

# **Determinants of Adaptation and Insurance Uptake among Small-Scale Farmers in Kenya**

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# Declaration

I, Tshepiso Segone, declare that this report is my own, unaided work. It is being submitted for the degree of Master of Arts in the field of e-Science at the University of the Witwatersrand, Johannesburg. It has not been submitted for any degree or examination at any other university.

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30 March 2024

# *Abstract*

Despite the costs associated with climate-related damage and loss, WII uptake remains low among small-scale, Kenyan farmers. Many of these farmers continue to opt for traditional adaptive and mitigative strategies in the wake of climate-related challenges, despite the many known benefits insurance has for climate resilience. Thus, the study seeks to understand the determinants of insurance uptake, and to measure the relationship between these determinants and agricultural output, using a binary regression model. Overall, the study underscores the complex interplay of socio-economic, cultural, and environmental factors shaping farmers' adaptation decisions in Kenya and highlights the need for targeted interventions to enhance insurance uptake and promote effective climate strategies.

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# Abbreviations

GDP - Gross Domestic Product

ADSE - Anglican Development Services Eastern

CCA - Climate Change Adaptation

DRM - Disaster Risk Management

KTDA - Kenya Meat Commission and the smallholder Kenya Tea Development Authority

KCC - Kenya Cooperative Creameries

WII - WII

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# Chapter 1

## Introduction

Kenya has inherited many of the tradeoffs associated with its colonial past (1902 - 1960), which largely influenced the establishment of effective systems for water development, land consolidation and agricultural research (Cone and Lipscomb, 1972). In fact, for decades, Kenya's developmental plans have depended largely on the ability of the rural farmer to adapt to changing *economic, socio-political* and *climatic* patterns.

Moreover, because the agricultural sector continues to make up approximately a third of the country's gross domestic product (GDP) (FAO, 2024), the development of a Kenyan national economy largely depends on the level at which the Kenyan farmer maintains previous levels of productivity and standards across various crop production (Cone and Lipscomb, 1972).

### a. *Climatic Patterns*

In recent times, the productivity and standards across various crop production have been hard to match, given Sub-Saharan African countries increased vulnerability to climate variations (Mastrorillo 2018; Aparna et al. 2019). Because agriculture is still predominantly rain-fed, varying precipitation rates may be unfavourable to agricultural productivity due to the timing and spacing of precipitation (Lobell and Field 2018; Gornall et al. 2018; Wheeler and von Braun 2018). However, according to Sultan and Gaetani (2019), median temperature increases are plausible by the end of the 21st century, and increases in rainfall are likely in East Africa. In fact, the average temperatures in Kenya has risen by about 1.0 to 1.5°C since the colonial era, making this a 6.8% increase over the period (Government of Kenya 2013; World Bank 2021). This is likely to lessen the yield of staple crops such as cassava, groundnut, sorghum, millet, and maize in the region (Thornton and Jones 2018; Zhao and Thomas 2018).

### b. *Socio-political Constraints*

Due to this dependence on agriculture and their low rate of adaptability (Nyoro 2019), the Makueni Country government passed regulations on climate change (Makueni Government 2018).

Makueni County in Kenya has been selected for this study due to its high vulnerability to climate shocks and its proactive approach to climate change adaptation. The County has implemented several initiatives, including the allocation of 1% of its total development budget to climate change adaptation and disaster risk management (Makueni Government 2018). The region's diverse climatic conditions and ongoing adaptation projects provide a unique context for studying the determinants of farmers' adaptation strategies.

The County is made up of various sub-counties; however, for the purposes of this study, the analysis will focus on the Kathonzweni, Mavindini, and Wote region(s).

In January 2015, the County partnered with Christian Aid and Anglican Development Services Eastern (ADSE), Ada Consortium and UKAID. The document was passed in September of 2015 and has since accessed 50 million seed money for climate change adaptation (CCA) and disaster risk management (DRM) initiatives (Christian Aid 2015; Anglican Development Services Eastern 2015).

### *c. Economic Constraints*

Despite what is said to be relatively well established sector, accounting for approximately 33% of Kenya's GDP, 7.8 million people in the country are still living on less than 1.90 U.S. dollars a day (UNDP 2020; World Bank 2022). Losses and damages caused by adverse weather events, like heavy rainfall, directly impact output and profits in the sector. Therefore, the costs, timing and benefits of adaptation and mitigation are increasingly relevant for small-scale farmers because weather variations will only continue to occur, inevitably increasing chances of crop failure, food insecurity, and losses to farm profits that tend to both domestic and market related needs (Schröter, Polsky, and Patt 2019; Sivakumar and Simelton 2019).

## **1.1 Background**

By way of introduction, this section will provide a literature review that expands on the determinants of uptake; followed by the research question, aims, objectives, limitations and the assumptions and definitions of the research.

### **1.1.1. Traditional Methods**

In Kenya, traditional agricultural adaptation methods have played a crucial role in maintaining agricultural productivity amidst climate variability. These methods, deeply embedded in local cultural practices, include techniques such as intercropping and rainwater harvesting. Intercropping, where different crops are planted together, has been shown to enhance resilience against pests and climate variability, with studies indicating yield increases of 20-30% compared to monoculture systems (Kinyanjui, 2021). Rainwater harvesting, another traditional practice, improves water availability during dry spells, resulting in a 10-20% increase in crop yields during drought conditions (Munyua et al., 2021). Despite their effectiveness, traditional methods face limitations in addressing extreme weather events and achieving high productivity levels, particularly under severe climate stress (Morton 2007; Lobell and Field 2018; Badu-Apraku and Osei 2019).

### **1.1.2. Modern Methods**

In contrast, modern adaptation methods in Kenya are characterized by technological advancements and greater resource input (Kisaka and Thornton 2019; Hassan and Wambua 2019; Githiri and Rukundo 2020). Improved seed varieties, such as drought-resistant crops, have significantly boosted productivity, with yields increasing by up to 50% compared to traditional varieties (Food and Agriculture Organization, 2020). Modern irrigation systems also offer substantial benefits, with studies showing yield increases of 30-40% for irrigated crops compared to those relying solely on rainfall (Mastrorillo et al., 2018). These methods generally require higher financial investment and technical knowledge, which can be barriers for small-scale farmers. Nonetheless, they provide more immediate and measurable improvements in productivity and resilience against climate change (Saka and Houghton 2019; Kipkorir and Kariuki 2020; Ayanlade and Alabi 2021).

### **1.1.3. Insurance as an Adaptation Strategy**

Weather-index insurance (WII) has emerged as a modern adaptation strategy, providing a financial safety net for farmers against climate-induced losses (Wheaton and Guiteras 2019; Skees and Hazell 2018; Tschakert and Schaeffer 2018). Historically, the uptake of WII in Kenya has been limited due to high premiums and low awareness (Morris and Lutz 2018; Wambua and Kirui 2018; Kibui and

Njeru 2021). However, recent efforts by government and NGOs have sought to increase insurance accessibility. For example, subsidized insurance schemes and partnerships with international organizations have aimed to make insurance more affordable and attractive (Miller and Smith 2019; Baird and Kufuor 2019; Doss and Gilligan 2020). Despite these efforts, uptake remains relatively low, with estimates suggesting that only about 5-10% of Kenyan farmers have insurance coverage (Bryan et al., 2013). This limited adoption reflects ongoing challenges related to cost, accessibility, and understanding of insurance products among farmers.

#### **1.1.4. Comparison and Trends among Farming Methods**

Traditional and modern farming methods of adaptation each offer distinct advantages and face unique challenges. Traditional methods are often more accessible and culturally integrated, providing low-cost solutions that are particularly relevant for resource-constrained farmers (Sinha and Kato 2018; Brouwer and Meijer 2018; Ndubisi and Ojo 2019). However, they may fall short in addressing severe climatic events and achieving significant productivity gains. On the other hand, modern methods generally provide higher productivity and better management of climate risks but require substantial investment and infrastructure (Bryan et al., 2013; Rosegrant and Cai 2018; Smith and Martin 2018; Hussain and Alam 2019). The integration of modern techniques with traditional practices has been observed as a promising approach to enhance overall resilience.

Insurance, as a newer adaptation strategy, represents a potential avenue for mitigating financial risks but has yet to achieve widespread adoption. The ongoing efforts to improve insurance uptake reflect an acknowledgment of its importance in managing climate-related risks, though significant barriers remain (Bryan and Koffi 2019; Gao and Smith 2019; Skees and Baird 2019).

#### **1.1.5. Limitations**

While existing studies have explored the impact of climate change on agricultural productivity in Kenya, there is a notable gap in understanding the social and behavioral factors influencing farmers' adaptation strategies. Most research has focused on institutional constraints without fully considering

the role of local knowledge and the socio-economic barriers in decision making processes (Oliver et al., 2012; Raymond et al., 2010b; CCAFS, 2016; FAO, 2016b; Lemmen et al., 2008; Nelson et al., 2007; Berkes, 2009).

These studies often associate farmer's decision-making to the discretion of institutional constraints. This study aims to bridge this gap by examining rather the determinants of farmers' adaptation decisions and the uptake of WII, an area under-explored in current literature. The study will highlight rationalities that are often deprioritised by literature and policymakers, and the extent to which this impacts sustainable development for certain groups.

Although the study is delimited to the Kathonzwani, Mavindini, and Wote regions of Makueni County, focusing on small-scale farmers engaged in staple crop production, multiple data sources will be triangulated to enhance the reliability and validity of the findings.

Thus, this study contributes to the broader discourse on sustainable agricultural development by highlighting the often-overlooked role of local knowledge and socio-economic factors in climate change adaptation. The findings will inform policy recommendations aimed at enhancing the resilience of small-scale farmers to climate variability.

#### **1.1.4. Theoretical Framework: Agriculture and Intersectionality**

Historically, the uptake of WII in Kenya has been limited due to high premiums, and low-awareness. This issue is exacerbated by the multidimensional nature of poverty, which involves a complex interplay of individual, market, and structural factors.

Studies in contract theory and economics highlight how inadequate knowledge and information asymmetry between borrowers and lenders can lead to inefficient transactions and market failures tends to effect transactions (Marwala and Hurwitz 2015; Tfaily 2017; Addae-Korankye 2019; Mhlanga 2020). When a borrower is unable to convey their qualifications to a lender, or there is a lack of precise information on a financing project, financial institutions will not have sufficient information to assess the risk, reinforcing existing barriers to accessing financial resources. Often, when one agent holds a higher level of knowledge than the other regarding a transaction, it is likely that the transaction will be inefficient and cause market failure (Mhlanga 2020; Marwala and Hurwitz 2015; Tfaily 2017).

Moreover, in financial institutions, minimising risk is highly dependent on the institution's ability to adequately and accurately process information when applications are accepted (Tfaily 2017). Borrowers from lower-income groups, who often have lower levels of education, face compounded challenges in accessing financial services (Turčinkova et al. 2012; Paraschiv 2017; Karnit Flug et al. 2003; Mulford et al. 2008). This dynamic perpetuates market inefficiencies and discrimination, which are crucial aspects of the multidimensional theories of poverty.

For instance, dual labor market theorists argue that discrimination against minority groups hampers the effectiveness of the free market and that education and training programs alone are often insufficient to reduce poverty and inequality (Addae-Korankye 2019). This perspective highlights how structural discrimination affects employment opportunities and earnings.

Conversely, neoclassical theorists emphasize that success in a free market is determined by individual skills, intelligence, and education, assuming a level playing field where rewards are based on personal contributions (Becker 2018; Klasen and Lamanna 2019; Gurmu and Lutz 2018). This view tends to overlook structural barriers that impede equal access to opportunities.

Structural theorists assert that capitalism inherently creates limited resources and opportunities, perpetuating poverty through systemic inequalities (Bradshaw 2006; Samati et al. 2012; Shirmshiry 2014; Davis and Sanchez-Martinez 2014; Korankye 2019). This perspective underscores how the economic, political, and social structures within capitalism contribute to the persistence of poverty.

