Environmental and Geographical Science at the University of Cape Town

Climate Risks and Constraints to Adaptation in sub-Saharan Africa: A Case Study of Sustainable Livelihoods of Rural Poor in North-Eastern South Africa.

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This is a minor dissertation presented for the approval of Senate in partial fulfilment of the requirements for the <*MSc or MPhil*> specializing in Climate Change and Sustainable Development in approved courses and a minor dissertation. I hereby declare that I have read and understood the regulations governing the submission of <*MSc or MPhil*> specializing in Climate Change and Sustainable Development dissertations, including those relating to length and plagiarism, as contained in the rules of this University, and that this minor dissertation conforms to those regulations.

Steven A. Arowolo

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Abstract

Sporadic natural disasters are not new to this generation, but the perennial nature of extreme climate events seems to have precipitated a calamity of monumental proportion in recent times. This is evident among poor and vulnerable communities in rural sub-Saharan Africa; this study investigates the impacts of climate shocks on households' income, with a view to identifying possible constraints to adaptation to extreme climate events among poor households whose means of livelihoods is crop production. This study utilises the panel data collected between 2010 and 2012 from Agincourt DSS field-site among nine rural villages comprising of 897 households in North-Eastern part of South Africa. Socio-economic indicators were used as proxy variables to model the impact of households' shocks resulting from climate risks on household livelihood strategies and vulnerability. Using the log of households' income as a measure of household vulnerability, the results indicate that crop failure, one of the proxies for climate shocks, has a negative and significant impact on household income. The second part of this study considers possible constraints to adaptation, in particular the use of seed varieties and fertilizers. Weak social capital (membership to a farmers' association) was identified as an important factor influencing adaptation in this study with a positive and significant impact on expenditure on seed varieties. Other constraints to adaptation seem to be the age of the household head, education and income earning activities of the household.

Key words: Adaptation, Climate policy, Climate shocks, Constraints, Proxy variables, Fixed Effects, Random Effects, Social capital.

CHAPTER 1
INTRODUCTION

1.1 Background

In terms of economic development, most countries in Sub-Saharan Africa are yet to keep pace with the rest of the world. This region of the world has the highest population of people living in the extreme poverty (UN, 2006). Stern (2006) observes that poor people are often at the risks of been more susceptible to the problems associated with extreme climatic events. The effects that climate change will have on the world may not be equally dispersed, it has been said that the poorest countries and the poor living in those countries will suffer the most (Stern, 2006). Therefore, since climate variability and extreme climatic events are part of the global threats to life and properties in most part of the world, sub-Saharan Africa region will require new and effective ways of adapting to the risks that will be imposed by climate change. Studies have shown that adapting to climate risks varies from one country to the other, as a result of the fact that the factors responsible for change often interact in ways that could influence vulnerability as a consequence of perennial changes in climate (Smit and Wandel, 2006; Ziervogel et al., 2006).

It is essential to view adaptation as a way of minimizing the risks often imposed by changes in climate with respect to the living condition of the people (DFID, 2006); this suggests that adaptation is very important to people's condition of living in sub-Saharan Africa, and any research interest that focuses on investigating the constraints to adaptation with respect to the sustainable livelihoods of the people in this region of the world is worth embarking on.

1.2 Problem statement

Studies have revealed that variability in climate and dangerous change in climatic condition that could result in excessive storms, flooding and prolonged droughts have shown considerable impacts on the locations and amenities available to the people (Freeman and Warner, 2001; Mirza, 2003; Niasse et al., 2004). These extreme events often constitute major stresses to the livelihoods of the poor especially in sub-Saharan Africa.

Adapting to variability is determined by a number of factors often related to "wealth, technology, education, information, skills, infrastructure, and access to resources, effective

governance structure and other essential management capabilities" (Adger and Vincent, 2005; Brooks et al., 2005; Grothmann and Patt, 2005); poorer communities in sub-Saharan Africa are known to be lacking in many of these factors, hence, their high vulnerability to climate variability. As climate variability is becoming more severe, the livelihoods of the poor may increasingly become endanger and reliance on ecosystem services may thus increase considerably. The need to discover alternative approaches for adaptation becomes very important; and investigations into the lack of understanding of those constraints facing poor communities that may impede their ability to adapt should be prioritized.

Adger et al. (2009) contend that with the available range of conceptual tools, there will be challenges in putting adaptation theory into practice because of the uncertainty factors inherent in the of future climate change and its anticipated effects, and also because of the difficulty in evaluating and relating adaptation measures due to time scales with respect to costs and opportunities, being interpreted locally within the 'limits' of existing socio-political entities. Given the persistent influence of climate variability, and its attendant risks on the most vulnerable rural communities in sub-Saharan Africa, this study seeks to identify those plausible and possible factors that could constitute constraints to adaptation in the study area.

1.3 Research objectives

The overall objective of the study will be to identify the various constraints to adaptation in the study area, with respect to environmental and human activities that could influence the vulnerability of the rural community.

Sub-objectives:

I. To identify factors affecting the livelihoods of the rural poor in the study area e.g. the impacts of climate shocks on household income.
II. To investigate ways by which various households in the study area are adapting to climate change and climate variability.
III. To investigate possible constraints to climate risks adaptation in the study area.

1.4 Hypotheses

The following hypotheses were tested in tandem with the broader objective of this research:

I. Climate shocks are affecting the livelihoods of the poor in the study area (e.g. to test the impact of climate shocks on households income).
II. There are possible constraints to adaptation to climate shocks resulting from climate variability and extreme climate events in the study area.

1.5 Justification for the study

Ecosystems offer a range of vital services which strengthen human well-being (e.g. provision of basic needs, physical health, food and nutrition security, mental health, and peaceful social relations). However, human societies have significantly influenced the speed, scale and nature of global environmental change in ways which could jeopardise ecosystem health and the biosphere's future capacity to provide for human needs and security. Moreover, as climate variability is becoming more austere, the livelihoods of the poor may increasingly become uncertain and reliance on ecosystem services may in turn escalate. The need to discover alternative strategies for adaptation and understanding constraints facing the poor that may hamper their ability to adapt is therefore imperative.

