RISK PERCEPTIONS, ATTITUDES, AND CLIMATE CHANGE ADAPTATION BEHAVIORS: A CASE OF FARMERS IN NYABIHU DISTRICT, RWANDA

By

Jean François Regis Nisengwe

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ABSTRACT

RISK PERCEPTIONS, ATTITUDES, AND CLIMATE CHANGE ADAPTATION BEHAVIORS: A CASE OF FARMERS IN NYABIHU DISTRICT, RWANDA

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Although risk perception and risk attitude have been separately studied as factors that affect risk behaviors, there is a dearth of studies that investigate the interaction between risk perception and risk attitude and how their combination can explain risk behavior. The study argues that both risk perception and risk attitude can be used as determinants to predict whether farmers will take up adaptive measures. This study seeks to improve understanding of farmers' behaviors, especially in the face of climate risk. The study was carried out in 9 sectors and a survey was administered to 313 randomly selected respondents. Descriptive statistics were used to describe the data. Logistic regression results showed that factors like access to forecast information, belonging to a cooperative, experience with floods have a significant effect on farmers' adaptive behaviors. Risk perception and risk attitude both have an effect on adaptive behaviors but the effect was not found to be significant. Results show that policies or programs that encourage farmers to participate in cooperatives and improve farmers' access to forecast information can lead to adaptive actions. Gathering accurate information on risk perception and risk attitude is challenging and needs further work.

Keywords: Risk perception, risk attitude, adaptive behaviors.

To my late parents, this thesis is dedicated.
How I wish you were here!

"A university is not about results in the next quarter; it is not even about who a student has become by graduation. It is about learning that molds a lifetime, learning that transmits the heritage of millennia; learning that shapes the future"

— Drew Gilpin Faust, President of Harvard University

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Introduction

Risk perception is important in understanding people's behavior (Slovic, Fischhoff, & Lichtenstein, 1982). In addition, understanding farmers' perceptions of climate change, adaptive measures, and decisions to adapt their farming practices is important to craft better policies and programs for adaptation to climate change, especially in the agricultural sector (Bryan, Deressa, Gbetibouo, & Ringler, 2009). People's orientation or predisposition towards risk, i.e. risk attitude, is also another important factor in understanding how people respond to risk (van Winsen et al., 2014).

Although risk perception and risk attitude have been separately studied as factors that affect risk behaviors, there is a dearth of studies that investigate the interaction between risk perception and risk attitude and how their combination can explain risk behavior (Keil, Wallace, Turk, Dixon-Randall, & Nulden, 2000). Both risk perception and risk attitude can influence people's behaviors under risk.

Farming provides a good case to study risk behavior, as it is ripe with risk from a number of sources, including production, price volatility, weather, and others (van Winsen et al., 2014). In particular, because this study investigates farmers' risk behaviors in the face of climate adaptation, the focus will be placed solely on risk posed by weather uncertainty, referred to hereafter as climate risk. Studying farmers' risk perception and risk attitudes is important for predicting their behaviors (Lucas & Pabuayon, 2011). The argument in this study is that both risk perception and risk attitude can be used as determinants to predict whether farmers will take up adaptive measures.

Policy-makers seek to understand farmers' decision-making in the face of climate change so as to design better adaptation policies. In order for policy makers to predict farmers' reaction to such policies, they need a better understanding of farmers' behaviors (van Winsen et al., 2014). Thus, the objective of this study is to improve understanding of farmers' behaviors, especially in the face of climate risk. Another important objective of the study is to contribute to the research field that studies people's risk behaviors through risk perception and risk attitude.

Rwanda is a country where extreme weather-related events have been reported and claimed considerable damages. In northwestern Rwanda, floods and landslides have claimed human lives and other resources. Farmers are the most affected by these events as they depend on rain-fed agriculture. This study investigates farmers' risk perceptions and risk attitudes in Nyabihu District in northwestern Rwanda, as it is one of the most affected by climate-related extreme events, floods, in particular (MIDIMAR, 2012b).

To attain its objectives, this study will resolve to answer the following questions:

1. How does risk perception affect adaptation behaviors?
2. How does risk attitude affect adaptation behaviors?
3. What are other determinants that influence adaptation behaviors?

Data were collected on 313 farmers randomly selected from 9 different Sectors of the District. A survey questionnaire was used to collect data on risk perception while a loss aversion experiment was carried out to collect data on risk attitude.

Literature review

While there exist various factors that influence decision-making, risk perception and risk attitude are known to be central (Keil et al., 2000). Risk perception can be regarded as "an assessment of the risk inherent in a situation" (Hamid & Rangel, 2013). Risk attitude refers to the tendency or propensity to take or avoid risk (van Winsen et al., 2014). Risk attitude can also be referred to as risk orientation, risk preference, and sometimes risk predisposition.

Risk perception and risk attitude

Definition of main concepts

Due to the confusion that often results from risk literature, below are the definitions of some of the main concepts on risk:

Risk: This is a result of uncertainty – lack of or incomplete information (ISO, 2009). Risk has two important aspects: the likelihood of a negative event to happen and its consequences (Rayner & Cantor, 1987).

Risk perception: This is described as an assessment or evaluation that an individual makes before making a decision whose outcomes are uncertain (Hamid & Rangel, 2013).

Risk attitude: This refers to the individual's current tendency (orientation, propensity, or predisposition) towards risk (MacCrimmon & Wehrung, 1985; van Winsen et al., 2014).

Risk behavior: This can be thought of as an action (or inaction) taken in response to a situation considered to be risky (Das & Teng, 1997); or a decision chosen while facing a situation with uncertain outcomes (Kahneman & Tversky, 1979).

Risk perception and climate adaptation

A decision is known to be risky when the consequences involved with taking that decision are uncertain. People's behavior under risk, i.e. risk behavior, depends on how they perceive the risk involved (Keil et al., 2000). Risk perception can be thought of as a subjective assessment of the likelihood of an event and the concern people have about the consequences of that event. Thus, risk perception too has the aspect of likelihood (probability) but also the concern about the seriousness (magnitude) of a given negative event or outcome (Sjöberg, Moen, & Rundmo, 2004)

Risk behavior, in this context, can be thought of as taking action in response to a risk; the outcomes of the action may be gains or losses depending upon the nature of the action (Das & Teng, 1997). Risk behavior is the actual behavior of a person when facing a risk situation (Bernd Rohrmann, 2005). In the context of climate change, risk behavior may refer to people's action to react to climate change as a risk. Farmers, for instance, may take action such as changing crops, changing planting dates, and other actions to react to climatic changes. This type of action reflects decision making at the farmer's level since farmers need to make decisions before they take any action.

The true nature of the effect of risk perception on decision-making is difficult to determine because of two reasons. First, among the studies that investigate different factors that affect decision-making only a small portion has directly measured risk perception. The second reason

lies in the fact that even studies that attempted to understand the relationship between risk perception and decision-making provided mixed and inconsistent findings (Keil et al., 2000).

Risk attitude and climate adaptation

Risk attitude may have an effect on decision making, especially in conditions that involve risk and uncertainty (Keil et al., 2000). In fact, it is known that it is risk attitude that leads to the actual risk behaviors (Weber, Blais, & Betz, 2002). However, one of the long-standing debates in literature on risk attitude revolves around whether risk attitude is a constant personal trait or a characteristic that depends upon a specific situation (Bernd Rohrmann, 2005). Some researchers argue that risk attitude or risk propensity is a personality trait that leads individuals to behave in a constant manner or demonstrate the same and consistent risk tendencies in different situations (Keil et al., 2000). Other studies, however, have described risk propensity as a situation-specific variable; this means that individuals may change their risk propensity depending on the situation (MacCrimmon & Wehrung, 1985; Bernd Rohrmann, 2005; Wang, Zhao, Zhang, & Wang, 2015).

Individuals tend to hold *domain-specific*[1] attitudes towards risk (B Rohrmann, 2008; Weber et al., 2002), which means the same people may demonstrate different risk tendencies in different domains - gambling, financial investment decisions, personal decisions (MacCrimmon & Wehrung, 1985). Thus, in order to predict individuals decision-making in a particular risk context, it is critical to assess the individuals risk propensity in that particular situation (MacCrimmon & Wehrung, 1985; Bernd Rohrmann, 2005). This suggests, for example, that if

[1] Domain specific means that same individuals may not necessarily exhibit the same risk tendencies or degrees of risk tendencies in different domains or situations. As such, individuals may change their risk their tendencies depending on whether they are gambling or making financial decisions, and so on (Lee & Blais, 2014; MacCrimmon & Wehrung, 1985; Weber et al., 2002).

one is interested in predicting decision-making in a climate risk context, then it is necessary to examine risk propensity in situations concerning climate risk decision-making, i.e. decision to take adaptive action. This study has focused on risk behaviors that farmers have towards climate risk.

Other determinants

There are other determinants that are known to influence people's risk behaviors apart from risk perception and risk attitude. These may include past experience with risk, access to information, social factors, and trust in public adaptation programs. This influence is mediated through risk perception or risk attitude and this is why some studies refer to these determinants as indirect determinants (van Winsen et al., 2014).

Experiential factors

In general individuals' experience of hazards or risk positively affects their risk perception; farmers who experienced climate-related experience, for example, are prone to have higher perception of climate risk (Le Dang, Li, Nuberg, & Bruwer, 2014)**.** According to the availability heuristic theory by Tversky & Kahneman (1973)**,** people judge risks based on the familiarity with images or examples of risk that they can picture in their minds. This means that people who have experienced a hazard in the past are likely to have a higher risk perception of that hazard. Le Dang, Li, Nuberg, & Bruwer (2014), for example, found that farmers who have experienced climate-related events like severe floods have a higher climate risk perception. Duinen et al. (2014) tested (and later confirmed) the hypothesis that the more often farmers have experienced financial damage due to drought events the higher their perception. This contention is

corroborated by other studies that found positive correlation between hazard experience (or damage) and risk perceptions (Botzen, Aerts, & Van Den Bergh, 2009; Kellens, Terpstra, & De Maeyer, 2013; Tang, Folmer, & Xue, 2013).

