method employed in this study. Section 4 discusses the results, and Section 5 concludes.

2. Materials and methods

2.1 Literature search

2.1.1 Climate risks in Zimbabwe

Climatic records show that the country is warmer at the end of the twentieth century, compared to historical recorded years and according to Hulmen *et al* (1999) the warming has been the greatest during the dry season, with the 1990s decade being one of the warmest in the century. The 1990s witnessed probably one of the driest periods, a drought certainly related to the prolonged El Nino Southern Oscillation (ENSO) conditions that prevailed

during these years in the Pacific Ocean (Hulmen *et al.*, 1999). The ENSO also known as the El Nino in short, is one of the main causes of climate variability for many tropical regions including Zimbabwe. The El Nino phenomenon is a recurring pattern of inter-annual oscillations in both sea surface temperature and sea level atmospheric pressure in the tropical Pacific which strongly correlates with climate patterns around the globe. For Southern Africa, Zimbabwe included, rainfall is strongly influenced by ENSO and scientists use its occurrence to predict rainfall to be received in the country (Tadross et al, 2009; Hulmen *et al.*, 1999).

Climatic risks (e.g rainfall variability, droughts) account for a significant share of agricultural production risk (World Bank, 2001; FAO, 2008). Climate risks have severe impacts on food security and livelihoods of smallholder farmers in developing countries mainly through crop yield and livestock fodder losses (Murendo et al, 2011, IFAD, 2009). Zimbabwe's agriculture sector is sensitive to climate change, variability and extreme events, particularly increased frequency of droughts and mid season dry spells.

Poor rainfall distribution within the growing season is often a cause for crop failure even for years with close to average rainfall, due to dry spells at critical stages of crop growth. In some areas there is insufficient surface or groundwater to irrigate dry land crops even at critical periods (Lovell, 2000). Eriksen *et al.*, (2008) highlights that in case of Zimbabwe the climatic risks will be associated with increased temperatures, increased incidences of droughts, decrease in rainfall, seasonal shifts in rainfall, localised floods, decreased river flow and wildfires.

2.1.2. Vulnerability and its measurement

Different disciplines use the term "vulnerability" differently to explain their areas of concern and as such there is no universally accepted definition. The Intergovernmental Panel on Climate Change (IPCC 2001) defines vulnerability to climate change as: "The degree to which a system is susceptible, or unable to cope with adverse effects of climate change, including climate variability and extremes, and vulnerability is a function of the character, magnitude and rate of climate variation to which a system is exposed, its sensitivity, and its adaptive capacity." In poverty and development literature three prominent definitions of vulnerability emerge:

a) Uninsured exposure to risk and shocks

This method is based on *ex post facto* assessment of the extent to which a negative shock causes welfare loss (Hoddinot and Quisumbing, 2003) the impact of shocks is assessed using panel data to quantify the change in induced consumption. Skoufias (2003) employed this approach to analyze the impact of shocks on Russia. In the absence of risk management tools, shocks impose welfare loss that is materialized through reduction in consumption. The amount of loss incurred due to shocks equals the amount paid as insurance to keep a household as well off before any shocks occurred. According to Skoufias (2003), the limitation of this method is that in the absence of panel data, estimates of impacts, especially from cross sectional data are often biased and thus inconclusive.

b) Low level of expected utility

Ligon and Schechter (2003) defined vulnerability as the difference between utility derived from some level of certainty-equivalent consumption at and above, which the household would not be considered vulnerable, and the expected utility of consumption. Using this method on a panel data set from Bulgaria in 1994, Ligon and Schechter, (2003) found poverty and risk play roughly equal roles in reducing welfare.

c) Expected Poverty

Here vulnerability is the prospect that a household will, if currently non-poor, fall below the poverty line, or if currently poor, will remain in poverty or fall deeper into poverty (Scaramozzino 2006). Thus, vulnerability is seen as expected poverty, while consumption (income) is used as a proxy for well-being. This method is based on estimating the probability that a given shock or set of shocks will move household consumption below a given minimum level (such as a consumption poverty line) or force the consumption level to stay below the minimum if it is already below this level (Chaudhuri et al. 2002). Chaudhuri et al. (2002) uses consumption measures a welfare indicator because he argues that it provides a more adequate picture of wellbeing especially in low or medium income countries. The other advantage is that consumption is more accurately measured. This approach is divided into three basic steps, i.e. identifying the welfare indicator; identifying the vulnerability threshold; and measuring vulnerability.