The consequences for the rural poor are particularly serious, as they are mostly dependent on immediate ecosystem services and, therefore, most vulnerable to localized environmental degradation. This is critically important in rural South Africa, which is characterized by the interlinked phenomena of high human densities due to the historic settlement patterns imposed by Apartheid, high level of poverty, substantial food insecurity, and high levels of reliance on natural resources for survival in rural livelihoods, climate variability and environmental destruction. These phenomena characterize much of the developing world, especially in sub-Saharan Africa. This study will offer suggestions and policy recommendations based on the findings from this study area with a view to contributing to the body of knowledge currently available to the people and the government.

1.6 Research outline

This study is made up of five chapters. The first chapter captures the overview to the research; the major context of this research was discussed in this chapter. This chapter also highlights the problem statement and the objectives of this study, as well as the basis for the

research. The chapter presents the research objectives and the specific hypotheses. It ended with the justification for the study. Chapter two presents the theory base for the study; it contains the body of literature previously published by other scholars while emphasizing their relevance to this study. Chapter three presents the theoretical and analytical frameworks; it encompasses the methodology used in this study, it also outlines the application of the theory used in this study with model specifications. This chapter also contains the detailed overview of the study area; criteria and processes, geographical characteristics and its significance to the study in general.

The results of this study are presented in chapters four; both descriptive statistics and econometric analysis were presented in this chapter. Summary of findings, conclusion and recommendations were presented in chapter five which is the last chapter.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

The purpose of this study is to investigate the constraints to adaptation to climate shocks that may result from increasing climate variability in the study area. This chapter examines the theoretical foundations for this study; the objective of the literature review is to profile some of the previous works that have been done on the subject of climate variability and adaptation, with a view to providing theoretical basis for this study. The review will provide a critical perspective to the exposition of this study, with the aim of synchronising the core research objectives with the stated research statements, while clarifying the hypothesis to be tested.

This literature review is organised in three main sections as follows: (1) a review of the challenges of climate variability among rural communities (2) a review of the necessity of adapting to climate variability and the sustainable livelihoods of rural households; (3) a review of the significance of constraints to adaptation among rural poor in South Africa.

2.2 Challenges of climate variability among rural communities in sub-Saharan Africa

Hellmuth et al. (2007) observes that 70% of sub-Saharan Africans have their livelihoods from subsistence agriculture; this implies that they depend heavily on rainfall. Extreme climatic events could cause rainfall to fail; this will then have adverse effect on the lives of many of people in this region of the world. Although the poor are more vulnerable to climate risks, Hellmuth et al. (2007) contend that poor people often manage all kind of risks, including risks resulting from extreme climatic events. Farmers of all ages have devised ways of managing risks through various means ranging from their seasonal planting decisions to traditional ways of crop rotation. However, Hansen et al. (2004) argue that there is a limit to what these poor farmers could achieve, especially with respect to adapting to the impact of climate risks on their livelihoods. The authors find that risk reduction and the uncertainty often associated with extreme climatic events could inflict hardship on the livelihoods of the rural poor.

Giannecchini et al. (2007) observe that the resilience "of socio-ecological systems" in rural areas may become weakened in the face of increasing pressures "such as population growth, drought, and shortages of land, grazing and wood resources, weakening institutional governance of natural resources and the diversification of livelihood strategies".

2.3 Necessity of adaptation to climate variability and sustainable livelihoods of the poor

Since subsistence agriculture remains the major means of livelihoods in most rural communities, adaptation to the negative impact of climate risks should be encouraged. In their research on adaptation to climate change in Ethiopia and South Africa, Bryan et al. (2008) contend that a better understanding on farmers' perception of climate change is essential, with a view to understanding the adaptation process of measures, and the key issues affecting their decision to adapt; they argue that this is essential for policy formulation in programmes focussed on improving adaptation in farming sector. They conclude that adaptation will involve stakeholders across sectors and disciplines such as: "policymakers, extension agents, NGOs, researchers, communities, and farmers" Bryan et al. (2008).

2.4 Determinants of constraints to adaptation to climate variability among rural poor

Studies have shown that the former Bantustans or "homelands" in South Africa provide a home for almost "2.4 million rural households" (Statistics South Africa, 1999) a greater percentage of them rely heavily on agriculture and natural resources for their livelihoods (Shackleton and Shackleton, 2004). In most African villages and less advanced communities, natural resources usually cushion households against stresses and shocks, providing them with means of livelihoods (Hunter et al., 2007). Study by Twine et al. (2003) reveal that the "annual direct-use value of indigenous bio-resources in South Africa, averaged across all households, was R3959 per household or R564 per person with the value being highest in the poorest villages".

Di Falco et al. (2011) examined the determinants of rural households' decisions in adapting to changes in climate. These researchers proceeded to study how adaptation would impact on food security amongst farmers. Their findings show that access to credit and information are crucial factors influencing adaptive behaviors among rural households. Specifically, they found that access to information has a positive effect on food productivity among rural

households. Further studies by Deressa at al. (2009) reveal that certain factors affect adaptive capacity of rural households to climate variability, thereby constituting constrains to adaptation. Their findings revealed that access to extension and credit; as well as timely awareness about climate change and a good social capital within any community, would impact on farmers' choices, they contend that information on adaptation methods and financial constraints presents obstacles to decision making that could enhance adaptation.

According to Deressa et al. (2008) having access to credit would increase the possibility that Ethiopian farmers will utilize new methods on how to conserve soil, adjust their dates of planting and use of irrigation techniques. Similarly, Binswanger and Sillers (1983) argue that the role of institutions such as insurance and credit markets would be valuable in sharing the burden of the risk borne by farmers in rural communities. They contend that "unless farmers have a reliable means of self-insurance or access to credit, they might continue to engage in some risky farming techniques". Murdoch (1995) corroborates their views by stating that when households are unable to borrow or insure, they tend to resort to conservative ways of farming practices such as reducing farm inputs and production techniques, which might be detrimental to the environment.