Access to information and sources of information

Information is of importance in risk literature because it affects risk perception; this is also relevant to understand individuals' decision to take adaptive measures. Having information about the effects of climate change may affect risk perception and adaptive behaviors (Le Dang et al., 2014). As Daniel et al. (2010) hypothesized, providing information leads to higher risk perception, which, in turn, leads to motivation to adapt.

Furthermore, Le Dang et al. (2014) observed that farmers may receive information from different sources such as neighbors, friends, relatives, local authorities, associations, or public media. This implies that not only is information about climate change important but also sources of information are equally as important; this is because different sources of information have differing reliability. This has implications on farmers in that some of them may have less reliable information than others. In case where farmers get information from their children for example, educating children about climate change and its effects may ensure that farmers get more or less reliable information. In areas where some farmers join associations or cooperatives and some others do not, the approach would be to encourage membership because associations or cooperatives may serve as good platforms to provide information about climate change.

Social factors

Relatively few quantitative studies have focused on the effect of social determinants of individual risk perception in the context of climate change (Van der Linden, 2015). However, risk perception can be linked to social norms; in fact, Lo (2013) observed that risk perception can be associated with behaviors through social norms. For example, Frank, Eakin, & López-Carr (2011) showed that farmers' social identity affects risk perception due to its influence on motivation; this has implications on adaptation behavior. As Van der Linden (2015) found, the more social referents – friends, family etc. – perceive climate change as a risk the more it increases one's individual perception. This is in alignment with the Social Amplification of Risk Framework (also known as SARF) introduced by Kasperson et al. (1988). According to this framework, not only are social and economic impacts of an event determined by physical consequences but also by an interaction of processes including social processes; other processes include psychological, social, institutional, and cultural processes (Renn, 2011). This framework states that risk perceptions are influenced by social norms via social networks (Duinen et al., 2014).

Trust in public adaptation

Risk perception can also be influenced by trust in public adaptation programs (Le Dang et al., 2014). This assertion is reconcilable with hypotheses put forward by both (Dang, And, & Johan, 2012) and (Grothmann & Reusswig, 2006) who argued that trust in public adaptation programs influences perception of climate risk. This has implications on risk behaviors; for example, it is argued that when farmers know that there is an adaptation program going on in the area they might be reluctant to take any adaptive measure (Dang et al., 2012). If, for example, a

government program seeks to manage a watershed in a flood-prone area, farmers in the area may decide not to take any adaptive measures because they believe the project will take care of that and thus reduce the danger of floods and losses. As such, trust in public adaptation endeavors negatively influences risk perception, and ultimately risk behavior.

However, although there is not enough literature on the counter-argument, it might be reasonable to posit that public adaptation could increase risk perception. This might be true because if farmers learn that the government is concerned about floods in their area, farmers might also be worried, thus increasing their risk perception. But this hypothesis needs to be tested and proven. Trust in public adaptation is an important factor because it is linked to risk appraisal (Dang et al., 2012), which is an important step in adaptation decision-making (Daniel et al., 2010; Grothmann & Patt, 2005).

Adaptation practices

Adaptation practices refer to adjustments meant to reduce vulnerability to observed or expected changes in climate (Adger, Agrawala, & Qader, 2007). A review of adaptation practices, especially in the context of smallholder farmers, identifies a number of practices most found in literature. These practices include diversification beyond farm such as off-farm income sources, migration, planting different crops, planting different plant varieties, changing planting dates, irrigation of farms, water conservation techniques, conservation agriculture, and others (Artner, 2010). Use of fertilizer is also considered as an adaptation in the agricultural context (Olarinde, Adepoju, & Jabaru, 2014). In this study, the adaptation practices considered are off-farm income, changing crops, use of fertilizer and changing cropping practices.

Theoretical framework and hypotheses

In the face of climate change, farmers need to take decisions to adapt. The model for this study discusses how risk perception and risk attitude influence farmers' decision to adopt adaptive measures. Other determinants that are believed to influence people's behavior, such past experience with risk, access to forecast information, and others, are also considered in the model along with the socio-demographic characteristics. The following figure depicts the big idea of the model whereby risk behavior is influenced by risk perception and risk attitude.

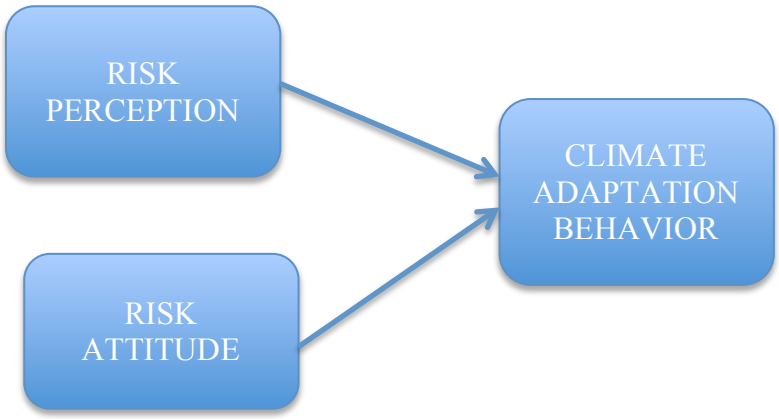

Figure 1: General theoretical framework

Risk perception

Virtually every decision is made in the face of uncertainty. A decision is considered risky when the consequences of the decision are uncertain. Different individuals assess the level or degree of uncertainty differently. The individual's assessment of a risky situation, which is perceived risk, is dependent upon the individual's psychological characteristics (Cho & Lee, 2006). Dowling &

Staelin (1994) argued that perceived risk motivates individuals to take certain actions. In the context of climate change, Daniel, Elyssa, and Pohl (2010) argued that the higher the risk perception the more likely people take up adaptive measures due to higher motivation. This leads to the first hypothesis:

Hypothesis 1: risk perception positively influences adaptive behavior. That means that the higher the perceived risk the more likely to adapt.

The interest in risk perception as a determinant of risk behavior gained interest in academic research as some researchers started to question the validity of studies that only consider socio-economic determinants to explain people's behaviors. In the context of climate change in particular, the Model of Private Proactive Adaptation to Climate Change (MPPACC) has been proposed by Grothmann and Patt (2005) to go beyond mere socio-economic determinants and capture the human cognition dimension of people's motives to engage in adaptive behavior. The model is known as a "socio-cognitive[2]" model. This model considers psychological steps involved in decision-making and it tries to understand the farmers' constraints to adapt. These constraints include risk perception and adaptive capacity. This model was developed from Protection Motivation Theory (PMT), which was originally intended for health risks (Grothmann & Patt, 2005).

[2] For further information about the socio-cognitive model see (Grothmann & Patt, 2005).

Risk attitude

Risk attitude is the propensity to take or avoid risk (Cho & Lee, 2006). Risk and uncertainty are important in economic decision-making and studying them may lead to a better understanding of individuals' economic behavior (Dohmen et al., 2011). Risk attitude is documented both in economic and psychological literature. From the economic perspective, risk attitude can be described in the *expected utility theory*, which explains how to choose rationally when outcomes are uncertain.

The framework of expected utility has been used extensively to explain individuals' behavior under uncertainty or risky situations. According to the theory, a decision maker makes a choice between risky or uncertain options or prospects by comparing their expected utility values, which are basically the weighted sums resulting from adding the utility values of outcomes multiplied by their respective probabilities (Mongin, 1997). What this implies is that in a risky or uncertain situation an individual makes a choice between alternatives and is assumed to have preference ordering and those alternatives can be evaluated using the expected utility function, the curvature of which is the measurement of risk attitude (J. M. E. Pennings & Garcia, 2001).

The use of expected utility theory as a way to describe individuals' decision-making in risky situations started with Daniel Bernoulli back in 1730s (see Bernoulli, 1954) and later formalized and justified by major contributions from Von Neumann & Morgenstern (1944). Since then, it has been considered the normative model for rational decision-making and has been widely applied as a descriptive model for economic behavior.

On the other hand, from the psychological perspective, risk attitude can be explained by the *prospect theory*, which is an alternative account of how to choose under uncertainty. The seminal paper by Kahneman & Tversky, (1979), put forward some of the major deviations from the expected utility theory and proposed the prospect theory, which is now believed to be the best candidate to account for making choices under uncertainty.

In this theory values are assigned both to gains and losses unlike in expected utility model where values are assigned to final assets. Additionally, probabilities are replaced by decision weights (Kahneman & Tversky, 1979). As Barberis (2013) observed, prospect theory managed to capture well the experimental evidence on decision making under risk and uncertainty, including the violations of expected utility theory; thus it is still widely regarded as the best account of how individuals evaluate risk in experimental settings. Prospect theory features four important elements, namely: (1) reference dependence, (2) loss aversion, (3) diminishing sensitivity, and (4) probability weighting.

First, In contrast to expected utility theory that postulates that individuals derive utility from absolute levels of wealth, prospect theory posits that individuals can get utility from gains and losses, which are measured in relation to a reference point, rather than from absolute degrees or levels of wealth. The idea that people derive utility both from gains and losses, which is measured in relation to a reference point, is considered to be the main idea of the prospect theory (Barberis, 2013).

Second, as for loss aversion, the distinctive feature is the idea that people are much more sensitive to losses—even small losses—than to gains of the same magnitude. For instance, in a hypothetical gamble of (-$500, ½; $510, ½) it was found that while it might be attractive according to the expected utility model since the expected value is positive, risk-averse individuals, on the other hand, tend to find this gamble unappealing. This is simply because for risk-averse individuals, the pain of losing $500 outweighs the gain of $510. As Rabin (2000) argued, you cannot account for this fact using expected utility model, thus the use of prospect theory.