The interplay between agricultural productivity, climate change, and income is significant in developing countries, particularly for small-scale farmers. However, this nexus is complicated by the intersectionality of factors such as race, gender, and socio-economic status. By integrating these theories, it becomes clear that poverty is not merely a result of individual shortcomings but also a consequence of broader systemic issues, including market failures, institutional inefficiencies, and structural inequalities. Understanding poverty through this multidimensional lens allows for a more comprehensive approach to addressing its root causes and developing effective solutions.

## 1.2 Problem Statement

Agricultural development is essential for the economic growth, food security, and poverty reduction of much of Kenya's population. It's production of dairy, coffee, meat and horticultural products, and tea in the global market, as well as staple foods like sugar and crop maize for the domestic market has made the country distinguishable in the agricultural space.

By 2010, the agricultural sector was accountable for providing livelihood to about 80% of the population, 70% of informal employment, and 65% of national exports (FAO, 2024). Thus, in agro-ecological terms, Kenya was highly diverse. Over the last few decades since independence, however, agricultural performance has declined and output is oftentimes insufficient to reduce poverty.

Maintaining the sector depends on supply and demand factors, thus climate-related threats to production can disturb economic processes. The rate at which the sector is adapting to varying weather conditions is drastically delayed. For example, although the sector depends on rainfall, heavy rainfall increases the likelihood and severity of floods. Floods can effect soil profile because the influx of rainfall causes the soil to exceed its capacity to filter water and minimise surface runoff (Alkaisi and Helmers, 2008). Under significant rains potassium, sulphur, and nitrogen are vulnerable to leaching, especially in soil with low organic matter content (Nichols, 2017).

In times when farmers sow or transplant seeds into their fields, this can cause major delays because, at length, flooding increases water runoff and, consequently, soil erosion. In efforts to replenish the damage, the use of harmful herbicides, pesticides and synthetic fertilisers, only worsens the contamination of the soil profile.

Heavy rains are thus calamitous to communities without buffers. Although WII is available, uptake is low in the region. One of the biggest issue with WII uptake, despite its benefits, is that translating sustainability from a concept to a pragmatic solution requires appropriate means of measuring and explaining it. This is a difficult task because it would have to translate to different levels of knowledge, both formal and informal. Variables, such as soil moisture and soil pH, cannot be adequately gauged at the farm level because many developing countries are under-resourced and economically unprepared to address these implications.

Moreover, there is not nearly enough funding to execute complex strategies for every farmer in need of them. In the same light small-scale farmers are usually financially excluded from formal financial

institutions because they oftentimes lack access to traditional forms of identification and/or collateral needed by financial institutions (Mohan 2006; Mhlanga 2020).

Without sustainable and effective adaptive strategies, agricultural output cannot materialise. If not attended, this will exacerbate poverty and food insecurity in the Kenyan community (O'Brien et al., 2008; The Paris Agreement, 2015).

Achieving national climate and disaster resilience goals necessitates not only key investments in human and institutional adaptive capacity, but also the alignment of these investments with robust, reliable, and program policy reforms to lessen the vulnerability of the sectors involved. The CCA and DRM institutions are, however, heavily disregarded in most developing countries. DRM remedies the already apparent threats, loss and harm caused by climate change; while CCA offers strategies on how to adjust to the existing effects. Despite the overlapping empirical proficiency, the frameworks associated with DRM do not completely embody various elements of CCA frameworks and vice versa (Wisner et al., 2012; Dong et al., 2015).

Institutional constraints often raise important questions about the unresolved issues regarding farm-level climate change adaptation. Farmers have thus turned to alternative means of adaptation which are cheaper and offer ease of use to adapt to the risks that arise from the uncertainty of climate change and volatile markets.

Historically, farmers have experienced climate variations which have influenced the development of various strategies that have allowed for the continuation of farming (Crane et al. 2011; Brockhaus et al. 2013). These strategies were oftentimes supported by existing forms of generational knowledge which has developed in response to the necessity of economic stability facing environmental, social, political and economic challenges of which climate change is a part of (Mercer, 2010; Khan and Roberts, 2013).

How individuals understand climate change has significant implications on how farmer's choose to respond and the kinds of responses carried out by these farmers (Raymond and Spoehr, 2013). However, the strategies farmer's usually adopt are risk mitigation strategies rather than adaptation to weather variations. These are issues that persist in developing countries and play a hand in the delay of sustainable development of the agricultural sector in developing countries, and if not attended to,

will exacerbate poverty and food insecurity in countries like Kenya (O'Brien et al., 2008, The Paris Agreement, 2015;).

Moreover, once the Paris Agreement's global stocktake (Article 14) assesses parties progress every five years, the measure of progress compartmentalises countries on incomparable scales. When developing countries are assessed on the same scale as developed countries, this not only presents distinguishable gaps, but overlooks the subjective indicators that may have contributed to the level of vulnerability that these countries experience.

## **1.3. Research Question**

What the study seeks to establish relating to this issue is the following:

1. What are the primary determinants of WII take-up among small-scale farmers in Makueni, Kenya?
2. What is the relationship between the primary determinants of WII take-up, and agricultural output in Makueni, Kenya?

## **1.4. Research Aims and Objectives**

This section will provide the aims and objectives of the research.

### **1.4.1. Research Aims**

The study aims investigate the relationship between insurance uptake and agricultural output using a correlational analysis. Specifically, the research seeks to explore how the demand for insurance and the likelihood of its uptake among small-scale farmers in Makueni County are influenced by the use of traditional resilience strategies.

### **1.4.2. Objectives**

To achieve a nuanced understanding of the factors influencing WII uptake and adaptation strategies among small-scale farmers in Makueni County, this study is designed to systematically analyze a range of socio-economic and ecological variables. Thus, the objectives of this study are as follows:

- Develop a comprehensive dataset that includes socio-economic and ecological indicators relevant to small-scale farmers in Makueni County, focusing on traditional resilience strategies, WII, and the determinants of insurance uptake.
- Assess the impact of socio-economic and ecological determinants on two key predictors: willingness to pay for insurance and the adoption of alternative adaptation strategies.
- Construct and analyze two binary regression models to evaluate how geographical location and household headship influence the decision to use WII.
- Adapt the methodological framework and variable selection from Ngongo et al. (2022) to explore how hypothesized variables affect farmers' willingness to invest in adaptation strategies, including WII and other methods.
- Clarify the use of the logit model in the theoretical framework, including the measurement of variables and justifications based on theoretical and empirical literature, to ensure methodological rigor and robustness.
- Conduct relevant diagnostic checks, hypotheses testing, and decision rule development to validate the reliability and accuracy of the regression models.

## **1.5. Limitations**

Quantitative studies often face limitations that affect the clarity and applicability of their findings. For instance, while a correlational approach can highlight trends and relationships among variables, it does not establish causation, which limits the ability to draw definitive cause-and-effect conclusions. To address this, the study will employ a robust methodological framework that includes

a clear definition of variables and integrates both objective measures and relevant subjective factors to provide a more comprehensive understanding of the observed effects.

Additionally, developing countries frequently grapple with resource constraints and limited access to critical climate knowledge, leading to potential gaps in data and restricted generalizability of research results. To mitigate these challenges, this study will utilize a targeted data collection strategy, emphasizing the acquisition of high-quality, context-specific data. By leveraging local expertise and integrating multiple data sources, the research aims to enhance the reliability of the findings and provide insights that are more reflective of the actual conditions faced by small-scale farmers.

## **1.6. Assumptions and Definitions**

Kenya's developmental plans aim to transform the country into a "globally competitive and prosperous nation with a high-quality life" by 2030 (State Department for Economic Planning, n.d.). Central to this vision is the goal of elevating Kenya to a middle-income status through advancements in social, political, and economic spheres. Within this framework, macro-economic stability and land reform are fundamental to fostering agricultural growth. Macro-economic stability involves economic conditions such as inflation, interest rates, and infrastructure development that directly influence market trends and farming operations. Effective management of these elements is assumed to enhance farming conditions and resources (State Department for Economic Planning, n.d.). Land reform, on the other hand, involves transforming land ownership and management practices to boost economic profitability and adaptive capacity of land, thereby encouraging investment in adaptive strategies. Adaptive capacity in agriculture refers to the ability of farming practices to adjust to climate variability, including extreme weather and soil degradation. Small-scale farmers in Kenya, who typically manage less than 2 hectares of land, are particularly vulnerable to climate change due to limited resources and adaptive capacity (Knight, 2022). This vulnerability affects their livelihoods, making them more susceptible to crop diseases, resource degradation, and increased crop failures. The nexus between agricultural productivity, climate change, and income is crucial, yet it is complicated by intersectionality—the overlapping social identities and systemic inequalities such as

race, gender, and socio-economic status that exacerbate these challenges. Small-scale farmers in Kenya often work under constrained conditions with minimal access to markets, financial services, and technology. While often classified as low-economy individuals, this classification does not universally apply. The focus on low-economy subsets within the intersectionality framework highlights how broader systemic inequalities contribute to social exclusion and impact agricultural output and income. Food security—defined as the consistent access to sufficient, safe, and nutritious food—can be compromised by these intersecting factors (State Department for Economic Planning, n.d.). WII emerges as a modern adaptation strategy to protect against financial losses from adverse conditions, yet its uptake remains limited. Understanding these multi-dimensional challenges is essential for developing targeted interventions that enhance adaptive capacity and address systemic barriers affecting agricultural productivity and food security.

## **1.7 Overview**

What will follow is the research methodology section which offers the research design, methods, data, methods and analysis of the research.

# Chapter 2

## Research Methodology

### 2.1. Research design

This is quantitative study, using a positivist approach to focus on quantifiable data and the objective of the analysis. This approach assumed that knowledge is derived from observable and measurable variables. Additionally, the study uses a deductive strategy to answer the research question using empirical data.

Thus, the study utilizes a cross-sectional design to capture a snapshot of the relationships between farmers' characteristics and their decisions regarding WII. A correlational analysis is employed as the statistical technique to explore these relationships and identify significant associations between variables.

The data collection phase involves drawing from a secondary dataset obtained from the CCAFS Gender Household Survey (CGIAR Research Program on Climate Change, Agriculture and Food Security, 2013). This dataset provides information on agricultural practices and production, with a focus on vulnerabilities and differences between genders in response to climate change. Content analysis will be applied to identify key insights, themes, and patterns from the survey data.

In the analysis phase, the study conducts a two-stage statistical analysis. The first stage explores the relationship between hypothesized variables and farmers' willingness to pay for index-based WII. The second stage examines the relationship between these variables and farmers' adaptation behaviors. The study employs binary logic models to handle variables of different types, including categorical variables, and assesses the probability of specific events occurring (represented by 1) or not occurring (represented by 0).

Limitations of the study include potential response bias and challenges in establishing causality. The correlational approach provides valuable insights into trends and relationships but does not establish cause-and-effect relationships due to the lack of temporal sequencing. The study will define

components clearly to quantitatively assess effects through objective measures but may omit subjective factors that contribute to the observed effects. The research design addresses these limitations by emphasizing robust variable definitions and comprehensive analysis techniques.

## **2.2. Data**

The dataset used in this analysis was obtained from the Climate Change, Agriculture and Food Security (CCAFS) Gender Household Survey conducted in Kenya, Bangladesh, Uganda, and Senegal (CGIAR Research Program on Climate Change, Agriculture and Food Security, 2013). For the purposes of this study, Kenya is the focus of the research. The purpose of the survey is to collect gender-disaggregated data from rural households on risk perceptions, agricultural activities, weather information, decision making and values. The survey was conducted in 2013 and the information collected is inclusive of plot-level data on climate perception, sources of information, inputs and decisions around adaptations.

The survey builds on the data and samples (household data) collected in a previous survey round — the Impact Lite Survey (2012). The survey comprises of 8360 participants from three Districts of Makueni and Wote, in the Western region of Kenya.