A study conducted by Giné and Yang (2009) in Malawi among farming households who are vulnerable to climate variability due to perennial variability in rainfall level, examined whether access to credit and insurance encourages farmers to adopt high-yielding hybrid maize and groundnut seeds. Their findings revealed that there is a positive correlation between adoption of the insured loan and farmers' level of education. This finding suggests that underinvestment in crop technology in resource-poor settings should be examined not only with respect to risk preferences and access to finance but levels of education as well as financial literacy should equally be taken into consideration. It must therefore be stressed that eliminating those constraints to adaptation among poor communities would mean that measures are strategically for improving adaptability among rural households. Tompkins and Adger (2004) contend that increasing the adaptive capacity of a community is possible through "collective community-based management" practices that could enhance resilience. Ostrom, (1990) stresses that collective action could be encouraged among people aiming at the same goal in order for them achieve what individual could not have been able to achieve on their own.

This study will specifically focus on the those constraints to adaptation to climate variability among poor rural households in the study area, it will investigate the role of social capital, access to credit and insurance, as well as the diversification of livelihoods strategies in the form of coping strategies to shocks and stresses imposed by climate risks in the study area.

CHAPTER THREE
RESEARCH METHOD

3.1 Introduction

This chapter focuses specifically on the review of the methodology used in this study; it highlights the different motivations that form the basis for the study, the methods used at different levels of the investigation. To set the context for the review, the study area and its geographical settings were succinctly discussed; the socio-economic profile of the rural poor in the study area was highlighted. The chapter then turns to the research process by describing the research tools, methods of data generation and processing. Furthermore, the chapter presents details of the models adapted in the analysis and the data specifications of the study were clearly explained. The econometric models employed in this study are the Fixed Effects (FE) model and Random Effects (RE) model for three period panel data, and this is comprehensively described in the chapter.

3.2 Study Area

This study was carried out in Agincourt DSS field-site located about 500 kms north-east Johannesburg in the Agincourt sub-district of Bushbuckridge region, of the Northern Province. Until 1994 the site was located within a "homeland" or Bantustan area. The site extends from 24°50‟ to 24°56‟ south latitude and 31°08‟ to 31°25‟ east longitude. The altitude range is 400 to 600 metres above mean sea level. The field site and the village communities cover "390 sq. km, measuring 38 km by 16 km at its widest points". (Collinson et al 2002). According to the historical information available on (Agincourt webpage) http://www.agincourt.co.za/index.php/about/. Tollman et al. (1999), observe that Agincourt site has a population of about 60,000 people in 20 villages comprising Mozambican refugees living in a former 'homeland' area which has massive labour migration. However, it is good to mention that only 9 out of these villages were surveyed for the purpose of this study.

3.3 Data Collection and analytical tools

The panel data for this study was obtained for three consecutive years; 2010, 2011 and 2012, from 9 villages: Agincourt, Cunningmore B, Huntington, Ireagh A, Ireagh B, Justicia A, Kildare A, Lillydale B , and Xanthia. These 9 villages constitute the study area. Table 3.1 presents the villages and the numbers of households that were surveyed and sampled during the three year period (2010-2012). Data were collected from both household and individual through the use of structured questionnaires. For the purpose of this study, only household data were considered for analysis. Some of the data collected from the household include the following: household demographic information, assets and income data, livestock ownership, crop cultivation, use of major natural resources, data on household shocks and coping strategies.

3.4 Study site

Focal individuals and their households were randomly selected across nine rural villages distributed along a rainfall gradient in the Agincourt site (Table 3.1). In 2010, these individuals and households were surveyed using detailed questionnaires collecting data on livelihood capital (financial, physical, social, human and natural), activities (on-farm and off-farm economic activities, migration, and natural resource harvesting) and well-being outcomes (socio-economic status, reported health, reported food and nutrition security, reported mental health, and heights and weights of children 1-5 years old). The location and the geographical boundary of the study site is depicted in Figure 3.1.

This study utilises environmental and socio-economic variables as proxies to infer climatic variability, ecosystem health (e.g. vigor, resilience and diversity) and delivery of ecosystem services (e.g. fuel wood, food, medicine, crop and forage production, nutrient and water cycling) in the communal lands surrounding the study villages.

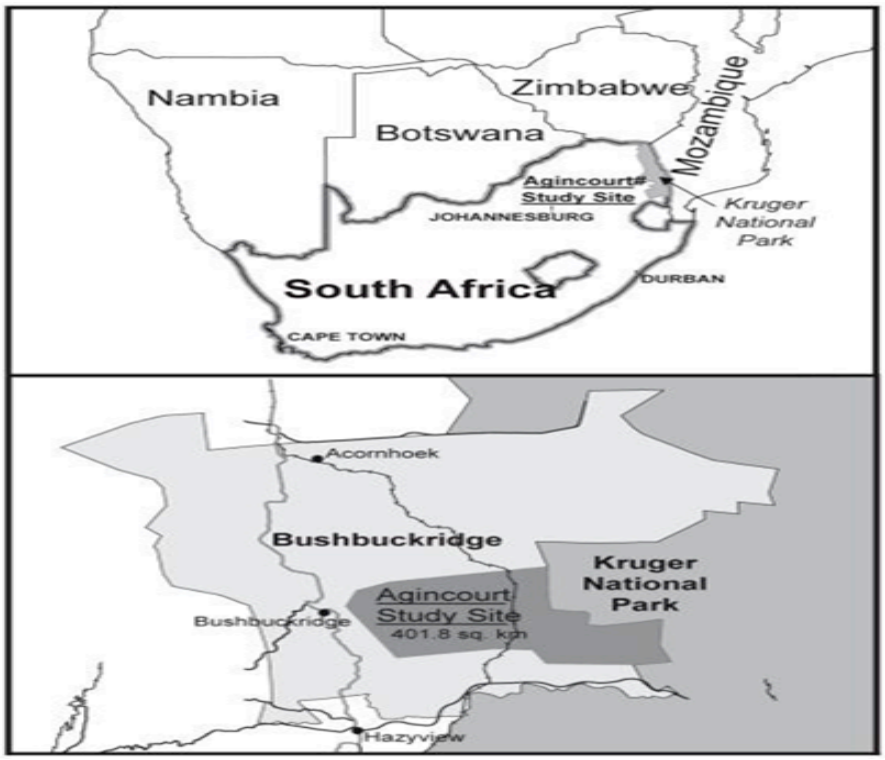

Figure 3.1: Maps showing regional location of the study Site (adapted from Kahn et al. 2010).