The third element, diminishing sensitivity, describes how individuals are more prone to be risk averse over moderate probability gains. That means they prefer a certain gain of, say, $500 to a 50% chance of $1,000. Furthermore, individuals tend to be risk preferring over losses; that means they prefer a 50% chance of losing, say, $1,000 to losing $500 for sure[3]. In other words (Barberis, 2013; Kahneman & Tversky, 1979).

The fourth, and last, element of the prospect theory is probability weighting. It stipulates that individuals do not weight outcomes by their objective probabilities but transformed probabilities (or decision weights) instead. What this means is that low probabilities are overweighed and high probabilities underweighted by the weighting function. In other words, people tend to overweight extreme events. For instance, people who are offered a minimal probability, say 0,001 of gaining a large sum of money, say $5,000, tend to overweight the gamble by weighting it by more than

[3] In other words, the value function is concave in the region of gains but convex in the region of losses (Barberis, 2013; Kahneman & Tversky, 1979).

0,001, although they know exactly that the chance they have is just 0,001 (Barberis, 2013; Kahneman & Tversky, 1979; Tversky & Kahneman, 1992). The weighting function is further and better explained and applied in a new variant of prospect theory, known as *Cumulative Prospect Theory*, which is basically an improved version of the theory. This study, however, will not discuss the theoretical differences between the two variants[4].

Endowment effect

One of the applications of the prospect theory is the *endowment effect*. As explained above, the utility function of the prospect theory exhibits the loss aversion and diminishing sensitivity elements such that people are more sensitive to losses than gains in relative to a reference point. Different experiments of endowment effect have confirmed this feature of prospect theory (Barberis, 2013).

The endowment theory has two characteristic features, one of which is *exchange asymmetry*, which posits that initial allocation has a considerable effect on subsequent choice; this observation is in sheer contrast with the traditional economic theory that stipulates that preferences do not depend on initial allocation (Knetsch, 1989). The explanation for this observation - exchange asymmetry - is the underlying psychology of *loss aversion*. Basically, in an endowment (exchange asymmetry) experiment setup, people tend to stick with their initial endowment (Barberis, 2013; Knetsch, 1989). The endowment effect is essential to this study because, as will be explained later, respondents were given endowment as part of the experiment to collect data on risk attitudes.

[4] For a detailed account of theoretical differences between prospect theory and cumulative prospect theory see (Fennema & Wakker, 1997)

Risk attitude in this study is conceptualized as a construct that can influence behaviors under uncertainty; for instance, farmers' adaptive behaviors in the face of climate risk may be influenced by their attitudes towards risk. It is expected that the more farmers are willing to take risk (i.e. the higher the risk attitude), the less prone they are to take adaptive measures, like changing crops or changing planting dates. This prompts another hypothesis of the study:

Hypothesis 2: farmers' risk attitudes negatively influence their adaptive behaviors.

Other determinants

Apart from risk perception and risk attitude, there are other determinants that are known to influence people's risk behaviors; these may include past experience with risk, access to information, social factors, and trust in public adaptation programs. This influence is mediated through risk perception or risk attitude and this is why some studies refer to these determinants as indirect determinants (van Winsen et al., 2014). This is corroborated by other studies that placed perception and attitude at the center of the risk behavior while recognizing other indirect determinants (Cho & Lee, 2006; Keil et al., 2000). These determinants were used as controls in many studies in the beginning and it was found that each of them had an influence on risk behaviors. This is why it is important to consider them while studying risk behavior (van Winsen et al., 2014).

Past experience

Experiential factors, such past experience with a certain risk, are known to affect people's behaviors. In general, individuals' experience of hazards or risk positively affects their risk perception; farmers who experienced climate-related experience, for example, are prone to have higher perception of climate risk (Le Dang et al., 2014)**.**

Past exposure may also influence risk attitude. Van Winsen et al., (2014) showed how past experience with risk tends to have a positive and significant effect on people's risk attitude. That means that farmers who experienced more risk in the past will be more averse to risk in the present. Furthermore, it was shown that farmers' past experience can be related, positively and significantly, to perceived risk. That is, farmers who had experience with risk in the past will have a higher risk perception in the present.

This prompts the next hypothesis:

Hypothesis 3: Past experience with floods positively affects risk behavior.

Access to information

It is also important to recognize that access to information is another determinant of risk behavior. For example, having access to weather information may affect people's perception, and ultimately their behavior (Le Dang et al., 2014). Moreover, sources of information may constitute an important determinant of risk behavior (Daniel et al., 2010).

***Hypothesis* 4**: Access to information positively influences farmers' risk behavior.

Social norms

Social factors may affect risk behaviors through risk perception. Lo (2013) observed that risk perception can be associated with behaviors through social norms. For example, Frank, Eakin, & López-Carr (2011) showed that farmers' social identity affects risk perception due to its influence on motivation; this has implications on adaptation behavior. As Van der Linden (2015) found, the more social referents – friends, family etc. – perceive climate change as a risk the more it increases one's individual perception.

***Hypothesis 5*:** Farmers whose friends are concerned or are taking actions tend to take adaptive measures.

Theoretical framework

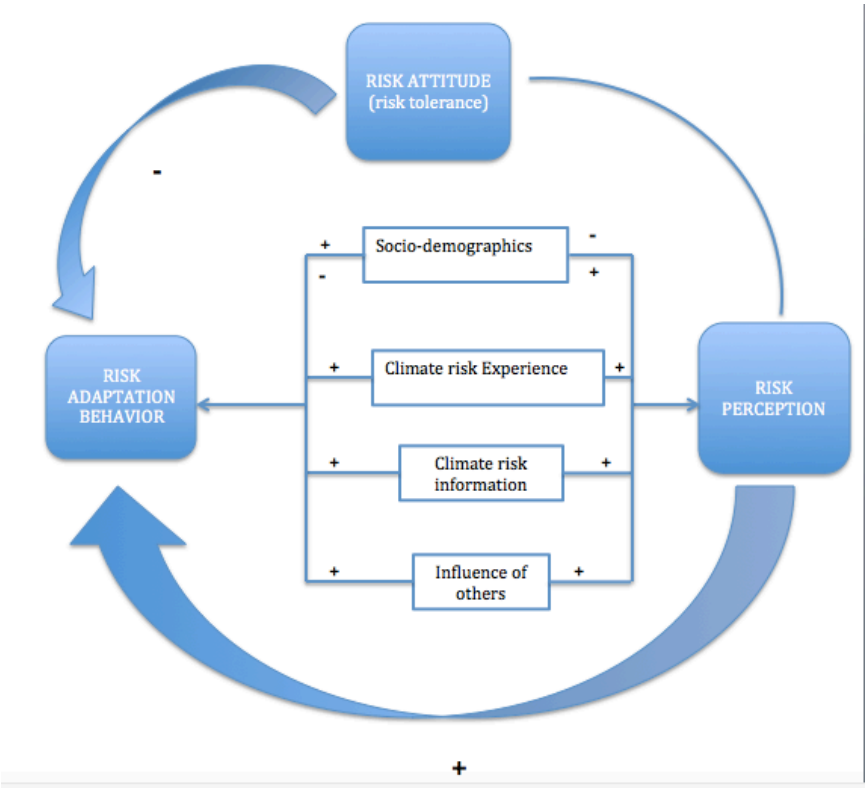

Figure 2: Detailed model for the study

This study will focus on risk perception and risk attitudes. As such the model for this study is grounded in understanding the factors that affect risk perception and risk attitude. There are a

number of factors that are hypothesized to affect risk perception and risk attitude and this study sets out to investigate them. As already discussed, these factors include not only risk attitude and risk perception but also socio-demographics (S. Van der Linden, 2015), experiential factors (Le Dang et al., 2014), social factors (Lo, 2013), trust in public adaptation program (Dang et al., 2012), access to weather information and information about climate change (Daniel et al., 2010). As such, this study is grounded into the conceptual model that includes all these factors and how they influence risk perception.

Methods

Study area

The study was conducted in Nyabihu District in Western Rwanda. The District has twelve (12) sectors, 73 cellules and 474 villages (Imidugudu) and has a surface area of 515,2 kilometer square (Zimmerman & Byizigiro, 2012). As of 2012, its population was 294,740 and the population density was 555 inhabitants per kilometer square (MINECOFIN, 2015). Its altitude ranges between 1,460 m and 4,507 m and the climate is mild in general; the average temperature is 15 degrees Celsius with rainfall of 1,400 mm per year. The economy heavily depends on agriculture, which provides most of the labor as well as food for the population.

Rwanda is vulnerable to natural disasters and the most affected areas are the districts in the north and west of the country, namely, Nyabihu, Musanze, Burera, Rubavu and others (MIDIMAR, 2012a). According to the Rapid Risk and Capacities Assessment and Livelihoods Profiling by the Ministry of Disaster Management and Refugee Affairs (MIDIMAR) and the International Organization of Migration (IOM), Nyabihu District is among the Districts that are at risk because of their exposure to floods and landslides (Zimmerman & Byizigiro, 2012). It is also one of the districts identified as vulnerable to climate-related natural hazards. More specifically, Bigogwe, Genda and Mukamira sectors were found to be more vulnerable to floods.