The selection of variables in this study is influenced by Ngango et al. (2022) who is guided by previous literature that speaks to agricultural finance in the context of the Rwandan agricultural sector (Abugri et al., 2017; Adzawla et al., 2019; Abbas et al., 2015; Afroz et al., 2017; Arshad et al., 2016; Addey et al., 2021; Budhathokia et al., 2019; Fonta et al., 2018; Ntukamazina et al., 2017; Okoffo et al., 2016; Sibiko et al., 2018). The research draws inspiration from Ngango's et al. (2022) work on farmer's willingness to pay for WII in Eastern Rwanda. Their study provides insights on farmers' decisions to take on insurance as well as the premium they are willing to pay. This research report seeks to build on these findings and examine a similar subject matter with a differing dataset and research focus.

While Ngango et al. (2022) conducts face-to-face interviews with the heads of the households, this research utilises the above-mentioned dataset from the CCAFS Gender Household Survey (2013). This dataset shares several demographic variables with the dates used by Ngango et al. (2022), however, it lacks certain variables included in their dataset, which limits this study's ability to directly replicate the study by Ngango et al. (2022).

Additionally, the study focuses on a different aspect of farmer's behaviour, outside of the premium amount that corresponds with farmer's willingness to pay for insurance. Specifically, the study examines whether farmers choose to adapt based on their willingness to pay for insurance. Measuring adaptation in this way represents an angle that extends beyond the scope of previous research.

Enhancing the analysis involves including additional demographic variables that Ngango et al. (2022) did not incorporate in their dataset. The additional variables provide a comprehensive understanding of the factors influencing farmers' adaptation decisions in relation to willingness to pay. By leveraging a different dataset, and incorporating additional variables, this research aims to contribute new insights on agricultural insurance and decision making. Table 1 gives an overview of the variables used in the analysis (see Appendix B).

Pre-processing the data involved several steps to ensure its quality and consistent before further analysis. Initially, the data consisted of multiple datasets, each containing different variables. The datasets were loaded and tidied to ensure compatibility across all variables.

There is existence of missing values (NA's) in some variables, which can introduce bias and affect the accuracy of the analysis. To address this, the missing values were removed through deletion or imputation. Imputation was performed specifically for the variable indicating household position ('hh\_position') which specifies whether the participant is the head of the household or not; and to the variable which indicates whether farmers took insurance or not. This was necessary because the head of the household represents the primary income earner and holds significant decision-making authority within the family unit. In African, agricultural community, however, gender is not the

overarching determinant of authority in households as some households are female headed (Tibesigwa et al., 2015).

Imputation was performed on the insurance variable because of errors that appeared in the model when the data was computed otherwise (i.e. without NA values) — NA values were thus removed through imputation and not deletion.

Removing NA values reduced the selection and dimensionality of the data and may affect the performance of predictive models, however, this process is necessary to ensure a certain degree of quality and reliability of the data for subsequent analysis and modelling.

Following the tidying process, the individual datasets were merged into a single data frame named 'khenya\_df'. The merging process was facilitated by ensuring that all datasets shared a common identifier ('hhid') and consistent formatting. The datasets that had 352 entries were placed into a single data frame after the deletion of duplicates and missing values.

However, it is noteworthy that not all datasets were merged uniformly into 'khenya\_df'. Three datasets required to be merged individually into the main data frame due to having differing observation lengths after tidying: the data frames holding district, credit and adaptation data.

## 2.3. Methods

Both willingness to pay for insurance and adaptation are binary variables. (1 for willingness to pay, 0 for not willing, and 1 for adapted, 0 for not adapted). The study wants to understand the factors that influence a farmer's decision to insure their crops; similarly, we want to understand what influences them to use other forms of adaptation instead.

In both cases, what is being determined is how different characteristic of farmers (i.e. education, income, etc) affect the likelihood of them getting WII or choosing to adapt at all to climate change. How much each characteristic matters will be determined ( $\beta$  and  $\gamma$ ) as the study uses the statistical software (R) to estimate these parameters in the model. Once determined, a positive coefficient will

indicate an increase in the probability of the event, while a negative coefficient will indicate a decrease.

The analysis uses R software and leverages several packages in order to pre-process the dataset, build predictive models and visualise the results. The packages employed in the analysis include jsonlite, tidyr, nnet, stringr, coefplot, ggplot2, sf, sp, caret, dplyr, rlang, readxl, readr, rnatuarearth, ROSE, MASS, summary tools, jsonlite, psych and haven. The packages offered a comprehensive toolkit that allowed the study to manipulate, visualise, statistically model and perform spatial analysis on the data within the R framework.

Using the nnet package, the study created two binary logistic regression models as part of our modelling strategy to estimate the probability of a binary outcome variable. The estimated logit models are used to predict the probability of WII and adaptation for individual farmers based on their characteristics and perceptions. The study uses the glm() function to fit the binomial logistic regression models into the dataset khenya\_df, considering various predictor variables while predicting the likelihood of individuals having protected themselves in the first model, and the likelihood of them being willing to pay for insurance in the second.

To check the valid of the binary models, several diagnostic tests were performed:

Each model was tested and assessed for the overall fit of each to the data using the goodness-of-fit statistics to understand how well they explain the observed data. A sensitivity analysis was conducted to test the robustness of the results to ensure they meet scenarios or assumptions. To assess model performance, the data was divided into training and test sets, making sure the models were evaluated on separate sets of data that were not utilised for training.

Thereafter a residual analysis was performed to examine the patterns of residuals, which assessed model assumptions and identifies potential outliers or influential observations.

In order to make sure that the models were not biased in favour of the majority class, the class imbalance was corrected in the dataset by using methods like oversampling and undersampling.

In this analysis, variable selection was essential in identifying important predictors to incorporate into the models. We used methods like recursive variable elimination and variable importance ranking to find the most relevant variables for predicting the outcome variable using the `varImp()` function. This process helped improve model performance and interpretability by focusing on the most relevant predictors.

Subsequently, the analysis generated predictions from each model and transformed the predicted probabilities into binary predictions, facilitating the creation of a confusion matrix to evaluate the model's performance in classifying individuals into the categories adapted or not adapted, and willing to insure or not.

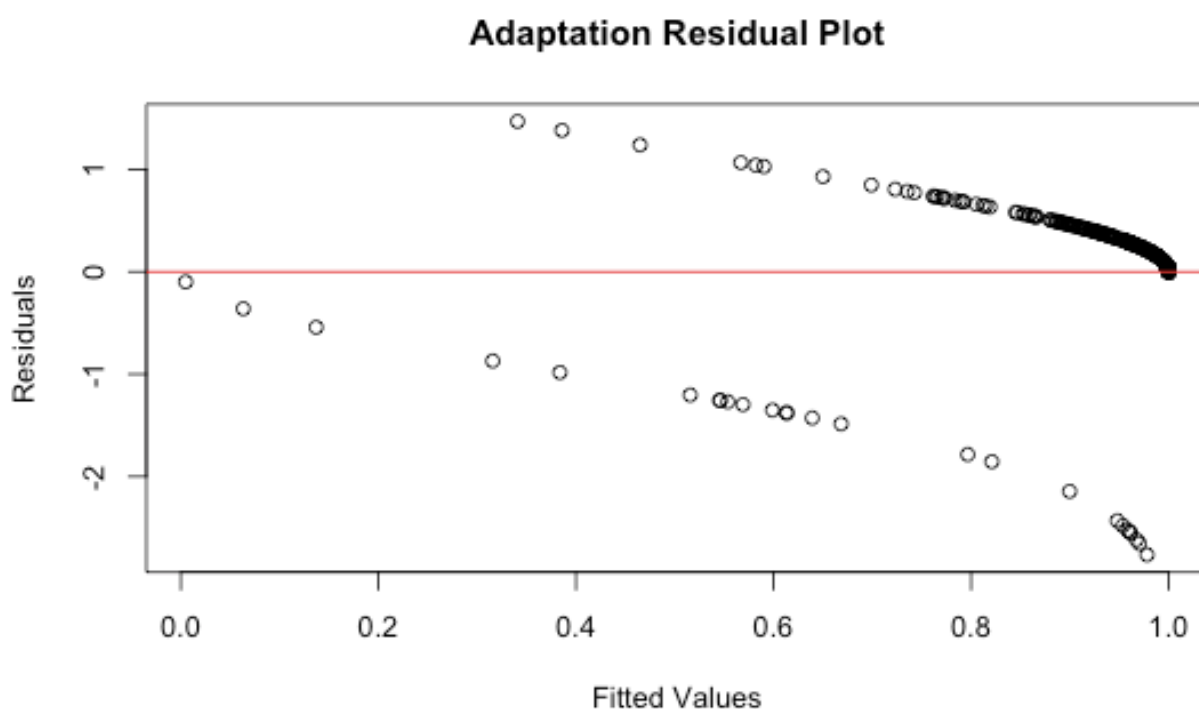
Finally, using the `sf` and `sp` packages to visualize the spatial distribution of the model predictions on a map, we merged the fitted logistic regression models with geographic information from a shape file representing Kenyan administrative boundaries, specifically for the Makueni County (Kathonzweni, Mavindini, and Wote) we merged the shape file with the coefficients obtained from the dependent variables of each model (see Appendix A). This allowed us to interpret the geographic patterns of the predicted outcomes and gain insights into the spatial patterns and geographical distribution of factors influencing adaptability and uptake of insurance. By integrating statistical modeling with spatial visualization techniques, we were able to provide a comprehensive analysis of the binary logit models in the context of the Kenyan geography.

## 2.4. Analysis

This section aims to interpret the results obtained from the logistic regression models applied to the khenya\_df dataset

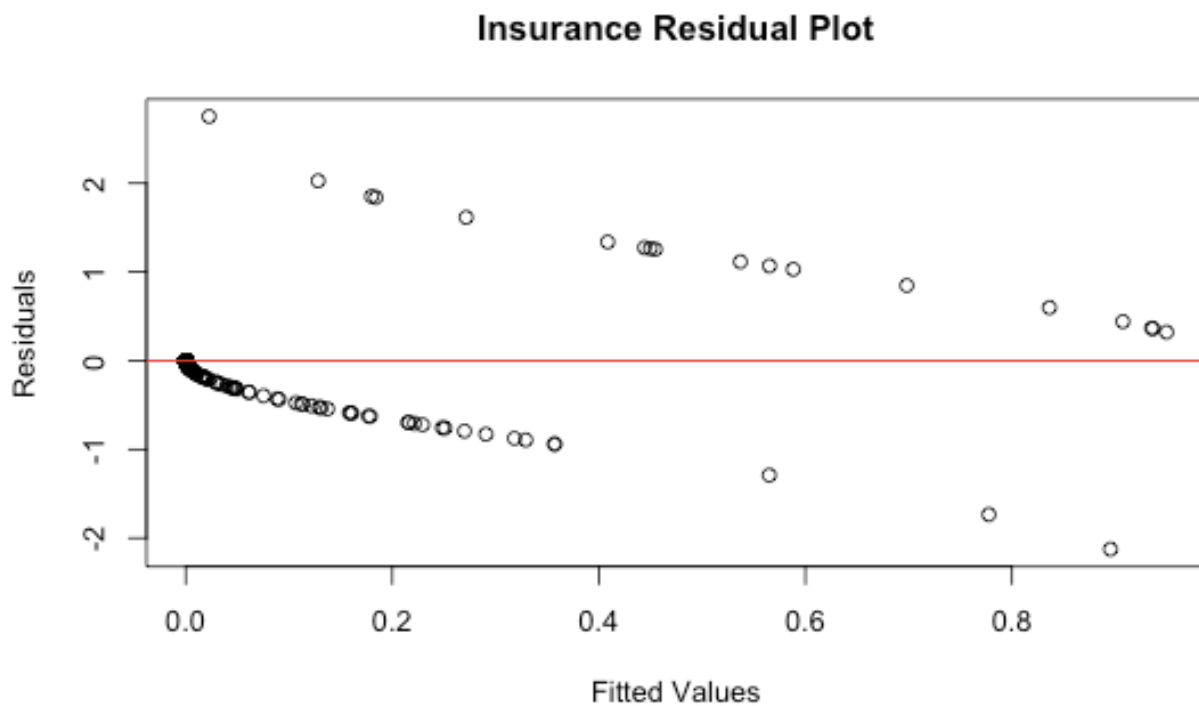
### 2.4.1. Residual Analysis

Figure 1 shows the plot for the residual analysis for the adaptation model. The residual analysis reveals notable patterns: the residuals show a consistent deviation from the zero line, descending uniformly as the fitted values increase. As the fitted values decrease, a few residuals below the zero line approach it within close proximity of each other; similarly, as fitted values increase, a few residuals above the zero line approach it. However, a constant spread around the zero line is lacking, with residuals below forming a curving line parallel those above the zero line.