Table 3.1: Study Sites by Year of Sampling of Households[1]

Village name	2010	2011	2012	Total
Agincourt	53	52	46	151
Cunningmore B	23	17	20	60
Huntington	21	21	16	58
Ireagh A	30	30	30	90
Ireagh B	10	7	10	27
Justicia A	53	48	48	149
Kildare A	71	69	71	211
Lillydale B	14	14	13	41
Xanthia	38	36	36	110
Total	**313**	**294**	**290**	**897**

Source: Author's own calculation from Agincourt-SUSCES panel data 2010-2012

[1] The information presented in Table 3.1 clearly shows the unbalanced nature of the panel data, some of the problems are due to missing responses and attrition issues when the data was being mined for analysis.

3.5 Descriptive statistics

Some of the major findings of this study are presented in tables showing frequency counts and percentages; charts and graphs are used where appropriate. The purpose of the descriptive statistics is to clarify and graphically present certain facts and assertions made in this study. The socio-economic characteristics of the respondents are succinctly described.

3.6 Model Explanation (Theory)

In order to identify and analyse the determinants of households' constraints to adaptation to climate risks, it is advisable to use both fixed effect and random effect models. This becomes necessary since we are dealing with panel data; the fixed effect model will allow us to understand the unobserved factors affecting the dependent variable from two major perspectives: those factors that remain constant and those varying over time. The random effect model is used based on the assumption that the unobserved effect is distributed independently of the independent variables, and partly because sampled population is derived from a random sampling of respondents.

3.6.1 Estimation of fixed effect model for panel data

If we consider the model equation:

$$y_{it} = \delta_1 + \delta_2 d2_t + \delta_3 d3_t + \beta_1 x_{it1} + \cdots + \beta_k x_{itk} + a_i + u_{it} \quad \ldots\ldots\ldots\ldots (1)$$

Where *i* denote the cross-sectional unit and *t* stands for the time period. Thus, a model with three panel data could be written as in equation (1); where *i* represent the respondents, and *t* stands for the time period. The notation a_i represents the unobserved effect, and it is commonly referred to as a fixed effect or unobserved heterogeneity, it is the error term that is fixed regardless of time. The "error U_{it} is referred to as idiosyncratic error and it represents the unobserved factors that change over time and affect y_{it} (the dependent variable)". Since the total number of observation is three, two time period dummies were included in the equation, and a separate intercept has been allowed for each time period. The idea of this model is that "if the fixed effect a_i is correlated with any of the explanatory variables, then the use of OLS on the three years of data will result in biased and inconsistent estimates" (Woodridge, 2003). The major assumption is that the explanatory variables are strictly exogenous after the fixed effect a_i has been taken out of the equation.. Another very good

reason to use fixed effect analysis is that, it does allow attrition to be correlated with a_i, the unobserved effect. This is necessary in order to ensure that some initial samplings that might have dropped out of the survey are taken into consideration by a_i. Assuming that regression analysis show some level of significance, we will still need to take unobserved heterogeneity into consideration, hence the need to estimate the fixed effect model for the two hypothesis in this study; and due to the problem of attrition encountered during the data mining process for this study. The fixed effect model will be modelled after equation (1).

For a model with a single explanatory variable the fixed effect transformation will take the form:

$$y_{it} = \beta_0 + \delta_0 d2_t + \beta_1 x_{it} + a_i + u_{it} \quad \text{..... (2)}$$

a_i captures all unobserved factors affecting y_{it} that are constant over time → **unobserved effect**, or **fixed effect**, or **unobserved heterogeneity.**

We should end up with an equation that has eliminated ai, the fixed effect. This process is referred to as 'within transformation'. When we add more explanatory variables, we'll use a "time demeaning on each explanatory variable", making use of time period dummies, and then carry out "pooled OLS regression, using all time-demeaned variables". (Woodridge, 2003)

It we consider the model:

$$y_{it} = \beta_1 x_{it} + a_i + u_{it} \quad \text{..... (3)}$$

Averaging over time we have:

$$\bar{y}_i = \beta_1 \bar{x}_i + a_i + \bar{u}_i \quad \text{..... (4)}$$

Running OLS on this equation will give us the "*between estimator"* and subtracting equation (4) from (3) gives:

$$y_{it} - \bar{y}_i = \beta_1 (x_{it} - \bar{x})_i + u_{it} - \bar{u}_i$$
$$\ddot{y}_{it} = \beta_1 \ddot{x}_{it} + \ddot{u}_{it} \quad \text{..... (5)}$$

Note: If we run a pooled OLS on equation (5) it yields the "*within estimator*" or **fixed effects estimator** which uses time variation in the variables within each cross-sectional observation. If E (u_{it} | $\boldsymbol{X}_i$, a_i) = 0 → the fixed effects estimator is unbiased, this implies that a_i can be correlated with the explanatory variables, while u_{it} are assumed to be homoskedastic and serially uncorrelated over time.

3.6.2 Estimation of random effect model for panel data

The assumption behind the random effect is that the error term present in the entity is not correlated with the predictors which allow variables that are not varying with time the chance to be active as explanatory variables.