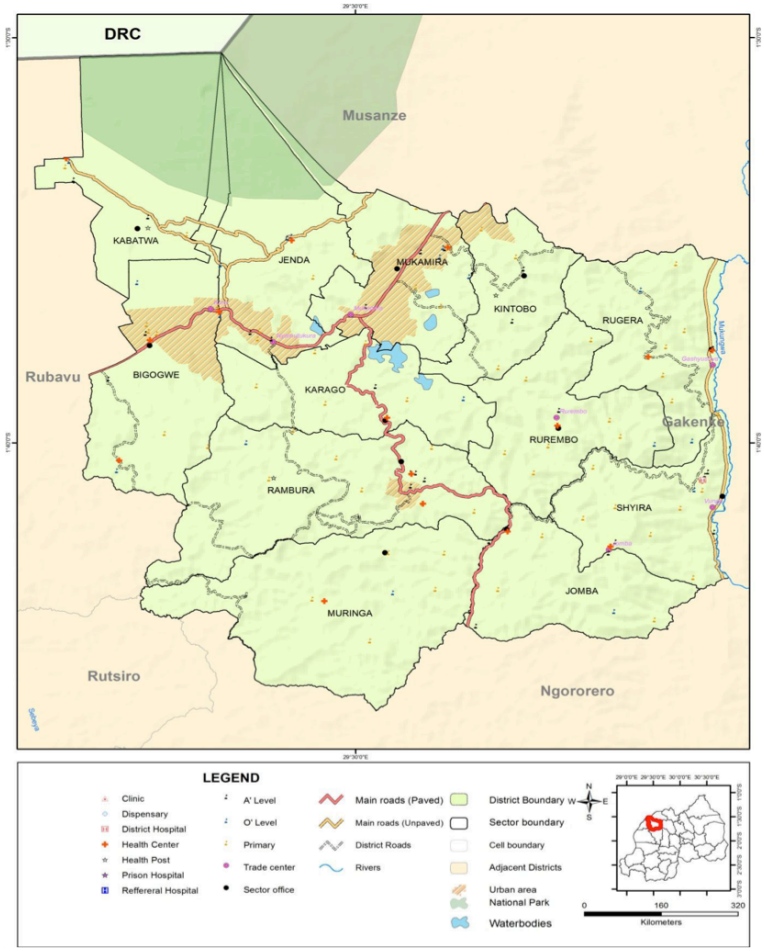

Figure 3: Administrative map of Nyabihu District (Source: NISR)

Study design

The study was carried out in 9 sectors out of the 12 sectors that constitute Nyabihu District. These sectors are Kintobo, Mulinga, Karago, Mukamira, Jenda, Rambura, Rurembo, Jomba, and Bigogwe. The approach was to collect data from farmers from those sectors in an effort to understand their perceptions of climate risk and their attitudes towards risk. All the farmers from

these sectors were randomly selected then a survey questionnaire and a loss aversion experiment were applied to gather information about risk perceptions and risk attitudes, respectively.

Data collection

In this study the population was constituted of all the farmers in the 9 Sectors that were covered by the study. The sample of this study was made of 313 respondents who were randomly selected from the farmers in those Sectors. The data were collected between end of July 2015 and end of August 2015 by the researcher and 4 research assistants who were trained and briefed for this specific data collection.

Random cluster sampling was used to collect data and this was prompted by the geographic characteristics of the region. Nyabihu District is a very mountainous region and people are settled at widely and sparsely spaced intervals. In most cases there was a considerable distance between one household and the next one. It took mostly 3 Km (around 1.8 miles) to get to the next house and sometimes it was further than that. It was rare to find centers where people lived in groups or settlements.

The sampling frame was the administrative surface area (block) of the District of Nyabihu. Different sectors of the District were the clusters and farmers in these clusters together constituted the population. From these clusters respondents were chosen randomly and they constituted the sample for the study.

The idea was to go to every sector and try to select farmers as randomly as possible. There are farmers that we found in their households but also there are others that we found in the field. If we found two or more households that were close (which was rare) we would ask one person in one household and skip the next house or the second next depending on whether there was someone in the house. For those that we found in the field, we could only ask a few of them that we chose randomly and we asked them separately at different spots in the field.

A survey was administered to 313 respondents to gather information on risk perceptions, risk attitudes, and risk behaviors. A questionnaire was used to collect data on risk perceptions (and socio-demographic information) and an experiment was used to collect data on risk attitudes. The survey was designed such that it had two distinct sections. The first section (questionnaire) was meant to elicit risk perceptions and other information from farmers while the second section (loss aversion experiment) was specifically designed to elicit farmers' risk attitudes. The survey also featured questions meant to gather information about socio-economic, demographic data, and some other information about farmers' livelihoods. These included things like sources of income, assets, land ownership, participation in cooperatives, and others. As such, the survey gathered information about socio-economic characteristics, risk perceptions and risk attitudes. After responding to questions about socio-economic characteristics and risk perceptions the same respondent would continue with the experiment.

All these questions about socio-economic characteristics, risk perceptions and the experiment about risk attitudes were administered using one tool, QuickTapSurvey, which is a survey

application for iPads, tablets and smartphones. Thus, all the data for this study were collected using iPads and smartphones.

Obtaining information about proportions

One of our data collection challenges was to obtain data about proportions. For example, after asking farmers about the sources of their incomes, we wanted to know the proportions of these sources. If a farmer said that their income comes from crops and agricultural labor, we would ask them how much comes from crops and how much comes from agricultural labor. It is clear that it would be difficult for farmers to know in exact terms the proportions or percentages of these sources, especially if it were more than two sources. To obtain information about percentage distributions, we would show respondents ten marbles and explain that the ten marbles represented 100 percent of the item of interest with each marble representing 10 percent. In the case mentioned above, for instance, we would show them ten marbles and ask them how many marbles would represent the amount of income that comes from different sources such as crops, livestock and agricultural labor. The same technique was used to collect information about proportions of crops farmers grow or grew, especially in case where a farmer grows different types of crops. It should be mentioned that these are not accurate measures but rather estimations by farmers of what they thought these measures were.

Risk perceptions: with regards to risk perceptions, respondents were asked to respond to questions that are related to the likelihood and severity of climate-related hazards. This is

because both likelihood and severity are known to be the two aspects of risk perceptions (Rayner & Cantor, 1987; Sjöberg et al., 2004). Thus, the survey had a set of questions meant to elicit farmers' perceived likelihood of the climate-related event (floods in this case) and another set of questions meant to elicit farmers' perceived severity of the flood consequences. Specifically, these questions are meant to ask farmers how they would rate the likelihood and seriousness (or severity) of the consequences of the floods.

In both cases, a 5-point Likert Scale was used to collect their responses. For perceived likelihood, the scale ranged from absolutely unlikely (1) to absolutely likely (5). For perceived severity, the scale ranged from not severe at all (1) to extremely severe (5). This method of measuring risk has been used by (O'Connor, Bord, & Fisher, 1999) and (Leiserowitz, 2006) who developed standard risk perception items and other studies (S. V. an Der Linden, 2014; S. Van der Linden, 2015) have drawn on that and measured risk perception. Most of those studies, however, used a 7-point scale but as Le Dang, Li, Nuberg, & Bruwer (2014) argued, while a more-point scale is preferable because of its increased sensitivity, it also demands increased effort in responding to questions. That point considered, this study used a 5-point scale to make it easier for farmers to respond.

Additionally, information about various factors that affect risk perceptions was collected. These factors, as discussed in previous sections of this study, include experiential factors, social factors, and others. Thus, the survey had questions about those factors such as experience with floods, access to information, trust in public adaptation, and others.

Risk attitudes: Experimental technique was used to study farmers' attitudes towards risk. This study used lottery choices whereby farmers were given a number of different decisions to make in the face of risky choices or options. This technique, which involved real monetary incentives has also been used by Binswanger (1980) while studying farmers' attitudes in rural India and Holt & Laury (2002) have used it when they were studying the effect of incentives in studying risk aversion. Other studies (Tanaka & Munro, 2014; Walker, 1981) have also used experimental designs to study farmers' risk attitudes.

As Lucas & Pabuayon (2011) reiterate, the advantage of using an experiment in studying farmers' risk attitudes is that the researcher has control over the decision environment. Decision choices are presented to farmers and the payoffs are real monetary incentives which mean farmers are paid with real money at the end of the experiment as opposed to hypothetical experiment with no real payoff (see for example, Lucas & Pabuayon, 2011). There is a probability *p* for a farmer to get payoff for a given choice made. The monetary values represent the amount of the payoffs to be gained for every choice made. It is critical that farmers understand the rules of the lottery; this is why during the elicitation process in this study, farmers were given the opportunity to ask as many questions as possible until they had a good understanding. To ensure that they understand, farmers were asked to explain what would happen if they made a certain choice.

The experiment setup

Each respondent was asked to make one choice among five possible options. Each option was represented by a circle, which had a pair of amounts. That pair of amounts represented two possible payoffs with each payoff having an equal 50 percent chance of occurring. That means there were five circles with varying pairs of possible payoffs (see the figure below). The researcher or research assistant would explain to the respondent what each circle represents and make sure the respondent fully understands the experiment. To do that the researcher or research assistant would ask the respondent what his or her choice would entail.

After making sure that the respondent understands the experiment, he or she was given an endowment of RWF 2,000 before making a choice. This endowment made the experiment a loss experiment, as opposed to a gain experiment in which a respondent faces an equal chance of gaining or not gaining. The loss experiment was preferred to the gain experiment because it resembles farmers' decision making in the face of uncertainty such as that posed by climate.

The game was setup such that the overall expected value was RWF 1,500, which is roughly a daily wage of a farmer in Rwanda. As such, the idea of a possible payoff served as an incentive for farmers to participate in the interview and a compensation for their time.

The possible choices are shown in the table below:

No	Endowment	Possible payout amounts		Expected value
1	2,000 RWF	- 1,000 RWF	- 1,000 RWF	1,000
2	2,000 RWF	- 1,300 RWF	-200 RWF	1,250
3	2,000 RWF	- 1,500 RWF	+ 500 RWF	1,500
4	2,000 RWF	-1,700 RWF	+ 1,200 RWF	1,750
5	2,000 RWF	- 2,000 RWF	+ 2,000 RWF	2,000

Table 1: Table showing different possible payoffs and the expected values

Please notice the positive and negative signs before the amounts. Any amount that has a positive sign means that a farmer would gain that much while a negative sign implies that a farmer would lose that much. It is also important to remember that farmers start with an endowment of RWF 2,000. For example, -1,000 RWF means taking RWF 1,000 from the endowment, in other words, losing RWF 1000 and remaining with RWF 1,000. While on the other hand, say, +1,200 RWF means gaining RWF 1,200 more, in other words accumulating RWF 3,120 (endowment plus RWF 1,200).