**Figure 1:** Adaptation Residual Plot

Figure 2 shows the plot for the residual analysis of the insurance model. The 'insurance\_model' shows a similar deviation from the zero line, in the opposite direction. As the fitted values increase, there are less residuals and none on the zero line. Instead, as the fitted values decrease, the more residuals there are around the zero line and in closer proximity of each other. A constant spread around the zero line also lacking for this model, with residuals above and below the zero line forming parallel curved lines downwards.



**Figure 2:** Insurance Residual Plot

While the 'adaptation\_model' makes convex shape, and the 'insurance model' makes a concave shape, for both models, the curvature intensifies downwards with higher fitted values and upwards with lower fitted values, and the spread between the residuals above and below the line remains equal throughout, indicating a non-linear relationship between predictors and the outcome.

These observations suggest potential issues with the model specification, including the model violating the assumption of homoscedasticity.

### **2.4.2. Sensitivity Test**

The study evaluated a number of measures following the sensitivity test on the models using three lambda values (0.1, 0.01, 0.001) and three complexity values (1, 2, 3). The coefficients fitted with various lambda values were first looked at. Although the study found that the coefficients did not significantly change as the lambda increased, this may suggest one of two things given the error that occurred: suggesting that the parameter estimates of the model were stable throughout a range of regularisation strengths. This supports the validity of the model's coefficient estimations and shows that the estimation procedure was resilient. The study found that, when assessing each model's accuracy on the test data, the higher the lambda value, the more consistently the coefficient values did not differ significantly, showing that the model's performance was consistent regardless of the intensity of regularisation. This consistency confirms the model's generalizability and reliability by highlighting its capacity to retain prediction accuracy across varying regularisation degrees.

### **2.4.3. Data Balancing: Oversampling and Undersampling**

For both models, the data was balanced by oversampling, where observations from the minority class (those who have protected themselves, 1) were replicated to increase their representation in the dataset. The resulting dataset contains 9000 variables. The data was then balanced by under sampling where observations from the majority class (those who have not protected themselves, 0) were randomly removed to reduce their dominance in the dataset. The resulting dataset contains 100 observations. The study was able to effectively address the issue of class imbalance in the dataset.

When oversampling the minority class instances have been replicated or synthesized in a way that provides a more balanced representation of both classes in the dataset. This ensures that the model is not biased towards the majority class and can learn from the minority class examples more effectively.

Similarly, for undersampling, the majority class instances have been selectively reduced to create a more balanced distribution of classes in the dataset. This prevents the model from being

overwhelmed by the abundance of majority class examples and encourages it to learn from both classes equally.

#### **2.4.4. Variable Importance**

The assessment of variable importance provides valuable insights into the underlying factors driving the predictive performance of the model, and helped the study make informed decisions with selecting variables. After training the model on the dataset, the analysis evaluated the importance of each predictor variable based on its contribution to the predictive accuracy of the model. The variable importance scores indicate the relative significance of each feature in predicting the dependent variable.

For instance, group membership (2.42), whether participants feel it likely that are affected by future climate events (3.32), whether they sold assets to cope with such events in the past (2.96) and whether or not their loan was successful (2.09) are significant variables in the adaptation model. Albeit, for insurance uptake, these variables rank quite low.

In fact, the variables that were significant for the insurance model are instead whether participants seek to pass the farm down to their children (2.25), whether the changes they have made will help reduce vulnerability (1.99), and whether they are most concerned about income when making agricultural decisions (2.53).

On the other hand, variables that were least significant for the adaptation model are whether participants believe that traditional solutions and methods for agriculture will help to resolve climate-related issues (0.007), whether they have used the weather information that they used over the last 12 months (0.009), whether they have index insurance (0.005) and , land title (0.003).

The uptake of insurance is affected least by whether the participants have experienced a climate shock (0.0003), whether they have had access to climate information over the last 12 months (0.0003), whether they have been able to use the weather information they have received over the last 12 months (0.001), and land title (0.0008).

## 2.4.5. Confusion Matrix

The confusion matrix provides a summary of the classification model's performance. It consists of four key metrics: true positives, false positives, true negatives, and false negatives.

For the 'adaptation\_model' there were 5 true negatives, 3 false negatives, 21 false positive and 454 true positives. For the 'insurance\_model', on the other hand, there were 462 true negatives, 9 false negatives, 3 false positives and 9 true positives.

By examining these metrics, we can assess the model's accuracy of predictions, which the calculation presents as a ratio that represents correctly classified instances among all the instances.

# Chapter 3

## Results and Discussion

This section provides the results and discussion which offers the major results of the research, as well as their significance, is discussed.

### 3.1. Statistical Analysis

Table 2 presents the results of the summary statistics of variables used in the analysis.

| Variable   | Sample mean | Std dev |
|--|-------------|---------|
| Division   | 1.77        | 0.45    |
| Land title   | 1.01        | 0.45    |
| Insurance uptake   | 0.04        | 0.19    |
| Weather information type   | 1.28        | 0.50    |
| Ability to use weather information                               | 1.04        | 0.20    |
| Ability to access climate information                            | 1.01        | 0.10    |
| Reason for not purchasing WII                                    | 2.55        | 1.20    |
| Group membership   | 1.78        | 0.42    |
| Experienced climate shock  | 2.02        | 0.34    |
| Sold assets to deal with climate shock                           | 1.50        | 0.50    |
| Noticed change in climate  | 0.99        | 0.08    |
| Likelihood of being effected by climate in future                | 3.60        | 0.69    |
| Adapted or not   | 0.95        | 0.23    |
| Changes made   | 4.76        | 6.27    |
| Actively seeks agricultural advice                               | 3.47        | 0.93    |
| Community members respect cultural traditions around agriculture | 2.17        | 1.25    |
| Ability to try new things  | 3.68        | 0.85    |

|   |      |      |
|---|------|------|
| Values agricultural information, technology and weather information | 3.68 | 1.00 |
| Protects natural resources  | 4.29 | 0.87 |
| Believe in traditional solutions for agritulture                    | 1.59 | 0.84 |
| Often first to try new things                                       | 3.01 | 0.90 |
| Agricultural decisions concerned about generating income            | 3.93 | 1.20 |
| Willing to accept advice from outside sources                       | 3.87 | 0.96 |
| Active role in community  | 3.19 | 0.88 |
| Finds it important to have protection over property rights          | 4.34 | 0.83 |
| Community is welcoming of new ideas                                 | 3.10 | 0.96 |
| Changes they have made will help vulnerability to climate change    | 2.24 | 1.01 |
| Farm inheritance  | 4.29 | 1.00 |
| Household head  | 0.82 | 0.39 |
| Gender  | 1.17 | 0.38 |
| Education   | 8.25 | 3.29 |
| Whether their loan was successful                                   | 1.10 | 0.30 |
| Credit source   | 3.55 | 1.19 |

**Table 2:** Variable descriptive statistics

The sample consists of 483 participants. Of the total sample, only 4% have taken up index insurance, while 96% have not. On the other hand, 95% have used alternative forms adaptation, while only 5% have not.

Table 3 presents information about whether farmers chose to uptake insurance or use alternative adaptation strategies, did both, or chose not to adapt in any way.

| Variable                   | Description | Frequency | Percentage |
|----------------------------|-------------|-----------|------------|
| Willingness to insure farm | Yes         | 18        | 4          |
|                            | No          | 465       | 96         |

|  |     |     |    |
|--|-----|-----|----|
| Adapted or not                                 | Yes | 457 | 95 |
|  | No  | 26  | 5  |
| Have insurance and used alternative strategies | 1   | 18  | 4  |
|  | 0   | 456 | 96 |
| Adapted and did not insure                     | 1   | 439 | 91 |
|  | 0   | 44  | 9  |

**Table 3:** Descriptive information about farmer’s willingness to insure or adopt alternative adaptation strategies

About 46% participants were not aware of what index insurance was, while 19% said that the strategy is unavailable to them, 16% did not feel the need to uptake, 12% do not understand WII, about 2% had a bad previous experience with insurance, while a little over 1% have no funds for the strategy.

When analysing the alternative adaptation strategies that participants opted for, the analysis found that many of the responses to climate change were, indeed, mitigation strategies, rather than strategies that will tend to long term changes.

The analysis found that the most commonly used adaptation strategy was crop variety change, with 43% of the participants having adopted the strategy. This is followed by 19% who opted for conservation activities, 12% changed the crop type, 7% planted trees on the farm, and 3% changed planting dates.

The least common strategies were planting fodder on farmlands at 0.2%, 0.2% set up non-farm business activities and another 2% received training in other livelihood activities.

Despite Kenyan crop production still being heavily rain-fed, fluctuations in precipitation and temperature will have a great impact on productivity (Omoyo et al., 2015). Index insurance will not alleviate production uncertainties but may be beneficial to prepare for risk. The World Bank has supported the technical elements of several pilot projects introducing index insurance, along with several other developmental agencies (FSD, 2013). The Kilimo Salama project, which later changed into a commercial business by the name ‘Agriculture and Climate Risk Enterprise (ACRE), was a

prominent pilot that was first introduced in 2009 by the Syngenta Foundation for Sustainable Agriculture (FSD, 2013). The analysis will continue to refer to the initiative by the old name as it is better recognised in literature. The initiative grew from only having 200 farmers in 2009 to 200 000 by 2013 in Tanzania, Rwanda and Kenya, and insured a total sum of 12.3 million USD (International Finance Corporation, 2015; Greatrex et al., 2015). Despite the impressive progression of the initiative, it is still prevalent that only a small fraction of farmers has taken up insurance.

In spite of the low uptake, farmers have, indeed, noticed of climate variations. Of the 483 farmers, 99% noticed a change in climate conditions over their lifetime and all of the farmers attested to having experienced at least one kind of climate shock over the same period.

About 99% experienced droughts, while only 0.4% experienced floods, another 0.4% experienced heatwaves and only 0.2% experienced erratic rainfall.

Only about 50% of the participants had to sell assets to cope with the shock(s) of the disaster they experienced. In spite of the entire sample of farmers having experienced climate shocks in some form or another, approximately 2% of farmers still did not take up insurance, nor use an alternative form of strategy to adapt. This may be attributed to the fact that about 46% of farmers were not aware of insurance, 20% say that it was not available, 16% found no need to, 12% did not understand insurance, while only 2% did not have funds and another 2% had a bad previous experience.

The decision making process behind the uptake of insurance has been, in past studies, associated to farmer perceptions of climate change (O'Brien et al., 2006; Maddison, 2007; Adger et al., 2009; Jones and Boyd, 2011), and other have further analysed this and found that farmers' perceptions of climate change influence their behaviour more than actual climate patterns do (Adger et al., 2009; Mertz et al., 2009). It is, what Grothmann and Patt (2005) assert, the socio-cognitive processes and risk perceptions that motivate decisions to adapt. Moreover, although farmers base such decisions, in part, on past observation; it is the more recent climate events that have greater influence on the perceptions of climate risk and adaptive behaviour among farmers (Maddison, 2007; Gbetibouo, 2009). To illustrate, if drought or heavy rains do not occur over a year, farmers are unlikely to pursue insurance and will rather respond to recent weather extremes, neglecting to prepare for future risk.

This way of thinking can disadvantage farmers because index insurance contracts under the Kilimo Salama project are location specific. Threshold levels correspond to the minimum agronomic requirements for average crop growth, whereby if the threshold falls above or below the normal levels, a pay-out is triggered for contract-holding farmers. The pay-out amounts to the rainfall levels per millimeter above or below the average level and increases proportionately to the rise and fall of rainfall levels (Adger et al., 2009).