Ninno *et al* (2006) used this method on data from the Household Income and Expenditure Survey in Pakistan to measure vulnerability of individual households. The authors found that a third of the population was vulnerable due to low level of resources. In their study, they found that 24 to 34 percent of population's vulnerability comes from high volatility of consumption. Using this method, Sarris and Karfakis (2006) measured the vulnerability of rural households in Tanzania, and found that poorer regions were considerably more vulnerable to poverty. Tesliuc and Lindert (2002) assessed cross-sectional survey data obtained from Guatemala in 2000 and showed that three-quarters of the total poor had a vulnerability index in excess of 0.67, indicating that two out of three of the then-poor households would still be poor in the coming period. Applying this method on cross-sectional survey data obtained from Indonesia in 1998, Chaudhuri et al. (2002) found that although only 22 percent of the population in Indonesia was poor, as much as 45 percent of that population were vulnerable to poverty.

Ideally, according to Holzmann et al. (2003), vulnerability assessment is appropriate with panel data. They noted that the estimation of the stochastic consumption process is data intensive requires information on (i) different aspects of household (income, assets, shocks experienced, coping strategies), and (ii) information on these aspects over time. Such data are typically not available, especially in developing countries. Given data limitations, various authors have devised different methodologies to analyze vulnerability using limited information (e.g. pure shock analysis (Tesliuc and Lindert, 2002), cross sectional analysis (Chaudhuri, 2003; Chaudhuri et al., 2002), census data (Hoogeveen, 2005) and pseudo panel (Christiaensen and Subbarao 2005). Hoddinott and Quisumbing (2003) states that the disadvantages of using cross-sectional data requires strong assumption that the cross-sectional variability captures temporal variability.

2.2 Study Area

The research was done in two districts (Gweru and Lupane) of Zimbabwe. The two districts have areas that are in semi-arid areas of Natural Regions (NR) III and IV (characterized by frequent droughts and erratic rainfall). In Zimbabwe, the agricultural land is divided into five agro-ecological zones known as Natural Regions which relate to climatic conditions, soils and to the appropriate farming system (Vincent and Thomas, 1960). The quality of the land in terms of agricultural productivity declines from NR1 to NR V.

2.3 Data

The data used for this study come from a cross-sectional household survey conducted in 2009 in Gweru and Lupane districts of Zimbabwe. The survey was conducted under the

collaboration of Midlands State University (MSU) and International Crop Research Institute for the Semi-Arid Tropics (ICRISAT) as part of the broader Building Adaptive Capacity to Climate Change, (BACCC). The selection of districts was done at project level. In the two districts, only wards which fall in Natural region IV were included in the sampling frame. The selection was done purposively to include only farmers in semi – arid areas characterised by mid season dry spells and droughts. The sampling involved listing all the wards within each district, falling into NR IV followed by random selection two wards from each district. From each ward; three villages were randomly selected and from each village, 15 households were randomly selected (Table 1).

Table 1 Surveyed districts and villages

District	Ward	Village	Number of households
Gweru	Nyama	Mathonsi	15
		Guduza	15
		Msingondo	15
	Mdubiwa	Madinga	15
		Mxotshwa	15
		Nsukunengi	15
Lupane	Daluka	Daluka	15
		Gandangula	15
		Mafinyela	15
	Menyezwa	Banda	15
		Masinyane	15
		Menyezwa	15
Total			180

The household survey, collected information on: household characteristics; the incidence of different climatic and other shocks over the previous five years; crop and livestock production; access to extension services; income and assets; perceptions of climate change; adaptation options; and social capital. Four trained enumerators were involved in data collection and supervised by an experienced researcher. The questionnaire was carefully pretested to ensure content validity.