Depending on which category a farmer falls into, he/she would be categorized as risk averse or risk preferring/tolerant. Choice 1 (-1,000/- 1,000) is very risk averse while choice 5 (- 2,000/+ 2,000) is very risk tolerant.

It is also important to note that the five circles that represented different choices were positioned in a circular arrangement (see figure below) on the paper in order to avoid any leading hints to

farmers, which would bias their choices. This caution stems from the argument that if presented with a line of circles, farmers may think that the circles are arranged in order of importance, in which it would lead to biased decision making.

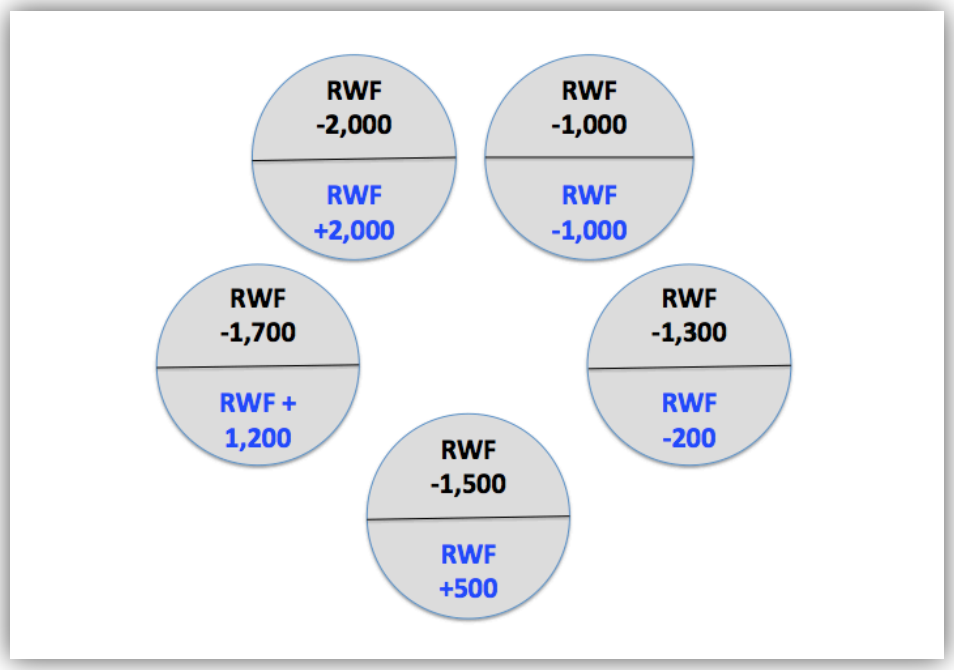

Figure 4: Possible payoffs as they appeared on the paper

When a farmer had made his or her choice and picked his or her preferred option on the paper it was time to determine which amount of payment a farmer would get. For example, if a farmer had chosen a -1,500/+500 circle, how to determine whether he or she would give RWF 1,500 back or earn RWF 500 more? To do this, a lottery was played using marbles of different colors. Ten marbles were placed into a paper bag; five marbles were of yellow color and other five marbles were of blue color. A farmer would randomly (without looking into the paper bag) pick one marble from the bag; if a marble was blue, then a farmer would be considered to have won and would get the higher amount. On the other hand, if a farmer picked a yellow marble, in that case, he would be given the lower amount.

So for example, if a farmer chose the pair of (-1,000; -1,000), his or her payment would be RWF 1,000 since both numbers are the same and so it doesn't matter if the marble is yellow or blue. However, if a farmer chose (-2,000; +2,000), and if the marble were blue, then he/she would get RWF 4,000 (RWF 2,000 plus the endowment); but if the marble were yellow he/she would remain with nothing because he/she would have to give back the endowment. Another example might be when a farmer chose, say, the pair (-1,500, +500); that means that he or she would get RWF 500 (endowment minus RWF 1,500) if the marble were yellow or get RWF 2,500 (endowment plus RWF 500) if the marble were blue.

It is very crucial to note that while carrying this experiment, there were two important assumptions. One was that farmers understood the experiment. This is why, as explained earlier, during the elicitation process in this study farmers were given the opportunity to ask as many questions as possible until they had a good understanding. To ensure that they understand,

farmers were asked to explain what would happen if they made a certain choice. The second assumption was that farmers made choices based on their attitudes towards risk. This is critical as measures of risk attitudes in this study will be built based on the respondents' choices.

Loss aversion experiment (Narrative)

In a few instances, farmers were reluctant to take part in the risk attitude experiment because it involved real monetary endowment and possible monetary payoffs. As explained in the experiment section, there was a RWF 2,000 endowment at the beginning of the experiment and a possible pecuniary payoff or loss at the end.

Farmers who hesitated and/or opted out of the experiment were reluctant for one of two reasons. One group said that they were afraid that we researchers and research assistants would trick them and steal their money. This fear is grounded in the prevalent belief in rural areas that there are tricksters from big cities who cheat people by giving them fake money, which later turns into ordinary note-sized papers. Ostensibly, when this happens people end up losing their actual money in their purses. Purportedly, this is common in Kigali, the capital city, where these con people give people fake money, which turns into papers a few hours later. It is not clear whether this true or not, but some people in rural areas strongly believe in this and hold that people from cities can do that to people in rural areas. This has led people in rural areas into having a conception that they must beware people from the capital city, especially when they offer to give them money. In our survey, a few farmers hesitated into participating in the experiment on grounds of fear that we might give them fake money and possibly making them lose their actual money.

Another reason for reservation was religion. Like in the case of fearing to be tricked, farmers in some sectors, because of their religious beliefs, were reluctant at first when they heard that the survey included a section that involves real money. They held that taking part into an experiment that involves money goes against their religious beliefs. It just did not feel right to them. However, upon thorough explanation of the experiment and its legitimacy, some farmers would accept taking part while some others would refuse to take part altogether. Whenever farmers declined to take part, we would move to another farmer, and so on. At the end of the day, only three farmers who participated in the survey declined to take part in the last section that involved money.

Between those who feared being cheated and those who objected on religious principles, three farmers out of 313 did not participate in the experiment. In other words, out of 313 farmers who responded to the survey, 310 took part in the whole survey including the experiment and three completed the survey but not the experiment.

Checking whether farmers understood the game

As already explained, the risk attitude experiment rested on a couple of assumptions, one of which is that farmers must understand the experiment and why they chose what they chose. How did we know that farmers understood the experiment?

First off, we tried our best to explain what the game was about and why we wanted them to participate in the experiment. It was made clear that the point of the experiment is study farmers' attitude toward climate-related risk.

To make the story of risk attitude clear to farmers, we would ask them to consider loss and gains in terms of seeds. For example, we would tell them the following:

> *Consider this endowment as your seeds. Now, in your usual life as a farmer, do you prefer to plant all your seeds? This means that if the weather is good and no floods happen, you will grow and reap more because you will have planted all your seeds. On the other hand, if the weather becomes bad and floods happen, you will lose everything.*
>
> *Alternatively, you can plant a portion of your seeds and if the weather is good you will grow and reap but not as much as you would have if you had planted everything. However, if the weather is bad, you will lose just a portion and save another portion that you did not plant, which you can plant later. There are different portions; you can plant half of your seeds, three quarters or less than a half. The more you plant the more you reap and the more you can possibly lose. The less you plant the less you grow and the less you can lose if things do not go well.*

The question is: how do we know whether the weather is good or bad? Since the weather is unpredictable, in our experiment we used a lottery to know whether it will be good or bad. That

means after a farmer had chosen an option which represents his portion he/she is willing to plant – which also implicitly reflects a portion he/she is willing to lose – we would ask them to pick randomly a marble from a paper bag. Depending on the color of the marble he/she chose we would know whether or not he/she would gain. There were 10 marbles, 5 of which were of blue color and 5 others were of yellow colors. Yellow represented good luck and good fortune, and blue represented bad luck and misfortune; that was the convention of our experiment. Illustratively, if you chose to plant everything and then picked the yellow marble that meant you would gain twice as much as you had risked. In real terms, that meant that if you put your entire endowment of RWF 2,000 at risk and drew a yellow marble you would get RWF 2,000 more, and go home with RWF 4,000. On the other hand, if you chose the blue one you would lose your endowment of RWF 2,000 and go home with nothing.

And farmers would start making their choices. But there was a caveat: every farmer would first tell us why he/she chose a given option and tell us what his/her choice would entail. This helped us ascertain the validity of their attitude and told us that they were not just picking randomly. For example, we started learning sayings we had never heard before. In one sector, one farmer told us that he wanted to choose the "plant all option" because of his belief in life as a farmer: *Homba, homboka!* When we asked him what that meant he explained to us and his reason can be loosely translated to "*come what may*". This is typical of a person who is risk preferring. Some other farmers had the same belief saying that they do not care whether they might lose everything as long as if they reap equally as much. Farmers who opted for that option were categorized in this study as risk preferring.

But not everyone wanted to risk everything. Some farmers were convinced that there is no point in planting all their seeds. What if the weather turns out to be bad? What if the floods hit again this year? They would argue. Farmers who said this opted for safer options. The safest of all options was the -1000/-1000 option. When asked why they chose this options, farmers who opted for this one argued that with this option they were 100 per cent sure that they would go home with RWF 1,000 in their pockets. That is the endowment of RWF 2,000 minus RWF 1,000. In the seeds analogy, they said that they were sure that even if the weather becomes bad and floods hit they are sure they will remain with half of what they had. This means that they will not reap as much as they would have if they had planted everything, but at least they are sure they only lose half of their seeds if things go wrong; thus, saving other half of their seeds for later.