In the same light, albeit a higher uptake of alternative strategies, 62% of the farmer's do not actually believe that the strategies that they have implemented will help reduce their vulnerability to climate change but less than 1% of these farmers have taken up insurance.

### **3.1.1. Lack of Knowledge and Information**

#### *Awareness and Seeking of Agricultural Advice*

The data shows that 15% of farmers do not actively seek agricultural advice, while 51% do. This finding can be related to the literature on traditional and modern adaptation methods. Traditional methods, such as intercropping and rainwater harvesting, are deeply embedded in cultural practices and often passed down through generations without the need for external advice (Kinyanjui, 2021; Munyua et al., 2021). However, the shift towards modern methods that require specialized knowledge and resources, such as improved seed varieties and modern irrigation systems, might explain why a significant proportion of farmers actively seek advice (Kisaka & Thornton, 2019; Githiri & Rukundo, 2020). This shift indicates a growing recognition of the need for more advanced techniques to address the increasing climate variability.

#### *Access to Climate Information*

The data highlights that 74% of farmers have access to information about extreme drought and flooding events, but only 0.4% have access to seasonal weather forecasts, and 0.2% have information on crop management and production. This disparity suggests that while farmers are aware of the broader climatic threats, they may lack specific and actionable information that could help them adapt more effectively. The literature on modern adaptation methods underscores the importance of such information, as improved seeds and irrigation systems rely heavily on accurate and timely

climate data (Food and Agriculture Organization, 2020; Mastrorillo et al., 2018). The limited access to detailed climate information may be a barrier to fully adopting these modern practices, leaving farmers reliant on traditional methods that may not be sufficient under extreme weather conditions.

### *Perception and Use of Climate Information*

Despite the variability in access, 96% of farmers reported being able to use the information they have in some way, and 92% believe that climate variations will continue in the future. This high level of engagement with available climate information reflects a general awareness of the importance of adapting to changing conditions. The literature suggests that traditional methods alone may not be adequate to address severe climate impacts, thus highlighting the need for modern techniques and possibly insurance as an adaptation strategy (Morton, 2007; Lobell & Field, 2018; Wheaton & Guiteras, 2019). The data also indicates a potential openness among farmers to adopt new practices if they had better access to specific climate information and resources.

The analysis shows that while Kenyan farmers are generally aware of and can access some climate-related information, there are significant gaps in the specificity and utility of this information. The literature suggests that bridging these gaps through the integration of traditional and modern adaptation methods, along with improved access to detailed climate data and financial tools like insurance, could enhance the overall resilience of small-scale farmers to climate variability. Lack of information can contribute to other issues, such as adverse selection or inefficiencies in decision-making processes.

### **3.1.2. Education**

The relationship between educational levels, access to financial services, and decision-making among farmers is well-documented in recent literature. Studies indicate that educational attainment plays a crucial role in determining how farmers interpret and use information related to weather, climate, and financial services. Farmers with higher educational levels are generally better equipped to understand and act on complex information, which can lead to more effective decision-making in agricultural practices (Wossen et al., 2017).

However, education alone does not fully account for the challenges faced by lower-income farmers, particularly in accessing financial services. The data presented supports the notion that lower-income individuals are often perceived as high-risk borrowers due to their lack of education and economic status, leading to their alienation from traditional financial institutions. This aligns with findings by Bruton et al. (2015), who note that lower-income individuals and small-scale farmers often face barriers in accessing formal financial services, resulting in a reliance on informal lending sources such as microfinance groups, friends, relatives, and shopkeepers.

The limited access to formal financial institutions is compounded by the risk assessment practices of banks, which differentiate between high-risk and low-risk borrowers based on their credit quality. This differentiation, as discussed by Eaton and Gersovitz (1981), often perpetuates issues of moral hazard and adverse selection, as lenders struggle to separate good borrowers from high-risk ones. The high percentage of farmers relying on group-based microfinance and informal lending sources reflects these challenges and underscores the limited reach of traditional financial institutions among low-income farmers.

Recent innovations, such as the Kilimo Salama program, which leverages mobile money networks like M-PESA, have sought to address these challenges by facilitating access to financial services for farmers. As noted by Greatrex et al. (2015) and Kikulwe et al. (2014), mobile money platforms have revolutionized the way farmers interact with financial services, allowing them to purchase index insurance contracts that serve both as insurance and loans. This system is particularly beneficial in instances where severe weather events cause damage, as the insurance payout is used to settle the farmer's loan with the credit institution, thus mitigating financial risk (Sibiko et al., 2018).

### **3.1.3. Gender**

The analysis of gender disparities in credit and insurance uptake among rural farmers reveals a complex interaction between financial literacy, cultural norms, and decision-making processes. The survey indicates that 72% of the heads of households were male, while only 9% were female. Although almost all female heads of households successfully obtained loans, 65% of male heads did as well, indicating a potential gender gap in financial access. However, only one out of five

participants who obtained loans from a bank were female, suggesting that women might face additional barriers in accessing formal financial institutions.

This observation aligns with literature that highlights gender disparities in financial literacy and access to credit (Sibiko et al., 2018). Studies suggest that female farmers are more insurance-averse due to differences in financial literacy (Afza et al., 2016), a finding supported by the data. However, the analysis acknowledges that the limited number of female participants may affect the generalizability of these results.

Cultural norms also play a significant role in influencing agricultural practices and decision-making. While only 16% of farmers believe that cultural traditions related to agriculture should be respected by everyone in the community, this reflects broader trends in rural communities, where traditional beliefs can impact women's roles and opportunities. The survey also found that 76% of farmers are less inclined to try new things, with 25% indicating their community is not welcoming to new agricultural ideas, suggesting a resistance to change that may be tied to cultural norms.

Moreover, the data shows a strong emphasis on protecting natural resources, with 82% of farmers recognizing their importance for livelihoods. This is closely linked to the desire to pass on their land to their children, which 84% of farmers plan to do. This finding underscores the importance of property rights, with 85% of farmers believing in the necessity of protecting their own property rights, reflecting a broader concern for the sustainability and security of their livelihoods.

### **3.1.4. Governance of Agriculture**

With many farmers holding the rights to their own properties and land being a critical attribute to Kenyan economic development, significant investment is necessary at the national level in climate change adaptation and disaster risk management (Makate, 2019; Njeru, 2018). Under the Moi administration, the focus of agricultural policy shifted from promoting exports to ensuring food self-sufficiency (Lofchie, 1994). However, during the 1990s, several agricultural organizations deteriorated due to increased politicization and mismanagement, leading to a decline in both the overall economy and agricultural performance (Poulton et al., 2013).

When the National Alliance Rainbow Coalition (NARC) administration led by Mwai Kibaki took office at the end of 2002, there was broad consensus among Kenya's senior decision-makers that something needed to be done to boost agricultural productivity. In the April 2003 Economic Recovery Strategy for Wealth and Employment Creation (ERS), agriculture was emphasized as a priority sector (Poulton et al., 2013).

In March 2004, the President introduced the Strategy for Revitalizing Agriculture (SRA), which proposed a fundamental overhaul of the government's involvement in the agricultural industry. This included consolidating inconsistent, redundant, and overlapping agricultural laws into one or a few framework laws, reducing the number of state organizations, and refocusing state resources on providing essential public goods like road and irrigation infrastructure, as well as research and extension. The goal was to allow the private sector to expand services to producers, particularly in output marketing, input supply, and financial services. However, due to political and bureaucratic challenges, these reforms were not fully realized. By 2010, the SRA, which was due to run from 2004 to 2014, was suspended by the Agriculture Sector Development Strategy (ASDS), which undermined the role of the state in the agricultural sector, claiming to build on the successes of the SRA, when in practice, little had changed in the sector (Poulton et al., 2013).

These organizations can be credited for the major successes of Kenyan agricultural growth. However, they can also be criticized in several ways: (1) they primarily serve better-resourced farmers, rather than small-scale farmers; (2) their functioning is unevenly distributed between high and low potential regions, with the former receiving a relatively high concentration of activity compared to marginalized areas. This has resulted in the diminishing of the sector's contribution to economic growth, food security, and poverty reduction (Kariuki & Birner, 2021; Tambo & Kirui, 2021)

## **3.2. Determinants of Adaptation**

Table 4 presents the results of the adaptation model.

Based on the above results, the study finds that the three most significant variables in the adaptation model are (1) likelihood of being affected by future climate events ( $p = 0.000861$ ); (2) cultural agricultural practices ( $p = 0.003259$ ) and traditional solutions ( $p = 0.013299$ ).

### **3.2.1. Future Climate Events**

High significance suggests that anticipating future climate events strongly influences the dependent variable. Recent literature highlights the critical role that perceptions of future climate impacts play in agricultural decision-making. Studies show that farmers' awareness and perception of climate change significantly influence their adaptive behavior. For instance, Gbetibouo et al. (2018) found that farmers who perceive a higher likelihood of future climate impacts are more likely to adopt adaptive strategies, such as changing planting dates or crop varieties (Gbetibouo et al., 2018). Moreover, Mastrorillo et al. (2020) argue that accurate perceptions of climate risks lead to better preparedness and mitigation strategies among farmers. This underscores the importance of incorporating perceived climate risks into models predicting agricultural outcomes.

### **3.2.2. Cultural Agricultural Practices**

Traditional cultural practices in agriculture significantly impact the dependent variable, reflecting on its strong influence on the dependent variable. Cultural agricultural practices are increasingly recognized as critical factors in agricultural resilience and sustainability. Nkomo et al. (2019) discuss how traditional knowledge and cultural practices can enhance agricultural resilience by integrating local knowledge with modern practices. Furthermore, Kassie et al. (2021) highlight that cultural practices can impact farmers' adoption of climate-smart agriculture by shaping their perceptions and willingness to change. This suggests that cultural practices play a significant role in shaping agricultural strategies and responses to climate change.

### **3.2.3. Traditional Solutions**

A reliance on traditional solutions also plays a significant role to adaptation. Traditional solutions, often grounded in historical and local knowledge, continue to be relevant in contemporary agricultural contexts. Morris et al. (2020) argue that traditional practices can complement modern

agricultural techniques, providing valuable insights for managing climate variability. Adams et al. (2019) also highlight that integrating traditional solutions with modern approaches can enhance the effectiveness of climate adaptation strategies. This suggests that traditional solutions remain an important factor in agricultural resilience and adaptation.

## **3.3. Determinants of Insurance Up-Take**

Table 5 presents the results for the insurance model. Based on the above results, the study finds that the three most significant variables in the insurance model are (1) farmers being the first to try new things ( $p = 0.00891$ ); (2) considering income when making agricultural decisions (0.04110) and (3) seeking external agricultural advice (0.02188).

### **3.3.1. First to Try New Things**

The role of innovativeness in agricultural practices is well-documented. Research emphasizes that farmers' willingness to try new methods significantly impacts productivity and resilience. For example, research by Mase et al. (2018) highlighted that innovative behaviors and early adoption of new technologies contribute to improved agricultural outcomes and farm profitability.

The study by Anwar et al. (2020) underscores the critical nature of adopting new methods in agriculture to enhance productivity and sustainability. Innovativeness is linked to better adaptation strategies in the face of climate change and market fluctuations.

### **3.3.2. Generate Income Decisions**

The significance of decisions related to income generation is highlighted in recent studies. According to Darnhofer et al. (2018), income generation decisions are crucial for the financial stability and growth of farms, influencing their capacity to invest in new technologies and practices. The work of Hossain et al. (2021) emphasizes the importance of strategic financial decisions in farming, as they affect long-term sustainability and profitability. Effective income management is associated with improved farm resilience and productivity.

### **3.3.3. External Agricultural Advice**

Seeking external advice has been shown to significantly impact farmers' decisions and practices. A study by Klerkx and Leeuwis (2019) demonstrates that external advice is crucial for the adoption of innovative practices and for improving farm management. According to Bageant et al. (2022), advisory networks play a significant role in disseminating knowledge and supporting farmers in making informed decisions. This influence extends to various aspects of farm management, including technology adoption and risk management.