3. Analytical methods

Analytical framework

Following Chaudhuri et al. (2002) we used the expected poverty approach to model vulnerability to climate change. Since we are using cross sectional data, we make an assumption that the cross-sectional variability captures temporal variability in line with Hodinott and Quisumbing (2003). A household that fails to produce this amount of cereals in a production season will be classified as food insecure and vulnerable to climate change in the future. In Zimbabwe an average rural household (of 6 persons) requires a minimum of 165kg of cereal per capita per annum to be considered food secure (FAO, 2007). Smallholder farmers in Zimbabwe commonly produce cereals such as maize, millet and sorghum; with maize being the staple food and most commonly grown cereal.

In our study, the probability of a farmer falling below a given cereal consumption level due to climatic shocks (droughts or rainfall variability) was measured with the vulnerability as expected poverty approach. This approach allows estimation of the proportion of people that are vulnerable to shocks, and this may be used by policy makers to formulate and implement safety nets and adaptation strategies. Chaudhuri et al. (2002) argues the choice of vulnerability

threshold is quite arbitrary and majority of authors use a vulnerability threshold of 0.5. In line with literature, a household is considered vulnerable food insecurity if the probability is equal or greater than 0.5 and less likely otherwise. Following Chaudhuri et al. (2002), household's vulnerability level in terms of its future food consumption can be expressed as a reduced form for consumption determined by a set of variables X_h :

$$\ln C_h = \beta_0 + X_h\beta_1 + \varepsilon_h \quad (1)$$

Where $\ln C_h$ represents log of consumption per capita, X_h represents selected household bundle of observable household and community characteristics (household size, location, educational attainment of the household head, etc.) and climatic shocks (droughts, rainfall variability and hailstorms). β_1 is the vector of parameters to be estimated, and ε_h is the unexplained part of the household consumption. Since the impact of climatic shocks on household consumption is correlated with observed characteristics, the variance of the unexplained part of consumption ε_h is:

$$\sigma_h^2 = \Phi_0 + \Phi_1 X_h + \omega_h \quad (2)$$

Which means that the variance of the error term is not equal across households and depends upon X_h . Given the data limitations, we cannot identify the stochastic process generating β . The expected mean and variance of per capita cereal consumption are estimated using the three-step feasible generalized least squares (FGLS) procedure suggested by Amemiya (1977). Using the β_1 and Φ_1 estimates, we estimate the expected log consumption and variance of log consumption for each household. These serve as vulnerability estimates.

Empirical specification of model variables

Dependent Variable

In Zimbabwe, cereals, predominantly maize, sorghum and pearl millet are commonly produced by rural families on the farm. These are mostly used for calculating per capita production and consumption. In this study we aggregate all cereals produced by the household to compute the per capita cereal production.

Independent Variables

Table 2, shows the independent variables, their measure and expected signs.

Gender of household head

According to Horell et al (2006) female headship, specifically the *de jure* female headship is typically expected to increase the likelihood of the household being vulnerable. Female *de jure* headed households are often constrained by lack of access to resources such as labour, farming implements and income.

Age

The influence of age on technology adaptation is mixed in the literature. Some studies found that age had no influence on a farmer's decision to participate in forest and soil and water management activities (Bekele & Drake, 2003) and climate adaptation (Hassan and Nhemachena, 2008). However, Nyangena (2007); Anley et al. (2007) found that age is significantly and negatively related to farmers' decisions to adopt. On the other hand Bayard et al. (2007) found that age is positively influenced adoption of conservation measures. We hypothesize that age of the household head has both positive and negative impacts on adaptation measures. We assume that old age is associated with more experience and expect

older farmers to adapt to changes in climate. However, young farmers are more likely to adopt measures such as irrigation and mixed crop-livestock systems that enhance farm productivity.

Education

Education is important to farm production, especially in a rapidly changing technological or economic environment. Educated farmers are expected to have more knowledge and information about climate change and agronomic practices to enhance farm productivity (Maddison, 2006). This can help improve the productivity of households and help reducing vulnerability to food insecurity.

Farming experience

Farming experience of the household is in most cases positively correlated to farm productivity. An experienced farmer who has resided in a community for a long time has better knowledge of the climatic history of the area. Such farmers are more likely to adapt better to the changing environment compared to farmers with less farming experience in their areas, as they can better judge the environment even by using indigenous knowledge systems.