And in between the two extremes – the –2,000/+2000 and -1,000/-1,000 – there were other options. These were options for farmers who did not want to choose the safest option or the riskiest options. For instance there are farmers, who, on the one hand, did not want to risk everything and, on the other hand, did not want to play it too safe by risk only half of their seeds. Instead, they opted for options that, though not too risky, involved varying degrees of risk – and varying degrees of potential gain. It was curious to find out why these farmers opted for the comparatively less obvious choices. These farmers explained their choices saying that they cannot risk everything but at the same time they would rather risk more than half of what they had – their endowment - in the hope that if things go well they would get more than what they would get if they only risk half of their endowment. To them, there was hope for losing less than RWF 1,000 (in the case -1300/-200 option) or, even better, getting more than just the endowment

they started with (in the cases of -1,500/+500, and -1,700/+1,200). Depending on how much they were willing to risk these farmers fell in those three categories (-1,300/-200, -1,500/+500, and -1,700/+1,200). Notice how the risk of losing increases as the chance of gaining more increases.

An important note is that although these three categories lie between two extreme categories of risk – loss averse and loss preferring – it might not be appropriate to categorize all of these options as risk neutral since, as is clear from the experiment, farmers made their choices based on varying degrees of risk they were willing to take. For instance, the -1,300/ -200 is closer to the risk aversion option than to risk preferring and this makes it a less accentuated version of risk aversion. In the same way, the -1,700/+1,200 option is closer to the risk preferring, which makes it an attenuated version of risk preference. However, the -1,500/+500 lies right in the middle of all options and this makes it more of a neutral option than other options.

Econometric models and estimation methods

This study investigates how risk attitude and risk perception affect farmers' climate adaptation behaviors. As explained in earlier sections, in this study risk perception is reflected in variables such as perceiving changes in climate, change in rainfall, change in crop seasons, or flood threat. Risk attitude is reflected in the variable riskatt, which describes the results of the loss aversion experiment. These variables will be independent variables in the econometric model. Farmers' adaptation behaviors – the dependent variables in this analysis – are captured by different variables including changing crops, changing cropping practices, having off-farm income, and

use of fertilizer. All these variables are binary in nature and this means that the dependent variable in all cases will be binary.

Due to the binary nature of the outcome variable the right econometric model for this study is a binary model. The linear probability, which can be used to estimate the coefficients, was not deemed appropriate because its conditional probability is not constrained to lie between zero and one and, as Horowitz & Savin (2001) discuss, this is a defect while studying binary outcomes. To correct this defect it is advised to use a binary model that keeps the conditional probability between zero and one. When the probability function is a cumulative normal distribution it is called a *probit* model and it is called a logistic model when the probability function is a cumulative *logistic* distribution. Both of these models have similar shapes, except that the logistic one has fatter tails. This means that the conditional probability functions are (almost) similar for both models, except in the extreme tails. As a matter of an arbitrary choice, this study used logistic model. The econometric model assumes that there are a number of explanatory variables that affect farmers' adaptation behaviors. These explanatory variables are indicative of risk perception and risk attitude.

The probability that the outcome variable takes the value 1 is modeled as:

$$P(Yi = 1|xi) = F(zi) = F(\beta xi)$$

where β is a vector of parameters, xi represents a vector of independent variables and

$$zi = \beta xi$$

The probability function F can be transformed so that it is constrained between zero and one. In the logistic model, the transformation of function F is the logistic function. This leads to:

$$P(Yi = 1|\, xi) = \frac{e^{\beta Xi}}{1 + e^{\beta Xi}} = \frac{1}{1 + e^{-\beta Xi}}$$

The point of estimation is to estimate the unknown parameters β. As already discussed this study used logit model. Logistic (and probit) models are typically estimated by *maximum likelihood estimation* method, which means choosing the set of parameters for which the probability of the observed data is highest (Czepiel, 2012). This method is used because the maximum likelihood estimator has good properties in large samples. In particular, it is asymptotically efficient; that is, it is the most precise estimator in large samples (Horowitz & Savin, 2001). Moreover, this method was chosen not only because it is suitable for nonlinear functions but also because it is the unbiased estimation with the minimum variance as the sample increases (Wooldridge, 2013). This estimation rests on the strong assumption that the error term is normally distributed and homoscedastic. The maximum likelihood estimator is inconsistent in the presence of heteroskedasticity and robust covariance estimators cannot solve this (Schmidheiny, 2014).

$$P(riskbehavior = 1|\, X1, X2, X3, \dots)$$

$$= F(\beta xi) = F(\beta_0 + \beta X1 + \beta_2 X2 + \beta_3 X3 + \cdots .)$$

Transforming F gives:

$$\mathrm{P(Yi} = 1|\ \mathrm{xi}) = \frac{e^{zi}}{1 + e^{zi}} = \frac{1}{1 + e^{-zi}}$$

Thus:

$$riskbehavior = \beta_0 + \beta_1 X$$

Where: riskbehavior = farmers' adaptation behavior (outcome variable), X1 (independent variables)

In a non-linear model, like logistic model, there exists no way to fully depict the relationship between an outcome variable and an independent variable. This is mainly because estimated parameters from regression outputs offer no useful explanation for understanding the relationship between variables, which makes it difficult to interpret the results of a regression. One suggested way to provide a meaningful interpretation is to use the predicted probabilities and its functions such as ratios (Long & Freese, 2006). Thus, the results from various regressions in this study will be interpreted based on predicted probabilities. Another important point to make in this section is that the relationship between variables is reported based on estimated partial (or marginal) effects known as Average Partial Effect (APE), which means the weighted average of partial effects across the population at each independent outcome. This is important to note because there exists another way to do it, the partial effect at average (PEA), but was avoided in this

analysis because it is not suitable when some independent variables are binary, which is the case in this study.

Limitations of the study

Every research has limitations, often resulting from occurrences that go well beyond research's control. These limitations are important as they have a bearing on the interpretation of the results and the conclusions of the research (Simon & Goes, 2013). This study had its limitations too and it is fair to acknowledge them and suggest the way forward for future research.

One limitation regards the data collection approach. As already mentioned in the methods section, iPads, tablets, and smartphones were used to collect information. While these tools were chosen for their convenience – rightly so – they were not amenable to collecting some types of information that would have been useful for the study. For example, it was not possible to use open-ended questions in the survey. Although inputting text would have benefited the research it was not practical to let a farmer, or a research assistant for that matter, input text on a phone or iPad. This is a limitation because if we had used paper-based questionnaire it would have been possible. In the future, it will be more useful to consider using whatever means that allows more convenient and permitting options to collect as much information as possible.

The limitation with regards to measurement needs to be mentioned too. Risk perception and risk attitude are not easy variables to measure. With regards to risk perception, taking into account both the seriousness and the likelihood of the risk is usually recommended. However, in this study, both aspects of risk perception were not considered in depth. It will be important to go beyond the mere fact of perceiving change in climate and rainfall and seek to find out by how much severe and how likely farmers think the risks will be.

A loss aversion experiment was used to measure risk attitude. This was an attempt to measure risk attitude and thus should not be construed as an accurate measure of risk attitude. Moreover,

although care has been taken to set up the experiment so as to reflect the reality of farmers' risk attitude in decision-making, it is important to remember that it was an experiment. Thus, the results may not accurately reflect the reality but rather represents an approximation of farmers' risk attitude.

The study area for this research covered nine sectors of the district. However, the intention was to cover twelve sectors of the whole districts but due to the logistical and practical reasons, we have been able to reach to nine districts. A more thorough coverage will be important in the future to yield more refined results.

Results and discussion

This section presents the results of the study. Descriptive statistics were used to describe the results and to look at some relations between variables, and regressions were used to make some predictions. Socio-demographic information is presented first together with some economic indicators. Second, results on risk perception and other variables related to behaviors are presented. The last part of the section presents results from the loss aversion experiment/game.

Out of all respondents, almost 54 percent were females and 77 percent were married. The mean age of respondents was 38 years while the average of years of education was 4. Considering the maximum of years of education - 13 years – the average seemed to be low and this is because a bigger percentage of respondents – 22 percent - had no education.

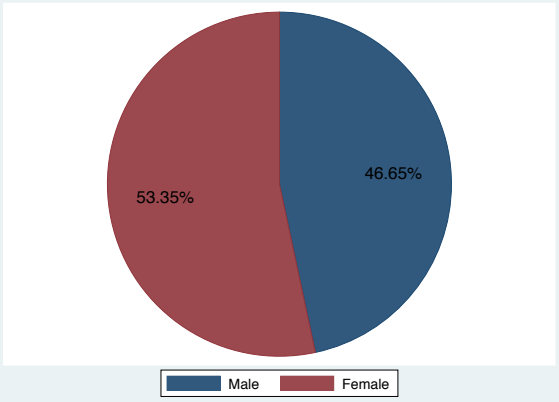

Figure 5: Gender of respondent

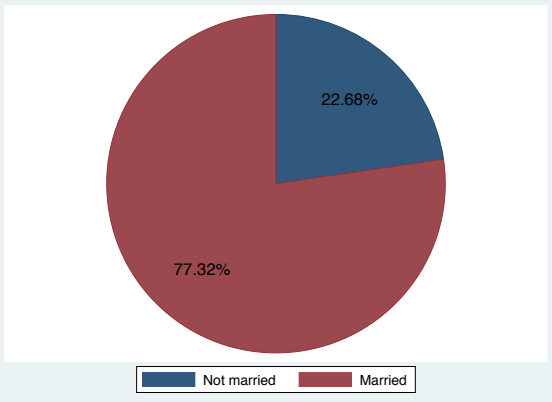

Figure 6: Marital status of respondents

Most farmers get their income from agricultural labor (67 percent), from crops (66.5 percent) and from livestock (34.2 percent). Hardly any get some money from relatives. On average, there are 2 adults in a household and 3 children.

Almost every farmer (97 percent) has a land to farm. The 3 percent who reported not having any land to farm still considered themselves as farmers because there is a possibility of farming in someone else's land or renting their land and still work as a farmer.