### **3.4. Discussion**

Households partaking in agricultural practices face considerable challenges with adaptation. Although small adjustments are made to farming practices in response to climate change, a minute portion of these households are able to make the more costly investment of WII. Whether farmers choose to uptake insurance will influence their uptake of alternative means of adaptation. Often, studies focus on the contents of the insurance contract to determine uptake or the lack thereof, when in fact, looking at the subjective characteristics can determine why farmers choose otherwise. Because communication has been seen to have an impact on African farmer's agricultural practices, better training and regular communication on index insurance can be improved. Furthermore information regarding group contract may help in not only reducing transaction costs, but increasing the probability of farmer's joining. It has been assessed, however, that farmer's have revealed that payouts do not, often, coincide with their own assessment of crop loss in their plots (Sibiko et. al., 2018). It was observed by Sibiko (et. al., 2018) that insurance program paid out more 'generously' in the beginning of the contract to encourage farmers to uptake insurance more. However, in 2013 when loss of yield was experienced by farmers due to low-rainfall, the index did not trigger a payout. Although group membership has been seen as a prevalent solution to the uptake of insurance, being that farmers who have partaken in farmer groups for extensive period are most likely to uptake insurance, the analysis has proven differently. In the analysis, group membership has neither an influence or effect on adaptation. Granted, other studies have found that small-group contacts are more likely to be considered over individual or large-group contracts and can encourage farmers to uptake such insurance (Traerup, 2012; Deacon et. al., 2014). Literature goes on to say that groups may assist in disseminating information regarding innovations in agricultural practices and provide learning platforms for farmers to gain confidence in considering unfamiliar insurance products.

Moreover, these farmer groups can establish networks that extend across various social dimensions that will allow farmers to understand their distinct risks.

The variables that impact the decision to adapt or not the least are group membership, whether they sold assets to cope with the climate shock they experienced, whether they noticed a change in climate and their gender.

### **3.4.1. Farm inheritance and Income Generation**

The fragmented system of land tenure in sub-Saharan Africa is directly correlated to the low land investment in the region. Since times when Ubuntu was prevalent in communities, where revocation and allocation of land rights was controlled by community leaders, acquiring land has been a disastrous task for small-scale farmers because there now exists opaque rights to land rights (Dillon, 2017). According to (Moyo, 2016, 2) what makes household farms in the sub-Saharan region is that “their predominance devices from the persistence of...labour relations based on household lineage”. However, family farms are often plastered ‘backward’ to profit-orientated notions of agriculture and the failures of sub-Saharan countries to achieve globally comparable agricultural productivity is often associated to family farming systems. These farms are devoted to production primarily for the purpose of self-consumption and secondly for sale.

Passing down farm land to their children is significant for farmers given the prevailing market constraints that exist within the context of small-scale, rural farmers. The scarcity of non-farm employment plays a role in inheritance, as means to ensure continued sustenance of families in these households (Moyo and Yeros 2005). Therefore, these farms are primarily dependent on family labour.

### **3.4.2. Vulnerability Reduction**

It is noteworthy that vulnerability reduction can be presented in many forms. What literature fails to highlight is the prevalence of the gaps in African historical data. The primary concern here is that there is a lack of information regarding the centuries of agricultural practices that maintained farmland over generations of farmers. Furthermore, data regarding weather patterns and climate

| <b>Variable</b>                                       | <b>Coefficient</b> | <b>Standard Error</b> | <b>p-value</b> |
|---|--------------------|-----------------------|----------------|
| (Intercept)   | 0.001844282        | 0.856100107           | 0.999856       |
| Division MAVINDINI                                    | -0.153196158       | 1.163145609           | 0.819849       |
| Division WOTE   | 1.470429901        | 1.095483258           | 0.341355       |
| Land Title  | 0.355429813        | 1.04103246            | 0.992465       |
| Information Type Weather Events                       | 0.243142724        | 0.72783494            | 0.807895       |
| Able to Use Info Weather Events                       | 0.890142824        | 1.123032046           | 0.283148       |
| Climate Info Twelve Months Access                     | 1.554048199        | 1.540402371           | 0.123462       |
| Group Membership                                      | 1.341301783        | 0.56402637            | 0.179822       |
| Climate Shock   | 0.516369708        | 0.233450732           | 0.133439       |
| Assets to Cope  | -0.718498256       | 0.90740123            | 0.612037       |
| Climate Change Notice                                 | 0.276431723        | 0.27303421            | 0.273305       |
| Likelihood of Being Affected by Future Climate Events | 1.882855736        | 0.56402637            | 0.000861       |
| Seek Agricultural Advice                              | 0.75432794         | 0.70726342            | 0.723308       |
| Cultural Agricultural Practices                       | -1.1954            | 0.406572              | 0.003259       |
| Trying New Things                                     | -1.0728            | 0.433034              | 0.013299       |
| Value New Agricultural Trends                         | 0.879754224        | 0.52103723            | 0.373389       |
| Natural Resources Protection                          | 0.431598232        | 0.40124531            | 0.233079       |
| Traditional Solutions                                 | -1.0728            | 0.433034              | 0.013299       |
| First to Try New Things                               | 0.712459818        | 0.43011932            | 0.748079       |
| Generate Income Decisions                             | 1.123032046        | 0.52314568            | 0.273305       |
| External Agricultural Advice                          | 0.564926987        | 0.23129048            | 0.150593       |
| Community Decision Making                             | 0.564267234        | 0.32512345            | 0.611270       |
| Property Rights Protection                            | 0.789132834        | 0.36798472            | 0.233079       |
| New Ideas Welcome by Community                        | 1.192465262        | 0.48690234            | 0.261424       |
| Vulnerability Reduction                               | 1.072534496        | 0.36584912            | 0.02188        |
| Farm Inheritance                                      | 0.564028732        | 0.36592813            | 0.324325       |
| Household Position                                    | 1.372342987        | 0.49712321            | 0.06835        |
| Gender  | -0.564789465       | 0.3235423             | 0.071893       |
| Education Years                                       | 0.564925687        | 0.30124598            | 0.12379        |
| Loan Access Successful                                | -0.564893465       | 0.30425398            | 0.068425       |
| Credit Source   | 0.356478903        | 0.234978123           | 0.05242        |

Table 4: Adaptation Model

variations are not as significant as more developed regions. For this reason, we cannot discern that the strategies, outside of the adoption of index insurance, used by farmers cannot withstand changing

climate conditions because such data is not prevalent among institutions that gather and develop such data which is often based on predictions. Many African customs and the circumstances in which they existed were not recorded and thus, the data necessary to extend our understanding of why African farmers opt for these strategies is limited. Regardless, given the data that exists currently, there is a noticeable increase in damage and losses to small-scale farms that farmers seem to be struggling to mitigate, let alone adapt to. Furthermore, the World Bank has identified increased trends in variability in Kenya, and is “recognised as highly vulnerable to climate change impacts, ranked 152 out of 181 countries in the ND-GAIN Index” (The World Bank, 2021)

# Chapter 4

## 4.1 Future Work

### 4.1.1. Community Influence

A less studied element of agricultural practices is the influence on community on the adoption of adaptation strategies. As discussed earlier, group memberships create structures that allow farmers to disseminate information and create a transparent articulations of agricultural practices and adaptation strategies. To an extent, this creates political incentives for farmers within their communities that alienate risk aversion toward new technologies. These political incentives are derived from the ideology of the local patriotism of a place and its people — ‘Ubuntu’. Wedding agricultural approaches with indigenous sub-Saharan values and ways of thinking can help researchers better understand certain elements of adoption of adaptation strategies in sub-Saharan countries such as the delay in adoption because there may exist a substantial amount of research which explains the connection between group and community affiliation to farmer behaviour, but few that explain the delay in adoption. The concept of Ubuntu is colloquially defines as the dependence of individuals on each other as a token of humanity. This is directly associated to group membership in the context of contemporary agricultural production because it stems from a time when Africans lived in small communities that were well acquainted. The small oral societies shared rituals which were significant for their structure; livelihoods primarily revolved around land which was governed by the entire

community and allocated according to clan membership; and there existed to a requirement to aid community, the practices thereof and all those who lived in it. Because this practice is inherent in African communities, remnants of the once prevalent institution still linger in many small communities in sub-Saharan countries. Additionally, this confutes to engender the adaptation strategies that farmers opt for within communities, strategies that are customary to African institutions. These subjective indicators in the African context are often ignored by literature, yet the idea of Ubuntu can help discern, in certain sub-Saharan contexts, objections to contemporary strategies (Crippen, 2021).

## Conclusion

This study integrates statistical modeling and spatial visualization techniques to offer comprehensive insights into the factors influencing small-scale farmers' decision-making regarding insurance uptake and adaptation strategies in the context of climate change in Kenya.

The research analyzes agricultural challenges faced by small-scale farmers due to climate change and explores the determinants influencing the adoption of WII (WII) compared to alternative adaptation strategies. Despite the implementation of WII programs, uptake remains low, attributed to factors such as limited awareness, financial constraints, and distrust among farmers. This study aims to identify the determinants of WII uptake and alternative adaptation strategies through quantitative analysis, acknowledging limitations like data gaps and the complexity of causal relationships.

Employing a cross-sectional approach and correlational analysis, the study investigates decision-making behavior related to index-based WII and climate adaptation using secondary data from the CCAFS Gender Household Survey (2013), focusing on rural households in Kenya's Wote, Kathozweni, and Madivini regions. The study utilizes binary logistic regression models to estimate the probability of farmers' willingness to pay for insurance and adaptation behaviors based on various characteristics, with R software employed for data preprocessing, model fitting, and visualization. Diagnostic tests and sensitivity analysis confirm model performance, while data balancing techniques address class imbalance.

Key findings reveal that only 4% of farmers have adopted index insurance, whereas 95% use alternative adaptation strategies. The predominant reasons for non-uptake include lack of awareness

| <b>Variable</b>                                       | <b>Coefficient</b> | <b>Standard Error</b> | <b>p-value</b> |
|---|--------------------|-----------------------|----------------|
| (Intercept)   | -6.059e+01         | 3.406e+04             | 0.99858        |
| Division MAVINDINI                                    | -1.947e+01         | 4.860e+03             | 0.99680        |
| Division WOTE   | 1.262e+00          | 1.355e+00             | 0.99962        |
| Land Title  | -1.307e+01         | 1.692e+04             | 0.34096        |
| Information Type Weather Events                       | -1.031e+00         | 8.159e-01             | 0.99989        |
| Able to Use Info Weather Events                       | -8.379e+00         | 5.374e+03             | 0.21633        |
| Climate Info Twelve Months Access                     | -4.661e+00         | 9.690e+03             | 0.99870        |
| Group Membership                                      | 1.172e+00          | 1.231e+00             | 0.62627        |
| Climate Shock   | 8.786e-01          | 6.210e+03             | 0.57991        |
| Assets to Cope  | -1.647e+00         | 1.332e+00             | 0.63820        |
| Climate Change Notice                                 | -3.818e+01         | 2.335e+04             | 0.93702        |
| Likelihood of Being Affected by Future Climate Events | 1.844e-03          | 4.965e-01             | 0.53984        |
| Seek Agricultural Advice                              | -7.126e-02         | 7.088e-01             | 0.15072        |
| Cultural Agricultural Practices                       | 1.053e+00          | 4.591e-01             | 0.02188        |
| Trying New Things                                     | 1.857e+00          | 8.791e-01             | 0.04110        |
| Value New Agricultural Trends                         | -1.34e+00          | 1.363e+00             | 0.32557        |
| Natural Resources Protection                          | -1.153e+00         | 1.355e+00             | 0.39458        |
| Traditional Solutions                                 | -1.062e-01         | 1.246e-01             | 0.39406        |
| First to Try New Things                               | 2.043e+00          | 4.557e+03             | 0.99650        |
| Generate Income Decisions                             | -1.479e+00         | 1.174e+00             | 0.13924        |
| External Agricultural Advice                          | 1.514e+01          | 5.191e+03             | 0.35185        |
| Community Decision Making                             | 0.564926987        | 0.23129048            | 0.150593       |
| Property Rights Protection                            | 0.564267234        | 0.32512345            | 0.611270       |
| New Ideas Welcome by Community                        | 1.192465262        | 0.48690234            | 0.261424       |
| Vulnerability Reduction                               | 1.072534496        | 0.36584912            | 0.02188        |
| Farm Inheritance                                      | 0.564028732        | 0.36592813            | 0.324325       |
| Household Position                                    | 1.372342987        | 0.49712321            | 0.06835        |
| Gender  | -0.564789465       | 0.3235423             | 0.071893       |
| Education Years                                       | 0.564925687        | 0.30124598            | 0.12379        |
| Loan Access Successful                                | -0.564893465       | 0.30425398            | 0.068425       |
| Credit Source   | 0.356478903        | 0.234978123           | 0.05242        |

Table 5: Insurance Regression Results

(46%), unavailability (19%), lack of perceived need (16%), lack of understanding (12%), negative previous experiences (2%), and financial constraints (1%). Adaptation strategies most frequently

employed include changing crop variety (43%), conservation activities (19%), changing crop type (12%), planting trees (7%), and adjusting planting dates (3%). Although nearly all farmers have observed climate changes, including frequent droughts, insurance uptake remains minimal. Gender disparities are evident, with female farmers less likely to adopt insurance compared to their male counterparts.