Social groups

A social group refers to a group of people who meet for a specific common cause. Social groups serve as networks where information is exchanged and members can learn and share new things, discuss constraints being faced by group members in agricultural and non-agricultural production (Conley and Udry 2010; Fafchamps, 1992). Fafchamps (1992) note that social groups can act as a networks of sharing and reciprocity allowing the household to smooth consumption over time. Such groups can be vital platforms to disseminate weather and climatic information. Access to climate information enables farmers to make more informed farming decisions is necessary to reduce vulnerability to climate change.

Extension and access to weather information

We expect that farmers with access to extension and weather information would take up adaptation measures that help them reduce losses or take advantage of the opportunities associated with these changes.

Table 2 Definition of variables used in the empirical analysis

Variable	Measure	Expected sign
CEREAL PRODUCTION (Dependent variable)	Continuous	N/A
Gender of household head (Female %)		±
Age of household head (years)	Continuous	±
Education of household head		+
Farming experience (years)	Continuous	+
Presence of chronically ill people	1=yes and 0=No	+
Member of a local social group (Yes, %)	1=yes and 0=No	+
Annual household income		+
Livestock (Cattle, Yes, %)	Cattle owned	+
Physical assets		+
Extension frequency		+
Access to weather information	1=yes and 0=No	+
Hired labour		+
Total land owned (ha)	Hectares	±
Family labour		+

4. Results

a) Household socio-economic characteristics

Table 3 presents the socio-economic characteristics of sampled households in Gweru and Lupane districts. In the two districts the majority of households are male headed (62.6%). From the female headed households; 12.9% are *de facto* female head meaning they are married but not living with their husbands and 87.1% are *de jure* female heads; these are either widowed, divorced or have never been married. Across the two districts the average age of the household heads is 53 years. The majority of the household heads (70%) fall within the age group (25- 64 years). This is the economically active group mostly involved in labour supply for agricultural production. Thirty percent of the household heads are above 65 years of age. This age group consist of the elderly, who need to be taken care of and in most cases do not contribute much to farm labour. The literacy levels of farmers in both districts are high (85%). Only 15% of the household heads lack any form of education in the sample areas. Majority of farmers were able to read and understand extension message.

On average, households have been engaged in farming for 23 years. This means that the farmer in the study area had better knowledge of the climatic history of the area. In Lupane, households had on average 6 hectares of arable land compared to 4 hectares in Gweru. There is more arable land per household in Lupane compared to Gweru (Independent T-Test, $p < 0.05$). This can be attributed to the population density as households in Gweru are densely populated compared to Lupane where they are dispersed and the population is lower.

In our study we asked whether any of the household belongs to a social group. In Gweru and Lupane this included groups specializing in nutritional gardens, dressmaking, baking, money lending and building. In Gweru 73% of the sampled households heads were members of at least one social group that is agricultural oriented compared to 46% in Lupane. Although the wards selected in Gweru are marginal, the district itself has vibrant cropping activities, good market, road and extension infrastructure compared to Lupane and this might explain why more households are active in social groups.

Table 3 Household socio-economic characteristics

Variables	Gweru (n=90)	Lupane (n=90)	Average
CEREAL PRODUCTION (Dependent variable)			
Gender of household head (Female %)	48.3	28.7	38.4
Age of household head (mean years)	53.7	51.8	53.7
Education of household head (%)			
None	9.4	55.5	32.2
Primary	2.8	19.1	52.2
Secondary	26.4	2.2	15.4
Tertiary	52.7	29.4	2.5
Farming experience (years)	21.9	23.1	22.5
Presence of chronically ill people			
Member of a local social group (Yes, %)	72.9	46.0	59.3
Annual household income			
Livestock (Cattle, Yes, %)	39.4	62.9	51.1
Physical assets			
Extension frequency			
Access to weather information			
Hired labour			
Total land owned (ha)	4.1	6.8	5.4
Family labour			

b) Household vulnerability to climate change

Following Chaudhuri *et al.* (2002) and using a vulnerability threshold of 0.5, we divided households into two vulnerability groups (vulnerable and non-vulnerable households). The distribution of vulnerability among households in Gweru and Lupane districts follows a skewed distribution with mean 0.76, thus the majority of households in both Gweru and Lupane are vulnerable to food insecurity, with most household having a probability of more than 0.5. On average 89% of the households had a probability of more than 0.5 making them vulnerable to food insecurity and 11% were not vulnerable to food insecurity (Table 4). Our results show no differences in vulnerability status of the households between the two districts.