If we consider this equation:

$$y_{it} = \beta_0 + \beta_1 x_{it1} + \ldots + \beta_k x_{itk} + a_i + u_{it} \quad \text{..... (6)}$$

If we assume that a_i is not correlated with other independent variables for all three years, then we have:

$$Cov(x_{itj}, a_i) = 0 \quad \text{..... (7)}$$

We could then assume that a_i is present in the composite for three years periods, and if we define composite error as:

$v_{it} = a_i + u_{it}$ as the composite error ..... (8)

then;

$$y_{it} = \beta_0 + \beta_1 x_{it1} + \ldots + \beta_k x_{itk} + v_{it} \quad \text{..... (9)}$$

Then due to the fact that a_i is in the composite error, then V_{it} are serially correlated, thus:

$$Corr(v_{it}, v_{is}) = \frac{Var(a_i)}{Var(a_i) + Var(u_{it})} \quad \text{..... (10)}$$

It suffices to note that random effect is a GLS transformation meant to eliminate serial correlation in the errors, therefore the transformed equation becomes: ..... (11)

$$y_{it} - \lambda\bar{y}_i = \beta_0(1-\lambda) + \beta_1(x_{it1} - \lambda\bar{x}_{i1}) + \ldots + \beta_k(x_{itk} - \lambda\bar{x}_{ik}) + (v_{it} - \lambda\bar{v}_i)$$

Where:

$$\lambda = 1 - \sqrt{\frac{Var(u_{it})}{Var(u_{it}) + T \cdot Var(a_i)}} \quad \text{..... (12)}$$

Note: The random effect estimator makes use of the value of λ; thus when:

The value of λ is 0, this implies pooled OLS estimator, and when λ carries the value 1, it implies fixed effect estimator.

3.6.3 Testing for both fixed and random effects: Hausman test

The rationale behind the use of Hausman test is to ascertain which of the two models is more appropriate in explaining the model. The output from Hausman test would provide a comparison between the two models; it makes use of the coefficient of time-varying independent variables. The null hypothesis is that individual effects are random, and that both fixed and random effects estimators should be similar because both are assumed to be consistent. The alternative hypothesis is that these estimators diverge and might not necessarily be consistent.

3.6.4 Model Specifications (Application)

The two models of interest to this study are stated as follows:

$$y_{it} = \delta_1 + \delta_2 d2_t + \delta_3 d3_t + \beta_1 x_{it1} + \beta_2 x_{it2} + \ldots + \beta_k x_{itk} + a_i + u_{it}$$

A. Y_{it} = Loghhincome (dependent variable) i.e. household income: This first model seeks to test the impact of climate shocks on household vulnerability in the study

area. It is expected that if household income is affected due to one form of shocks or the other as a result of extreme climate events, the livelihoods capital of the entire household may be threatened.

a_i = unobserved effects, or fixed effects or unobserved heterogeneity

U_{it} = Time-varying errors or idiosyncratic errors

X_{it1}, x_{it2}….. x_{itk}, represent the independent variables i.e:

Specifying independent variables for the first model:

A_1= age_hhd: Age of the household head

A_2 = educ_status_2: Education status of the household head

A_3= rain_zones: rainfall zones of the study area

A_4= peanut_grown_in_last_year: whether household planted peanut last year

A_5= maize_grown_in_last_year: whether household planted maize the last

A_6 = crop_failure_suffered: whether household suffered crop failure

A_7 = crop_loss_hail: whether household lost crop to hail/storm or heavy rainfall

B. Where Yit = Log Seed (dependent variable) i.e. household expenditure on seed procurement: This second model seeks to test the likely constraints to adaptation in the study area.

Specifying independent variables for the second model:

B_1 = membership_farm_livestock_assoc: whether any household member belongs to farmers association

B_2 = membership_credit_saving_group: whether any household member belongs to credit saving group

B_3 = membership_religious_group: whether any household member belongs to any religious association:

B_4 = Age: this represents the age of the household head

B_5 = housesize: size of the household

B6 = educ_status_2: education status of the household head

B_7 = income_erning_: whether household members engage in income earning activities

B_8 = life_insurance_paid: whether any household member has insurance policy

3.6.5 Definition of the variables used in the model

All the variables examined in this study are presented in Table 3.2. The table contains both the independent variables and the dependent variables for the models tested in this study. This section provides brief explanations of the variables and the rationale for choosing them.

a. ***Age of the household head*:** This variable takes accounts of the age of the household head, age plays a very important role in rural communities, in most cases, critical household and community decisions are expected to be undertaken by older people.

b. **Education status of the household head:** This variable represents the education status of the household head. It is expected that the more educated the household head is, the more informed she/he is likely to be, hence their ability to embrace information that has to do with adaptation with respect to climate variability in their environment.

c. **Rain zones:** This variable represents the three zones in the study area that have different rainfall distribution pattern. Rainfall zones could provide us with information about the location in the study area that is mostly affected by irregular rainfall over the three year period.

d. **Peanuts crops grown in the study area:** Evidence from the socio-economic characteristics of the respondents in the study area reveals that peanut is one of the major crops that support the daily livelihoods of the people in the study area. This variable is included in this model in order to investigate the extent to which growing this crop relative to other crops renders the households vulnerable. It therefore becomes very important to investigate the vulnerability of this important crop to climate variability in the study area; it is expected to serve as a proxy for household shocks relating to food security in the study area.

e. **Maize crops grown in the study area:** Similarly, maize constitutes a major staple food in the study area, any negative extreme climatic event that have direct impact on maize production will adversely affect livelihoods of the people in this study area. Therefore, maize, just like peanut is included in the model to serve as a proxy for household shocks relating to food security.

f. **Crop failure suffered:** This variable is included as a proxy for households' shocks resulting from extreme climatic events e.g. extreme rainfall or extreme temperature that could portend great danger to the livelihood strategies (e.g. crop production) of the people in the study area. Since crop production is generally vulnerable to climate variability, it is expected that any extreme event resulting in flooding or droughts would impact negatively on the livelihoods of the people in this study area where about 98% of the people engage in one form of crop production activity or the other.