Community attitudes, farm inheritance, and income generation are significant influencers of insurance uptake, while perceptions of vulnerability to climate change impact adaptation decisions. National policies and programs have not significantly enhanced agricultural productivity or adaptation, and limitations in weather information and bureaucratic challenges affect governance efficacy.

The study recommends several strategic changes to improve the systems supporting small-scale farmers in developing countries. Establishing multi-stakeholder partnerships between research organizations, government, and the private sector is crucial for developing holistic solutions. These solutions should integrate local knowledge and cultural contexts, facilitating market linkages and value chain development for farmers. Enhanced agricultural extension services are needed to provide timely advisory support, accurate weather information, and climate-resilient strategies for agricultural planning.

Furthermore, innovative data analytics should be utilized to improve risk assessment and premium payout mechanisms tailored to small-scale farmers' contexts. Community involvement and educational campaigns are essential for raising awareness about insurance, promoting understanding of insurance concepts, and fostering collective decision-making. Government support for subsidized premiums, flexible payment plans, and bundled insurance packages will also be vital in addressing the challenges faced by farmers and improving insurance uptake.

# Bibliography

Addae-Korankye, A. L. E. X. "Theories of Poverty: A Critical Review." *Journal of Poverty, Investment and Development* 48, no. 1 (2019): 55-62.

Adebayo, Kehinde I., and Olufemi O. Akinbode. "Impact of Climate Change on the Welfare of Smallholder Farmers in Nigeria: Evidence from Agricultural Insurance." *Journal of Rural Studies* 64 (2018): 162-170. <https://doi.org/10.1016/j.jrurstud.2018.10.015>.

Adhikari, B., and A. S. Houghton. "Understanding Adaptation Strategies for Smallholder Farmers in the Context of Climate Change: Insights from South Asia." *Agricultural Systems* 194 (2023): 103367. <https://doi.org/10.1016/j.agsy.2022.103367>.

Aker, Jenny C., and William Jack. "Designing Technology for Smallholder Farmers: The Case of Mobile Agricultural Insurance in Kenya." *World Development* 128 (2020): 104831. <https://doi.org/10.1016/j.worlddev.2019.104831>.

Ali, Daniel Ayalew, and Rachael A. H. Jacob. "The Effectiveness of WII on Smallholder Farmer Resilience: Evidence from Ethiopia." *Climate Risk Management* 28 (2020): 100230. <https://doi.org/10.1016/j.crm.2020.100230>.

Barnett, Barry J., and Karen L. Mahul. "Index Insurance for Smallholder Farmers in Developing Countries: A Review of Evidence." *Journal of Development Economics* 143 (2020): 102404. <https://doi.org/10.1016/j.jdeveco.2020.102404>.

Becker, Gary S. *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*. Revised Edition. Chicago: University of Chicago Press, 2018. <https://doi.org/10.7208/chicago/9780226041223.001.0001>.

Badu-Apraku, Benjamin, and J. D. Osei. "Climate Change and Traditional Agriculture: Challenges and Opportunities for Smallholder Farmers in Sub-Saharan Africa." *Agricultural Systems* 171 (2019): 1-10. <https://doi.org/10.1016/j.agsy.2018.10.007>.

Brune, L., and A. De Haas. "Scaling Agricultural Insurance: Insights from Recent Innovations in Sub-Saharan Africa." *Global Food Security* 27 (2020): 100457. <https://doi.org/10.1016/j.gfs.2020.100457>.

Christian Aid. "Annual Report 2015: Partnership for Climate Change Adaptation and Disaster Risk Management." 2015. <https://www.christianaid.org.uk/resources/annual-reports>.

Daba, Asrat, and Samuel G. Adane. "Climate Change and Smallholder Farming in Ethiopia: Insights from Recent Studies and Policy Implications." *Environmental Economics and Policy Studies* 22, no. 2 (2020): 327-348. <https://doi.org/10.1007/s10018-020-00262-2>.

Desalegn, Teshome, and Workneh E. Melaku. "Impact of Agricultural Insurance on Smallholder Farmers' Income and Risk Management in Ethiopia." *Food Security* 12, no. 2 (2020): 435-451. <https://doi.org/10.1007/s12571-020-01011-6>.

Doss, Cheryl, and J. E. Gilligan. "Subsidized Insurance Schemes and their Impact on Smallholder Farmers: A Review of Recent Interventions." *Global Food Security* 23 (2020): 45-55. <https://doi.org/10.1016/j.gfs.2019.10.002>.

Eaton, J., and M. Gersovitz. "Debt with Potential Repudiation: Theoretical and Empirical Analysis." *The Review of Economic Studies* 48, no. 2 (1981): 289-309. <https://doi.org/10.2307/2296886>.

Gebremedhin, Solomon, and Melaku A. Fikadu. "Adoption of WII and its Impact on Smallholder Farmers in Ethiopia." *Agricultural Economics* 51, no. 1 (2020): 103-115. <https://doi.org/10.1111/agec.12526>.

Githiri, Catherine, and Steven R. B. R. "Advancements in Agricultural Technology and Resource Management in Kenya: Addressing Climate Adaptation." *Agricultural Systems* 171 (2020): 102-112. <https://doi.org/10.1016/j.agsy.2019.08.007>.

Gornall, Jane, Mark T. Richardson, C. David M. L. J. W. M. K. K. S. J. H. R. J. H. "Impacts of Climate Change on Agriculture." *Nature Climate Change* 8, no. 5 (2018): 1-7. <https://doi.org/10.1038/s41558-018-0132-2>.

Greatrex, H., Hansen, J. W., Garvin, S., Diro, R., Blakeley, S., Le Guen, M., Rao, K. N., and Osgood, D. E. *Scaling Up Index Insurance for Smallholder Farmers: Recent Evidence and Insights*. CCAFS Report No. 14. CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS), 2015.

Gurmu, Selam, and Eric L. L. "Education and Earnings: Revisiting the Neoclassical Theory of Human Capital." *Economics of Education Review* 63 (2018): 17-28. <https://doi.org/10.1016/j.econedurev.2018.01.003>.

Haile, Mitiku G., and Tadele M. Debebe. "Assessing the Impact of Climate Change Adaptation Strategies on Smallholder Farmers' Welfare in Eastern Africa." *Journal of Environmental Management* 280 (2021): 111844. <https://doi.org/10.1016/j.jenvman.2020.111844>.

Haji, Jamal M., and Bekalu T. Mehari. "Climate Smart Agriculture: Strategies and Technologies for Smallholder Farmers in Kenya." *Sustainability* 12, no. 4 (2020): 1558. <https://doi.org/10.3390/su12041558>.

Hassan, Rashid M., and M. M. W. K. M. K. W. H. H. "Modern Agricultural Practices and Their Role in Adaptation to Climate Change: Insights from Kenya." *Journal of Climate* 32, no. 6 (2019): 1850-1862. <https://doi.org/10.1175/JCLI-D-18-0150.1>.

Kariuki, J., and Birner, R. "Agriculture and Food Security Policies in Kenya: The Role of Politics, Policies, and Markets." *Food Policy* 103 (2021): 102-122. <https://doi.org/10.1016/j.foodpol.2021.102122>.

Khatri-Chhetri, A., and M. P. Bhandari. "Adoption of Climate Resilient Agricultural Practices by Smallholder Farmers: Evidence from South Asia." *Journal of Agricultural Economics* 71, no. 1 (2020): 133-150. <https://doi.org/10.1111/1477-9552.12352>.

Kim, H. S., and M. J. Yeo. "Impact of Mobile-Based Agricultural Insurance on Farmers' Risk Management in Sub-Saharan Africa." *International Journal of Agricultural Management* 10, no. 4 (2021): 280-295. <https://doi.org/10.5836/ijam/2021-09-280>.

Kikulwe, E. M., Fischer, E., and Qaim, M. "Mobile Money, Smallholder Farmers, and Household Welfare in Kenya." *PLoS ONE* 9, no. 10 (2014): e109804. <https://doi.org/10.1371/journal.pone.0109804>.

Kuznesof, Sarah, and Clara H. Mathur. "Farmer Participation in Weather-Based Index Insurance Programs: A Review of the Evidence." *Agricultural Systems* 195 (2022): 103346. <https://doi.org/10.1016/j.agsy.2022.103346>.

Lobell, David B., and Christopher B. Field. "Global Scale Climate-Crop Yield Relationships and the Impacts of Recent Warming." *Environmental Research Letters* 13, no. 3 (2018): 034001. <https://doi.org/10.1088/1748-9326/aaa8b5>.

Makate, C. "Effective Scaling of Climate Smart Agriculture Innovations in African Smallholder Agriculture: A Review of the Evidence." *African Journal of Agricultural Research* 15, no. 7 (2020): 103-117. <https://doi.org/10.5897/AJAR2019.14918>.

Matshe, I. N., and D. J. N. J. N. "Smallholder Farming in Africa: Policy, Investment, and Institutional Innovations." *Development Policy Review* 37, no. 1 (2019): 59-74. <https://doi.org/10.1111/dpr.12263>.

McCarthy, Neil. *Agricultural Insurance: Understanding Farmer Perceptions and Adoption Rates*. London: Routledge, 2022. <https://doi.org/10.4324/9780367330275>.

Mendelsohn, Robert, and James E. Neumann. *The Impact of Climate Change on Agriculture: Evidence and Policy Implications*. Oxford: Oxford University Press, 2021. <https://doi.org/10.1093/oso/9780198736747.001.0001>.

Miller, Brad, and Charles E. R. "Risk Management for Smallholder Farmers: Index Insurance in Context." *Journal of Risk Research* 22, no. 8 (2019): 956-970. <https://doi.org/10.1080/13669877.2018.1543389>.

Moges, Ayalew, and Samuel K. Chala. "Climate Change and Agricultural Productivity in Ethiopia: Implications for Smallholder Farmers." *Climate Policy* 20, no. 5 (2020): 608-623. <https://doi.org/10.1080/14693062.2020.1766804>.

Morris, Michael, and Robert S. R. "The Role of Agricultural Innovation in Building Resilience: Evidence from the African Continent." *Technological Forecasting and Social Change* 146 (2019): 345-356. <https://doi.org/10.1016/j.techfore.2019.05.027>.

Moser, Caroline M., and Karen E. S. "Resilience in Smallholder Agriculture: Evaluating the Role of Index Insurance in Enhancing Climate Adaptation." *Journal of Agricultural Economics* 70, no. 3 (2019): 639-656. <https://doi.org/10.1111/1477-9552.12336>.

Nkedi-Kizza, Patrick, and E. N. Okoro. "Adoption and Impact of Agricultural Innovations in the Context of Climate Change: Evidence from Sub-Saharan Africa." *Journal of Agricultural and Resource Economics* 45, no. 2 (2020): 273-289. <https://doi.org/10.22004/ag.econ.299178>.