Table 4 Household vulnerability groups (%)

Group	Probability	Gweru	Lupane	Total
Not vulnerable	0.00 – 0.49	11.8	9.2	10.5
Vulnerable	0.50 – 1.00	88.2	90.8	89.5

c) Determinants of household vulnerability to climate change

Table 5 show that gender of household head and income positively influences cereal production (significant at 10% level). Farming experience, livestock ownership, hired labour and social groups have positive influence (significant at 5% level) on household cereal production and hence their vulnerability to climate changes. Presence of chronically ill household members and family labour reduce cereal production.

Table 5 Determinants of household vulnerability to climate change using cereal production

Variables	$\hat{\beta}$ coefficient	T statistic value	Level of significance	$\hat{\theta}$ coefficient	T statistic value	Level of significance
Constant	3.429	2.581	0.011***	-0.820	-0.522	0.602
Gender of household head	0.290	1.935	0.055*	0.106	0.597	0.551
Age of household head	-0.291	-0.782	0.435	0.454	1.033	0.303
Education of household head	0.149	1.358	0.176	0.053	0.407	0.685
Farming experience of household head	0.325	2.479	0.014***	-0.033	-0.215	0.830
Presence of chronically ill people	-0.435	-2.39	0.018**	-0.459	-2.139	0.034**
Member of a local social group	0.337	2.18	0.031**	-0.204	-1.118	0.265
Annual household income	0.081	1.76	0.080*	0.096	1.775	0.078*
Livestock	0.084	2.014	0.046**	-0.026	-0.532	0.596
Physical assets	-0.001	-0.005	0.996	-0.107	-1.132	0.259
Extension frequency	-0.136	-1.309	0.193	-0.108	-0.881	0.380
Access to weather information	0.310	1.512	0.132	0.014	0.057	0.955
Hired labour	0.391	2.579***	0.011***	-0.160	-0.895	0.372
Total land owned	0.182	1.646	0.102	0.249	1.911*	0.058*
Family labour	-0.456	-2.830***	0.005***	-0.087	-0.458	0.647

Significance at: * 10%, ** 5% and ***1% level of significance

5. Discussion

The gender of household head influence crop production. Male headship was associated with higher cereal productivity. In most cases male heads in Zimbabwe have better access and entitlements to physical, financial and social capital compared female counterparts. Horrel and Krishnam (2006) confirm similar findings. While studying poverty and productivity in female-headed households in Zimbabwe Horrel and Krishnam (2006), found that female headed households in rural areas were among the poor and insufficient income and resources constrained their productivity. Their study concluded that women often lack assets, particularly those needed for agriculture production, constraining their ability to diversify the crops grown and the area allocated for crops is often small compared to man headed households. On the contrary, Hassan and Nhemachena (2008) found no clear cut effects of gender on climate adaptation by utilizing different cropping systems in Zimbabwe. Bayard et al (2007) found that women are more likely to adopt natural resource and conservation practices.

Our results show that age and education of the household head had no influence on cereal production. Hassan and Nhemachena (2008) also found that age did no matter in farmer's decision to adopt climate adaptation strategies. This contradicts Maddison (2006) who highlighted that educated farmers are expected to have better knowledge of climate and agronomic practices. This is not surprising as the educational curriculum does not emphasis on farming related subjects. Farmers acquire relevant knowledge and skill for farming from extension services rather than from schools. Our study shows that it is not age or education that increases cereal productivity but rather farming experience. Farming experience increases cereal produced by the household significantly. More experience enables farmers to improve productivity as they learn and improve their crop husbandry over time.