g. **Crop loss due to hail or wind/rainfall:** Rootzen and Tajvidi (1997) observed that in modelling windstorms using extreme value statistics; it is predicted that large losses result with low probability, but the size of the loss could have a fairly large level of unpredictability. It is the uncertainly in the extent of damages that could result from windstorms and other climate extremes that has further lent credence to the risk exposure of the most vulnerable people. While it may be argued that wind/hail storm or flooding are natural occurrences, recent study has shown that "the severity of the impacts of climate extremes depends strongly on the level of the exposure and vulnerability to these extremes…" (IPCC, 2012). The livelihoods of the poor is severely threatened in the face of these extremes, this variable therefore stands as a proxy for climate extremes that could exacerbate household shocks in the study area.

h. **Membership of farmers' association:** This variable is fitted into the second model, and it serves as a proxy for determining the strength and significance of social capital in the study area. It is expected that a community with very strong social capital will be able to cope and adapt to stresses and shocks. Since the second model seeks to test likely constraints to adaptation in the study area, this variable will seek to clarify whether membership of social group like the farmers' association could constitute a constraint to adaptation among households in the study area. A social capital perspective to climate variability underscores the influence of social relations in understanding vulnerability and capacity for adaptation and opportunities for mitigation (Pelling, Undated). Access to timely and useful information is one of the hallmarks of a good social network.

i. **Membership of credit saving group**: This variable is also a measure of the strength of social capital. It seeks to test whether household members who are

members of the credit and savings group might be able to have access to credit facilities, and other incentives that could enhance adaptation in order to reduce their households' vulnerability to risks imposed by extreme events.

j. **Membership of religious group:** A strong social network is often built in religious gathering, especially in rural communities. Such gatherings are perceived as places of succour and support for these rural dwellers. It is expected that a religious gathering may provide physical, emotional and sometimes financial support to their members during the times of shock and stress. The absence of this type of gathering or the lack of its full utilisation could constitute a constraint to adaptation in the study area, hence the inclusion of this variable in the model.

k. **Household size**: This variable measures the association between the size of household and their ability to adapt to climate variability, it is expected that the larger the household the more likely will be the adaptive capability, especially among rural household where farming practices represent major livelihoods strategy.

l. **Income earning activities of households:** This variable represents the income earning activities that the respondents engage in. It was included in the model to determine the association between household shocks and their income earning activities; it is reasonable to assume that in the event of extreme shocks to households in crop production, households with other income sources might be able to better adapt than households whose livelihoods entirely depend on crop production. Hence, lack of or little alternative income earning activities could serve as constraints to adaptation in the study area.

m. **Insurance:** This variable represents respondents' use of insurance; the variable was included in the model based on the assumption that respondents with access to insurance facilities would be able to better adapt to vagaries of climate variability, expectedly, lack of insurance facility might constitute a constraint to adaptation, especially in crop production.

n. **Household income:** This is the dependent variable for the first model, it is premised on the assumption that evidence of climate variability in the study area could impact on the income of most households in the study area.

o. **The use of seed varieties:** This variable is a dependent variable for the second model, it is included in the model for the purpose of investigating likely constraints to adaptation, and it represents the purchase of different seed varieties as means of adapting to climate variability. Expectedly, households with little or no money to procure varieties of seeds would find it difficult to adapt to climate variability, i.e. they will be constrained. However, because the variable is specified in the second model as a dependent variable, its full implications and interpretation would depend on the other variables specified as independent variables in the model.

3.6.5.1 Model clarification

It is good to stress that this study made use of proxy variables in the model specifications, this becomes necessary as a result of lack of some sufficient meteorological and climate models data for the study area, as at the time of completing this first phase of this study; and partly because this study aims to provide an economic perspective to the subject matter of risks and vulnerability of rural livelihoods. While trying to justify the use of proxy variables, Sala-i-Martin (1997) has put forward two major methodological innovations.

The first involve the use of a proxies grouping process to determine averaged coefficient estimators for theoretical explanatory variables that have more than one possible measure. The second represents a proposition to use the actual empirical distribution of the available data to situate the inference over the confidence probabilities in selecting each possible measure as proxy for a theoretical variable (Sala-i- Martin; 1997). This study is premised on one or the combination of these assertions.

Bollinger and Miner (2009), while studying the impacts of proxy variables on correctly specified variables, discovered that if all proxy variables are included in the regression analysis there could be the tendencies for reduction in the bias on all other coefficients included for analysis. This explains the reason why more than one crop variables was included in our first model, and why more than one social capital variables was included in the second model.

Basically, the two models will seek to answer two out of the three research questions; the first question posed by this study is to determine the evidence(s) of the likelihood that climate variability is affecting the livelihoods of the respondents in the study area. The second research question is meant to address the mechanisms of adaptation being employed in the

study area; this is corroborated by findings from existing literature on the subject matter. Some of the issues relating to mechanisms of adaptation to climate variability were addressed in the questionnaire, and the responses provided by respondents are reported accordingly in subsequent chapter.

The third research question is meant to identify likely constraints to adaptation in the study area; it is premised on the already identified mechanisms and measures of adaptation. For the purpose of this study, the use of varieties of seeds was chosen as the dependent variable; and the independent variables which seek to reflect the nature of the existing constraints to adaptation in the study area are as follow: membership of farmers' association, Age, household size, education status, use of insurance, etc The dependent variable (use of seeds) is a continuous variable, hence a preliminary multiple regression analysis was carried out to identify significant variables, the estimation of fixed and random effects models were also embarked upon and the results are presented in Chapter 4.

3.6.5.2 Hypothesis testing

The hypotheses are tested based on research questions (I) and (III). The null hypothesis is designated by H_o while the alternative hypothesis is designated by H_a. The null (H_o) hypothesis is the hypothesis this research seeks to disprove, while the alternative hypothesis (H_1) is that which this research seeks to support. Therefore, based on the research question (1):

H_a: Climate variability is affecting the livelihoods of the poor in the study area.
H_o: Climate variability is NOT affecting the livelihoods of the poor in the study area.
Also, based on research question (III):
H_a: There are constraints to adaptation to climate variability in the study area.
H_o: There are NO constraints to adaptation to climate variability in the study area.
Therefore, based on the outcome of the data analysis premised on the model specifications for this research, we could either reject the null hypothesis, or not reject it. The results and interpretation of the hypothesis testing are presented in the Chapter 4.