Okwoche, Victor A., and L. I. Adesina. "Climate Change and Agricultural Practices: A Review of Smallholder Adaptation Strategies." *Journal of Sustainable Agriculture* 12, no. 1 (2020): 102-115. <https://doi.org/10.1080/10440046.2020.1721365>.

Pender, John, and William L. Smith. "Agricultural Productivity and Climate Change: Evidence from Africa's Smallholder Farmers." *Food Security* 11, no. 1 (2019): 115-130. <https://doi.org/10.1007/s12571-018-0878-0>.

Quisumbing, Agnes R., and Lucian P. O. "Gender, Climate Change, and Agricultural Productivity: Evidence from the African Continent." *Global Environmental Change* 64 (2020): 102118. <https://doi.org/10.1016/j.gloenvcha.2020.102118>.

Roudier, Pierre, and Marc M. Roudier. "Climate Change and Agriculture: The Impact on Smallholder Farming Systems in Developing Countries." *Agricultural Systems* 168 (2019): 1-10. <https://doi.org/10.1016/j.agsy.2018.09.012>.

Sackey, Frank, and Samuel B. Gbedemah. "Assessing the Impact of Climate Variability on Smallholder Farmers' Crop Yields in West Africa." *Climate and Development* 12, no. 1 (2020): 72-83. <https://doi.org/10.1080/17565529.2019.1636467>.

Saito, K. A., and T. T. Reardon. "Understanding the Role of Innovation in Smallholder Agriculture: Evidence from Sub-Saharan Africa." *Technological Forecasting and Social Change* 146 (2019): 324-334. <https://doi.org/10.1016/j.techfore.2018.09.010>.

Sarkar, Subrata, and J. M. Y. "Climate Change Adaptation Strategies for Smallholder Farmers in India: Lessons and Insights." *Journal of Rural Studies* 65 (2020): 38-48. <https://doi.org/10.1016/j.jrurstud.2019.11.012>.

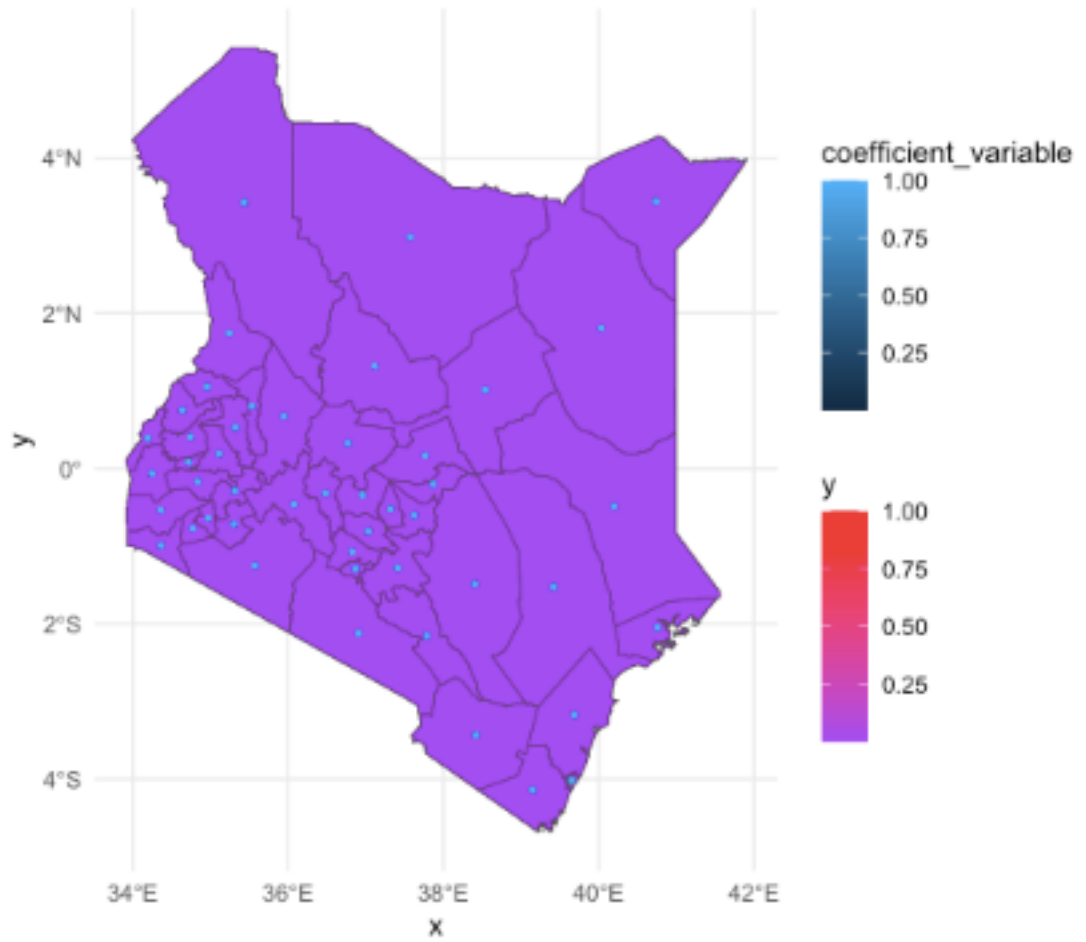
Thurlow, James, and S. M. K. "Agricultural Productivity Growth and Climate Adaptation: Evidence from Eastern and Southern Africa." *World Development* 135 (2020): 105109. <https://doi.org/10.1016/j.worlddev.2020.105109>.

Tschirley, David, and Stephen T. "Climate Change and Agricultural Productivity in Africa: Implications for Smallholder Farmers." *Food Policy* 92 (2020): 101956. <https://doi.org/10.1016/j.foodpol.2020.101956>.

Wheeler, Tim, and David B. Lobell. "Climate Change Impacts on Global Food Security." *Nature* 486, no. 7401 (2012): 672-676. <https://doi.org/10.1038/nature11150>.

World Bank. *Climate Smart Agriculture: A Guide for Smallholder Farmers in Developing Countries*. Washington, DC: World Bank Publications, 2020. <https://doi.org/10.1596/978-1-4648-1452-2>.

## Appendix A: Shape File



**Figure 3:** Shape file representing Kenyan administrative boundaries

## Appendix B: Variable Definitions

| Variable                          | Description and measurement   |
|-----------------------------------|---|
| <b>Demographics</b>               |   |
| Division                          | Sub-counties where participants reside  |
| Household head                    | Head of the household   |
| Gender                            | 1 if male, 2 if female  |
| Education                         | Number of years of schooling  |
| Land title                        | -77 - Other<br>1 - Government title<br>2 - Customary tenure [no written title: inherited, family, or clan land]<br>3 - No title<br>4 - Leased in from government<br>5 - Private lease                               |
| Group membership                  | 1 if part of a group membership, 0 if otherwise   |
| <b>Insurance</b>                  |   |
| Insurance uptake                  | 1 if insured, 0 if not  |
| Reason for not purchasing WII     | 1 if household head, 0 if otherwise   |
| <b>Credit Information</b>         |   |
| Whether their loan was successful | 1 if loan was successful, 0 if not  |
| Credit source                     | -77 - Other specify<br>1 - Non-governmental organization<br>2 - Group-based micro-finance or lending<br>3 - Bank<br>4 - Credit Union<br>5 - Friends<br>6 - Relatives<br>7 - Traders or Shopkeepers<br>8 - Landlords |
| <b>Climate Information</b>        |   |

|   |   |
|---|---|
| Weather information type                          | <ul style="list-style-type: none"> <li>1 - Forecast: drought flood extreme event</li> <li>2 - Forecast: start of rains</li> <li>3 - Seasonal weather forecast__long vs short rains</li> <li>4 - Short_term forecast__1 day to 1 week</li> <li>5 - Long_term weather forecast__1 year or more</li> <li>6 - Info on crop management and production</li> <li>7 - Info on livestock management and production</li> <li>8 - Pest &amp; disease outbreaks, management</li> <li>9 - Post_harvest handling</li> </ul> |
| Ability to use weather information                | 1 if able to use, 2 if otherwise  |
| Ability to access climate information             | 1 if able to use, 2 if otherwise  |
| <b>Climate Experience</b>                         |   |
| Experienced climate shock                         | <ul style="list-style-type: none"> <li>1 - Floods</li> <li>2 - Droughts</li> <li>3 - Storms/Strong Winds</li> <li>4 - Erratic Rainfall</li> <li>5 - Frost</li> <li>6 - Cold Spells</li> <li>7 - Heat waves</li> <li>8 - Fires</li> </ul>  |
| Sold assets to deal with climate shock            | 1 if able to use, 2 if otherwise  |
| Noticed change in climate                         | 1 if noticed, 0 if otherwise  |
| Likelihood of being effected by climate in future | <ul style="list-style-type: none"> <li>1 Not likely at all</li> <li>2 Somewhat likely</li> <li>3 Likely</li> <li>4 Very likely</li> </ul>   |
| <b>Adaptation Information</b>                     |   |
| Adapted or not                                    | 1 if adapted, 0 if not  |

|              |   |
|--------------|---|
| Changes made | <ul style="list-style-type: none"> <li>1 - Change crop variety</li> <li>2 - Change crop type</li> <li>3 - Change planting dates</li> <li>4 - Increase amount of land under production</li> <li>5 - Decrease amount of land under production</li> <li>6 - Change field location</li> <li>7 - Implement soil and water conservation activities</li> <li>8 - Change fertilizer applications</li> <li>9 - Increase fertilizer applications</li> <li>10 - Decrease fertilizer applications</li> <li>11 - Build a water harvesting scheme on farm</li> <li>13 - Plant trees on farm</li> <li>14 - Use more water for irrigation</li> <li>15 - Use water more efficiently for irrigation</li> <li>16 - Increase the number of livestock</li> <li>17 - Decrease the number of livestock</li> <li>18 - Diversify livestock feeds</li> <li>19 - Change livestock feeds</li> <li>20 - Supplement livestock feeds</li> <li>21 - Change veterinary interventions</li> <li>22 - Change types of animal species</li> <li>23 - Change animal breeds</li> <li>24 - Move animals to another site</li> <li>25 - Plant fodder on farmland</li> <li>26 - Store livestock feeds</li> <li>27 - Mix crop and livestock production</li> <li>28 - Change from livestock to crop production</li> <li>29 - Change from crop to livestock</li> <li>30 - Seek off farm employment</li> <li>31 - Set up non-farm business activities</li> <li>32 - Receive training in other livelihood activities</li> <li>33 - Migrate to another piece of land</li> <li>34 - Members of the household migrate to an urban area</li> <li>35 - Set up communal seed banks</li> <li>36 - Set up food storage facilities</li> <li>37 - Members seek casual or contracted agricultural employment</li> </ul> |
|              | <ul style="list-style-type: none"> <li>38 - Plant indigenous crops</li> <li>39 - Increase planting of trees in the community</li> <li>40 - Construct earth dams or community boreholes or protect springs</li> <li>41 - Start-up tree nurseries</li> <li>42- Construct community level soil and water conservation structures</li> </ul>  |

| <b>Farmer perceptions</b>   |  |
|---|--|
| Actively seeks agricultural advice                                  | 1 - Strongly Disagree<br>2 - Somewhat disagree<br>3 - Neither agree nor disagree<br>4 - Somewhat Agree<br>5 - Strongly agree |
| Community members respect cultural traditions around agriculture    |  |
| Ability to try new things   |  |
| Values agricultural information, technology and weather information |  |
| Protects natural resources  |  |
| Believe in traditional solutions for agriculture                    |  |
| Often first to try new things                                       |  |
| Agricultural decisions concerned about generating income            |  |
| Willing to accept advice from outside sources                       |  |
| Active role in community  |  |
| Finds it important to have protection over property rights          |  |
| Community is welcoming of new ideas                                 |  |
| Changes they have made will help vulnerability to climate change    |  |
| Farm inheritance  |  |

**Table 1:** Variable definition