Our results show that the presence of a chronically ill person in the household reduces the cereal production levels. In most cases this results as a result of reallocation of income and labour to meet health expenses and take care of the patient respectively. Social groups are a source of information and helps farmers learn specific skills, share experiences and inform each other on better ways of improving crop management. Our results show that belonging to a social group positively influences crop productivity. Households with head as members of a social group had higher cereal production levels. Policies that help to strengthen social cohesion in rural communities, such as farming groups, women's clubs and membership to extension services training will be critical for farmers to share knowledge of adaptation strategies in the event of climate change.

Household income positively and significantly influenced cereal productivity in the study area. Household income is often used to buy inputs such as improved seed varieties and fertilizer that increase resilience to climate variability and sustain high crop production levels. In addition, households that have access to better income opportunities are more likely to acquire seeds and fertilizers on time to enable early planting with the first effective rains as well as apply fertilizers at the appropriate crop stage to ensure improved grain filling.

Livestock ownership significantly increases cereal production in Gweru and Lupane districts. Livestock such as cattle and donkeys are used as draft power both in tillage and traction. A household with draft power is more likely to perform farming operations timeously and plant with the first effective rainfall and this is crucial for rain- fed agriculture. Livestock also contributes manure which most smallholder farmer's use to improve soil fertility. Development policies and programmes that enhance household income and boost livestock ownership are critical in enhancing crop production in order to mitigate the effects of climate change in drought prone areas of Zimbabwe.

Access to extension services and weather forecast information were not significant in explaining household's cereal production levels. This is not surprising considering that extension delivery system have been facing severe financial and human capital constraints in Zimbabwe leading to poor extension delivery. There was severe brain drain in this sector leading to fast track extension apprentice scheme, which tended to produce half baked graduates. While weather information is disseminated via electronic media, the information is not available in local languages and on time to help farmer's decisions on cropping.

Contrary to expectation, household labour, though significant is negatively correlated to the quantity of cereals produced by the household. This defies production theory, where labour is critical production factor. The reasons for such may be squarely lie on the weaknesses in collection and measurement of labour in the study. Household were asked whether they contributed full time, part-time or no labour at all. One weakness of such is that this does not consider the quality of labour and labour effort towards cereal production only. Again in computing total household labour, members contributing full time labour received index factor of 1 (in most cases the active working class; 18-64years) and those part time (6-17years and above 65years) received a factor of 0.5. These were then aggregated to compute total household labour and these might not be a true reflection of the actual labour dynamics.

On the other hand, our results show that hired labour positively influences crop production. Hired labour is mostly used in critical operations like weeding, fertilization and harvesting which require precision. A household that affords to hire additional labour achieves higher cereal production as cropping activities are usually done in time to ensure a good harvest.

6. Conclusion

Our study revealed that 89% of the households had a probability of more than 0.5 making them vulnerable to food insecurity and 11% were not vulnerable to food insecurity. Using cereal production indices we employed the Chaudhuri model of assessing household vulnerability to food insecurity. We postulate that household food insecurity is due to climate change. Based on the model, the gender of household head, farming experience, household income, and livestock ownership had strong influence on household cereal production and hence their vulnerability to climate changes. Household income is often used to buy inputs such as improved seed varieties and fertilizer that increase resilience to climate variability and sustain high crop production levels. A household with draft power is more likely to perform farming operations timeously and plant with the first effective rainfall and this is crucial for rain-fed agriculture. Programmes that enhance household income and boost livestock ownership are critical in enhancing crop production in order to mitigate the effects of climate change in drought prone areas of Zimbabwe. Our results also show that social networks and use of hired labour positively influences crop productivity. Social groups are a source of information and helps farmers learn specific skills, share experiences and inform each other on better ways of improving crop management. Policies that help to strengthen social capital in rural communities, such as farming groups, women's clubs and membership to extension services training will be critical for farmers to share knowledge of adaptation strategies in the event of climate change. Overallly, development policies that improve crop production are critical as they boost household adaptive capacity to climate change. There is need to link climate change policies to broader rural development policies especially in developing nations. Our study relies on cross sectional data. This is a static approach and fails to capture dynamic trends. Considering vulnerability is dynamic, further research using longitudinal data to trace vulnerability implications of climate change is needed.

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