Furthermore, it is good to mention that certain variables were identified as very relevant to this study based on what available literature and research experiences have to say about the subject matter. Such variables were well considered in advance for the model specifications for this study.

CHAPTER 4

RESULTS AND SUMMARY OF FINDINGS

4.1 Introduction

This chapter focuses on interpreting the model outputs; it provides relevant literature to corroborate the findings. Socio-economic characteristics of the respondents are provided in this chapter in order to give a basis for each of the findings, and to provide detailed but succinct information on the demographic nature of the people and their place. Most of these results are presented in tables showing frequency counts and percentages, literatures are cited where appropriate in order to corroborate some of the findings. Results from OLS, Fixed Effects (FE) Models and Random Effects (RE) models are presented in separate tables to indicate the findings from each of the two models based on the hypotheses for the two research questions. This chapter ends with implications of the results for the hypotheses that were meant to be tested; it offers justification and explanations based on already established empirical evidence as contained in cited literature.

4.2 Socio-Economic and Demographic Profile of Respondents

A socio-economic profile of the Households Heads (Table 4.1) shows that a greater percentage (81.16%) of their ages are concentrated between ages 41 to 80 years which has social and economic implications in the sense that this age groupings are near retirement, and their respective household might become more vulnerable if there are no structures in place to cater to their basic needs.

Furthermore, a significant number (44.64%) of the Heads of household have no formal education, while a very small percentage (3.57%) completed tertiary education.

A larger percentage (55.36%) of the household heads is single/never married, separated, widowed or divorced; this suggests that there is a tendency for them to migrate easily in the event of serious negative shocks. The resident status of the household head also suggests that a fairly large percentage (69.05%) have permanent resident status; it is therefore expected that since they have what it takes to move freely within the republic, migration as a means of adaptation to shocks and stresses is a possibility in the study area. A broader view into the larger spectrum of the entire community revealed that majority of the households

(30.5%) are unemployed. The socio-economic profile also indicates that a larger percentage (67.52%) of the respondents have no access to government grants.

Table 4.1: Showing the Demographic Status of the Household Head (HH).

Age of Household Head (years)	**Percent**
0-10	0.33
21-30	1.78
31-40	11.26
41-50	29.65
51-60	25.86
61-70	16.39
71-80	9.59
81-90	4.35
91-100	0.78
HH Head Education Status	
No formal education	44.64
Grade 1 – Grade 12	51.40
Partial Tertiary	0.38
Completed Tertiary	3.57
Marital Status of HH Head	
Single/never married	7.31
Married (formal)	48.14
Married (informal)	3.60
Widowed	33.07
Divorced	5.96
Separated	1.91
Resident Status of the HH Head	
Recent in-migrant	0.56
Recent out-migrant	0.45
Temporary migrant (others)	0.89
Permanent resident	69.05
Temporary migrant (working/looking for work)	29.05

Source: Author's own calculation from Agincourt-SUSCES panel data 2010-2012.

Expectedly, the average monthly income of these rural households is relatively low, since only very few households have monthly sources of income. The average monthly income shown in Table 4.2 reveals that a very small percentage (9.79%) of households in the study area earn between R4, 000 - R5, 999 pm, while about 26.81% earn below R1, 000 per month. Majority of the households depend on subsistence crop production for their livelihoods survival, hence their vulnerability to the vagaries of extreme climatic events; any extreme event that threatens crop production in this study area, is a threat to the very life of the people. This study is premised on that assumption, as it seeks to investigate the evidence that climate risks exacerbated by extreme events is affecting the livelihoods of the people in the study area, with a view to identifying the adaptive strategies being employed by these rural households.

Table 4.2: Showing Average Monthly Income of Households.

Average Monthly Income	**Percent**
<R1,000 pm	26.81
R1,000-R1,999 pm	23.83
R2,000-R3,999 pm	28.09
R4,000 - R5,999 pm	9.79
R6,000 + pm	11.49
Total	**100.00**

Source: Author's own calculation from Agincourt-SUSCES panel data 2010-2012.

This study observes that there are cases of crop losses due to flood as a result of unusual heavy rainfall; a fairly large percentage (36.83%) of the households have suffered crop failure due to rainfall and other extreme natural occurrences, out of which 51.21% alluded to the fact the crop failure resulted into financial hardship for their households Table 4.3 profiles more on household shocks and stresses.

The livelihoods strategies of respondents reveal farming activities as dominating the livelihoods activities in the study area. Crop production and livestock farming are the major occupations of most households. Table 4.4 reveals that 84.31% of the households have experienced financial failure due to illness and injury. This is understandable when one

considers the fact that 98.10% of households engage in crop production and a very large proportion (99.11%) of the households feed on maize; the use of household labour is therefore very common in subsistent agriculture, and any prolonged illness or injury could have direct impact on the livelihoods of the entire household.

Table 4.3: Showing Households Shocks and Stresses

Household Shocks and Stresses	Percent
Suffered Crop failure	36.83
Crop loss due to rainfall	79.32
Crop loss due to pest	27.94
Livestock loss suffered	8.94
Job loss suffered	8.82
Fire destruction suffered	2.79
Crop loss caused financial hardship	51.21
Death of HH member caused financial hardship	68.18
Illness and injury caused financial hardship	84.31
Livestock loss caused financial hardship	23.75

Source: Author's own calculation from Agincourt-SUSCES panel data 2010-2012

An overview of the assets and physical capital of the households reveals that most of the households have access to information channels, for instance, a larger percentage (98.89%) of these poor rural households have cell phones, 86.51% have functioning Television sets, while only 46.7% have access to information from Radio. Access to information is crucial in designing a sustainable adaptation programme for these rural people. Data on the rainfall distribution of the study area over the last three years reveals that there is a significant variation in rainfall pattern within the three locations present in the study area (Figure 4.1). The mid zones recorded the highest rainfall over the last three years, and the East zone received the least amount of rainfall. While this rainfall information might not be sufficient in providing us with the reasons for variation across the zones, it does suggest that different locations in the study area are subjected to different environmental demands and pressure.