The following table describes other variables:

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
Age of the respondent	313	38.23	13.00	18	73
Education of respondent	313	4.211	3.345	0	13
=1, if has off farm income	313	0.249	0.433	0	1
=1, if has money from relatives	313	0.0160	0.126	0	1
=1 if has income from crops	313	0.665	0.473	0	1
=1 if has income from agricultural labor	313	0.674	0.469	0	1
=1 if has income from livestock	313	0.342	0.475	0	1
=1, if has income from other sources	313	0.0128	0.113	0	1
Number of adults in the household	313	2.441	1.317	0	9
Number of children in the household	313	3.163	2.013	0	10
Number of people in the household who can work	313	2.645	1.409	1	10
Do you have any land for farming,=1 if yes	313	0.971	0.167	0	1
=1, if has tile roof	313	0.802	0.399	0	1
=1, if has metal roof	313	0.214	0.411	0	1
=1, if has dirt floor	313	0.866	0.341	0	1
=1, if has cemented roof	313	0.0639	0.245	0	1
=1, if has radio	313	0.534	0.500	0	1
=1, if has tv	313	0.00639	0.0798	0	1
=1, if has bicycle	313	0.0224	0.148	0	1
=1, if has motorbike	313	0	0	0	0
=1, if has mobile phone	313	0.578	0.495	0	1
Number of assets	313	3.086	0.935	1	6
Size of the land (Ares)	313	23.65	53.33	0	500
Land owned (Ares)	313	11.64	39.10	0	400
Land rented out (Ares)	313	0.163	1.346	0	18
Land rented in (Ares)	313	5.750	16.61	0	200
Land size at the top of the hill (Ares)	313	5.883	21.97	0	200
Land at top of the hill, =1, if yes	313	0.275	0.447	0	1
Land size in the middle of the hill (Ares)	313	12.44	41.45	0	500
Land in the middle of the hill, =1, if yes	313	0.419	0.494	0	1
Land size at the bottom of the hill (Ares)	313	5.682	21.12	0	300
Land at the bottom of the hill, =1, if yes	313	0.403	0.491	0	1

Table 2: Descriptive statistics

Out of a number of assets, farmers reported to have radio (53 percent) and cell phones (58 percent). Only a small fraction of respondents reported having a bicycle and hardly anybody has a TV and nobody has a motorcycle. The average size of a plot of land is 24 ares[5].

Risk perception and other determinants

VARIABLES	(1) N	(2) mean	(3) sd	(4) min	(5) max
=1, if noticed changes in rain patterns in 5 yrs	313	0.95	0.21	0	1
Perceived changes in climate in five years, =1, if yes	313	0.96	0.19	0	1
=1 if climate consistently wetter than 5 yrs ago	313	0.32	0.47	0	1
=1 if climate consistently drier than 5 yrs ago	313	0.10	0.31	0	1
=1 if last year was very wet but not a trend	313	0.06	0.24	0	1
=1 if last year was very dry but not a trend	313	0.03	0.18	0	1
=1 if there is one specific year that was really wet	313	0.04	0.21	0	1
=1 if there is one specific year that was really dry	313	0.02	0.15	0	1
=1 if hotter than the past 5 yrs	313	0.35	0.48	0	1
=1 if colder than the past 5 yrs	313	0.17	0.38	0	1
=1 if other	313	0.01	0.08	0	1
=1 if no change	313	0.02	0.13	0	1
=1 if your crops affected by too much rain	313	0.44	0.50	0	1
=1, if noticed change in crop seasons	313	0.68	0.47	0	1
Did you change cropping practices?	313	0.54	0.50	0	1
Did you change crops in past few years?, =1' if yes	313	0.64	0.48	0	1
=1 if changed crops due to rainfall	313	0.12	0.33	0	1
=1 if changed crop due to pest and disease	313	0.12	0.32	0	1
=1 if changed crops due to market higher demand	313	0.19	0.39	0	1
=1 if changed crops due to decreased fertility	313	0.17	0.38	0	1
=1 if changed crops due to land consolidation	313	0.17	0.38	0	1
=1, if uses fertilizer	313	0.72	0.45	0	1
Amount of fertilizer in Kgs	313	50.31	153.2	0	2,500
=1 if you changed amount of fertilizer used	313	0.58	0.49	0	1
Receive forecast, =1, if yes	313	0.77	0.42	0	1
Was forecast useful?, =1, if yes	313	0.08	0.28	0	1

Table 3: Results from risk perception descriptives

[5] An are is a unit of area equal to 100 square meters (or 0.0247 acre). 100 ares are equal to a hectare.

Table 3 (cont'd)

Flood experience in one's life =1, if yes	313	0.82	0.38	0	1
Friends concerned about floods?, =1, if yes	313	0.75	0.43	0	1
Friends doing something about floods?, =1, if yes	313	0.59	0.49	0	1
Do you belong to a cooperative =1, if yes	313	0.59	0.49	0	1
=1 if discuss about climate change in cooperative	313	0.22	0.41	0	1
Flood threat to farm, =1 if yes	313	0.75	0.43	0	1
Is govt doing something to protect you from floods, =1 if yes	313	0.92	0.27	0	1
=1 if govt builds terraces	313	0.57	0.50	0	1
=1 if govt plants trees	313	0.17	0.38	0	1
=1 if other	313	0.18	0.39	0	1

Risk attitude results

Results from the risk attitude experiment show that more farmers mainly fell into two opposing extreme risk categories. Almost 35 percent of farmers fell in the risk tolerant category (- 2,000/+ 2,000) and 35 other percent fell in the risk averse category (- 1,000/ - 1,000). Both categories make up almost 70 percent of the responses while the rest of categories in between share the rest of the responses. The (-1300/-200) category, which is a variant of risk aversion, received the least (5 percent) responses. The following table describes the distribution of the responses.

Risk attitude			
Option	**Freq.**	**Percent**	**Cum.**
-1000/-1000	110	35.48	35.48
-1300/-200	16	5.16	40.65
-1500/+500	38	12.26	52.90
-1700/+1200	38	12.26	65.16
-2000/+2000	108	34.84	100.00

Table 4: Distribution of risk attitude

As shown in the results, it was clear that most farmers fell under two extreme categories: the riskiest and the safest. This is in line with findings from (Camilo & Carpenter, 2013) who also found the same pattern in risk aversion. They found that two extremes garnered the most responses from respondents in their study done in Latin America.

It is important to acknowledge that the intention was not to have an accurate measure of risk attitude – and that is very hard to attain, if possible at all – but rather an attempt to have a good estimation of farmers' attitude towards risk, especially in climate adaptation context. Nonetheless, the approach used to explain the experiment in terms of real life experience helped us draw conclusions from the experiment and extrapolate them to real life situations.

Risk behaviors results

As pointed in earlier sections, this study considered three practices as risk behaviors or adaptation practices. These are changing crops, changing cropping practices, and having an off-

farm income source. The results from the survey show that a quarter of respondents have off-farm income source while 54 percent reported to have changed cropping practices. Out of al respondents, 64 percent have changed their crops.

	(1)	(2)	(3)	(4)	(5)
VARIABLES	N	mean	sd	min	max
Off-farm income, =1 if yes	313	0.25	0.43	0	1
Did you change cropping practices?, =1 if yes	313	0.54	0.50	0	1
Did you change crops in past few years?, =1 if yes	313	0.64	0.48	0	1

Table 5: Risk behaviors

Discussion from regression analysis

Risk perception and adaptive behaviors

This section discusses the effect of perception on adaptive behaviors. The dependent variables are changing crops and use of fertilizers as means to cope with changes in climate. The predictor variables considered in this analysis are perceived changes in climate, rain fall and crop seasons. All of these are binary variables. The following table shows the results of the regression.

	(1)	(2)
VARIABLES	Changing crops	Use of fertilizer
Perceived changes in climate in five years, =1, if yes	0.227	0.166
	(0.148)	(0.129)
=1, if noticed change in crop seasons	0.101*	-0.0694
	(0.0576)	(0.0574)
=1, if noticed changes in rain patterns in 5 years	-0.147	-0.00996
	(0.148)	(0.135)
Observations	313	313

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 6: Results for risk perception and adaptive behaviors

Of all three independent variables considered in this analysis, only perceiving changes in cropping seasons proved to have a significant positive effect on adaptive behavior. The results show that farmers who have perceived changes in cropping seasons are more likely to adapt than those who have not. More specifically, perceiving changes in cropping seasons increases the probability of changing your crops in order to cope with changing climates by 10 percent. The direction of the effect is in line with what literature says. This leads to confirming the first hypothesis of the study that: risk perception positively influences adaptive behavior.

Risk attitude and adaptive behaviors

This section looks at the effect of farmers' risk attitude on their adaptive behaviors. Specifically, changing crops - adaptive behavior - is treated as an outcome variable and the risk attitude is considered as a predictor variable. The results show that as hypothesized, risk attitude negatively affects adaptive behaviors. This study found that changing from a risk neutral category (3) to a risk averse category decreases the probability of changing your crops by almost 30 percent and this finding is significant.

On the other hand, changing from a risk neutral category to a risk tolerant category increases the probability of using fertilizers by 21 percent. It is important to note that category 3 was considered as a base level in the analysis. The reason for this is that it helps to intuitively explain the change in categories from a more central category than when done from one side. In terms of risk attitude, it makes more sense to see how the effect goes from a risk neutral category to other categories in both directions.

VARIABLES	(1) Changing crops and risk attitude	(2) Use of fertilizers and risk attitude
Risk attitude = 1, -1000/-1000	-0.100	0.0593
	(0.0849)	(0.0898)
Risk attitude = 2, -1300/-200	-0.299**	0.181
	(0.143)	(0.125)
Risk attitude = 4, -1700/+1200	-0.0789	0.211**
	(0.105)	(0.0981)
Risk attitude = 5, -2000/+2000	-0.107	0.118
	(0.0852)	(0.0887)
Observations	310	310

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 7: Results for risk attitude and adaptive behaviors

The second hypothesis of this study stated that farmers' risk attitude negatively influence their adaptive behaviors. This study showed that risk attitude affects farmers' behaviors, however, the direction of the effect may change depending on the type of adaptation considered. As shown in the table above, on the one hand, the effect is negative on the behavior of changing crops for farmers who tend to be risk averse. On the other hand, the effect is positive on the behavior of using fertilizer for farmers who tend to be risk tolerant.