Table 4.4: Showing Household Livelihoods Outcomes and Activities.

Household Livelihoods Outcomes and Activities	Percent
Household eating maize	99.11
Households eating dairy products	43.86
Households having Income earning activities	47.65
Young HH members involving in crop farming	58.45
Young HH members involving in livestock farming	52.15
Households engaging in crop production	98.10
Households raising Cattles	12.50
Household raising Chicken	57.61
Illness and injury caused financial hardship	84.31
Livestock loss caused financial hardship	23.75

Source: Author's own calculation from Agincourt-SUSCES panel data 2010-2012

4.3 Evidence of Risks Associated with Extreme Climate Events

This first model was set up in order to investigate the evidence of climate variability in the study area. We use household income as a measure of a household's livelihood strategy and also vulnerability. Age and Education Status of the household heads show significance at 5% and 1% respectively, the overall result of the first model is presented in Table 4.6.

Age and Education status of the household heads are very important in determining households' awareness of climate variability; it expected that a household whose head is well educated might also have awareness of the impact and implications of climate risks. Age on the other hand speaks to experience in terms of being able to reconcile past events with recent ones, it is also important in household decision making. There are three zones in the study area; East Mid and the West, each of these zones are likely to be subjected to different environmental changes and challenges, hence the significance of the variable representing the rainfall zones. This is included in the model as a dummy variable; where one of the zones serves as the base year and the other two are included as dummy variables.

Table 4.5: Showing Households Adaptive Measures to Shocks and Stresses.

Household Adaptive measures	**Percent**
Purchased fertilizer	2.81
Purchased pesticides	4.12
Use local and improved seeds	98.10
Access to loan facilities	3.91
Use of Cooperative (Stokvel)	39.68
Household Social capital and networks	
Membership farmers' association	6.13
Membership grocery stokvel	43.81
Membership of religious group	83.17
Membership of funeral society	41.36
Membership credit and savings group	33.56
Membership of Education group	5.02
Have friends in the village	45.70
Households Assets and Physical Capital	
Stove	82.61
Fridge	89.86
Television	86.51
Satellite dish	11.59
Radio	46.71
Cell phone	98.89
Plough	6.80
Car	23.41
Tractor	1.11
Bicycle	12.93

Source: Author's own calculation from Agincourt-SUSCES panel data 2010-2012.

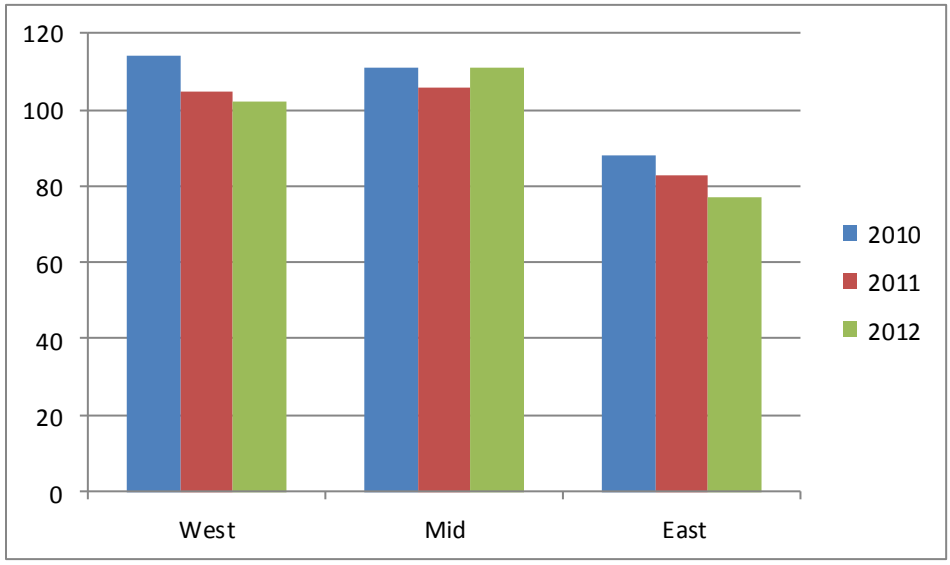

Figure 4.1: Annual rainfall distribution patterns per zones in the study area.

The socio-economic profile has shown that Maize constitutes a staple food in the study area, it was included in the model to control for the effect it will have on the household income (the dependent variable). It was significant at 1%, indicating its relevance to this study.

Table 4.6: Testing for Multicollinearity of Independent Variables in the First Model.

Variables	**VIF**	**1/VIF**
Age of the household head	1.24	0.802256
Education status of households head	1.18	0.847625
Rainfall zones dummy (second year)	1.37	0.731661
Rainfall zones dummy(third year)	1.40	0.712576
Households growing peanuts	1.03	0.975150
Households growing maize	1.03	0.968039
Households suffered crop failure	1.07	0.933671
Crop loss due to hail/windstorms	1.04	0.962190
Mean VIF	**1.09**	

Source: Author's own calculation from Agincourt-SUSCES panel data 2010-2012.

It has been stated that this study makes use of certain proxy variables, variable indicating whether households suffer crop loss, is significant at 5%, this variable is a proxy for extreme climate events that could constitute major stress and shocks to households in the study area. Another variable used as a proxy for extreme climate event is crop losses due to hail or windstorm as a result of heavy rainfall; it is also significant at 5%. It makes good sense of judgement to suspect the tendency for multicollinearity with the usage of these closely related proxy variables, hence the need for a test to clarify the absence of multicollinearity.