Adaptive behaviors and other determinants

The adaptive behaviors considered in this analysis, as shown in previous section, are changing crops and using fertilizer as a way to deal with changing climates. These are the outcome variables. The independent variables in this analysis are a number of variables that are known to have an influence on adaptive behaviors. In addition to these variables, this model included risk perception and risk attitude variables in order to see the effect that all of the variables have on behaviors. In previous sections, risk perception and risk attitude effects on farmers' behaviors were analyzed separately. However, this section analyses them together and that is the very basis of this research. The goal of this research is to understand how risk perception and risk attitude together affect farmers' behaviors. But also, there are other variables that influence adaptive behaviors. Thus, the following model recognizes all of these factors and put them into one analysis. The table below shows the results from the regression analysis.

VARIABLES	(1) Changing crops	(2) Use of fertilizer
Age of the respondent	0.000875	-0.00231
	(0.00232)	(0.00220)
Education of respondent	-0.00386	0.0161*
	(0.00947)	(0.00910)
Gender =1, if female	0.0254	-0.0184
	(0.0598)	(0.0574)
Marital status, =1, if married	-0.0873	-0.0564
	(0.0643)	(0.0615)
Sources of income	0.00261	0.00322
	(0.0378)	(0.0351)
Number of children in the household	0.00880	-0.0175
	(0.0144)	(0.0133)
Number of people in the household who can work	0.0154	0.00877
	(0.0227)	(0.0198)
Do you belong to a cooperative =1, if yes	0.131**	0.0250
	(0.0519)	(0.0509)
Friends doing something about floods?, =1, if yes	0.203***	-0.0765
	(0.0504)	(0.0519)
Number of assets	0.0295	0.0499
	(0.0334)	(0.0315)
=1, if noticed changes in rain patterns in 5 years	-0.247	-0.00699
	(0.157)	(0.145)
=1 if your crops affected by too much rain	0.00523	0.0326
	(0.0545)	(0.0515)
Receive forecast, =1, if yes	0.125*	0.0724
	(0.0656)	(0.0594)
Perceived changes in climate in five years, =1, if yes	0.0733	0.0734
	(0.149)	(0.135)
Size of the land (Ares)	-0.000177	1.07e-05
	(0.000537)	(0.000518)
Flood experience in one's life =1, if yes	-0.0277	-0.0770
	(0.0715)	(0.0676)
Land at top of the hill, =1, if yes	0.0308	0.0965
	(0.0736)	(0.0736)
Land in the middle of the hill, =1, if yes	0.00948	0.0169
	(0.0763)	(0.0750)

Table 8: Results for all determinants of adaptive behaviors

Table 8 (cont'd)

Land at the bottom of the hill, =1, if yes	-0.00916	0.0494
	(0.0728)	(0.0720)
Risk attitude = 1, -1000/-1000	-0.0528	0.113
	(0.0863)	(0.0890)
Risk attitude = 2, -1300/-200	-0.283**	0.243**
	(0.140)	(0.114)
Risk attitude = 4, -1700/+1200	0.00286	0.202*
	(0.102)	(0.104)
Risk attitude = 5, -2000/+2000	-0.0793	0.138
	(0.0857)	(0.0885)
=1, if noticed change in crop seasons	0.108*	-0.102*
	(0.0590)	(0.0587)
Observations	310	310

Standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Risk perception did not seem to change its effect on farmers' adaptive behaviors even after putting all variables together. Of all risk perception variables considered in the previous model and this one, having perceived changes in cropping seasons proved to be the only one with a significant effect. Specifically, it was found that, holding other things fixed, perceiving changes in cropping seasons increases the probability of changing your crops by 10-percentage point. This is expected according to the literature and the hypothesis of this research. This confirms the first hypothesis of the study: risk perception positively affects risk behavior.

In general, risk perception and risk attitude proved to have an influence on farmers' adaptive behaviors. Also there are other variables that were found have significant influence on risk behaviors. Additionally, risk attitude affects farmers' behaviors. The results show that changing from a risk neutral category to more or less risky categories affects farmers' adaptive behaviors.

One important note is that, unlike in a previous case where risk attitude was treated independently, a jump from a risk neutral to a risk averse category had a significant effect on the use of fertilizer – not just changing crops - and the direction of the effect is positive, unlike the first scenario. The table above shows that this jump increases the probability of using fertilizers and is significant. That means farmers who are risk averse are more likely to take adaptive measures than those who are risk neutral. This is in line with the second hypothesis of this study.

Contrary to the third hypothesis of the study, results showed no significant effect of past experience on farmers' behavior. This means that having experienced floods in one's life had no detectable effect on their behavior. Admittedly, this was not expected as the literature – and common sense – shows that people who experience floods tend to act in reaction to the events by, for instance, taking adaptive measures. However, from the analytical standpoint, it may make sense because it was found that the striking majority of the people sample (82 percent) has experienced floods; this lack of variation in responses may not result in a strong detectable effect.

There are other determinants too. Those that proved to have a significant effect on adaptive behaviors include having access to forecast information (at $p<0.05$). Having access to information increases the probability of changing crops by almost 12-percentage point as well, holding other variables fixed. This confirms the fourth hypothesis of this study, which states that: access to information positively influences farmers' risk behavior. Equally significant was the influence of having friends who are doing something about climate-related events such as floods. The results show a significant positive increase in probability to change crops (close to 26 percentage point) when a farmer has friends who are dealing with floods. This supports the fifth

hypothesis of the study, which puts forward the idea that farmers whose friends are concerned or are taking actions tend to take adaptive measures. Also, it was found that belonging to a cooperative increases the probability of changing crops by 13-percentage point (at $p<0.01$), holding other variables fixed. These results confirm that influence from others is crucial in deciding and taking adaptive action.

Education was also found to have an influence (only at $p<0.1$) on the use of fertilizer. This means that one more year of education tends to increase the likelihood of using fertilizer. In other words, farmers with more education are likely to use fertilizers. The number of assets in the households also proved to have an influence on the use of fertilizer (significant at $p<0.1$). This points to the fact that having more assets, which is an indication of wealth, increases the chance of buying and using fertilizer as a way to respond to changes in climatic conditions.

Conclusions and recommendations

Conclusions

This study attempted to look at how farmers' perception of and attitude toward risk have an influence on how they behave. This was applied in the context of climate risk and how farmers behave towards this risk. The main conclusions of the research are that risk perceptions and risk attitudes do affect farmers' adaptive behaviors. Moreover, considering risk perception and risk attitude together can give a better way to understand their effects on farmers' risk behaviors, as opposed to analyzing them separately, as has been done by previous studies.

Apart from risk perception and risk attitude, there are other factors that influence farmers' behaviors. It is important to include them in the model to better understand farmers' adaptive behaviors. The determinants that were found to be significant are being part of a cooperative, having friends who are doing something about climate-related events. This shows that influence from others is a critical component of farmers' adaptation. Access to forecast information was also found to be a good predictor of farmers' adaptation. Education was found to positively affect the use of fertilizer.

It is worth acknowledging that one of the conclusions of this research is that is difficult to accurately measure people's perceptions and attitudes. In future studies, it will be important to explore other methods and see if it will improve the measure of perception and attitude. Another important realization is that to better capture the perceptions of farmers it will also be important to consider using qualitative methods in the future.

Recommendations

Because farmers face situations fraught with uncertainty, it is important to investigate factors that play an important role in their decision-making, thus their behaviors. The most important factors considered for this research were risk perception and risk attitude. Both factors were found to have an influence on farmers' behaviors. Thus, we need to factor them in when we want to help farmers adapt to climate change. This is important for policy making; any adaptation program should be designed in a way that acknowledges that how farmers perceive risk and how they are predisposed to react to risk has an important bearing on the outcomes of the adaptation program. Moreover, based on the findings of the study, adaptation policies or strategies should design programs that target groups of farmers as it was found that farmers influence others in taking action. Also, increasing or improving farmers' access to forecast information can also serve as good way to address adaptation issues.

APPENDIX

Questionnaire

Study on climate risk perception and risk attitude among farmers in Nyabihu district, Rwanda

The purpose of this research is to study climate risk perceptions and risk attitudes among farmers in Nyabihu district, Rwanda. The participation in this survey is voluntary and the information collected from this survey is anonymous and strictly confidential.

Socio-economic and demographic information

1. Age (Year of birth):_____
2. Level of education (highest grade completed):_____
3. Gender: Male ☐ Female ☐
4. Marital status: Married ☐ Single ☐
5. Number of adults:_____
6. Number of children: _____
7. Number of people in the household who can work: _____
8. Do you have any plot of land? Yes ☐ No ☐
9. Total land area farmed (Ares)_____
10. Out of the land that you farm, how much total land area do you own (Ares):_____
11. How much land do you own but you rent out to others? _____

12. How many farms (plots) of land do you farm? _____ (number of plots)

13. Do you have plots in the following places:

a. Top of the hillside – number of ares
b. Middle of the hillside – number of ares
c. Bottom of the hillside – number of ares

Belief in climate change (perception of climate change)

14. Have you detected any change in the climate in this area in the last 5-7 years that has affected agriculture? Yes ☐; No:☐
15. If you have noticed any change, what changes did you notice?
    a. The climate is consistently wetter than the last 5 years or so ☐
    b. The climate is consistently drier than the last 5 years ☐
    c. Last year was very wet but not a trend ☐
    d. Last year was very dry but not a trend ☐
    e. There is one specific year that was really wet ☐
    f. There is one specific year that was really dry ☐

g. Hotter than the past 5 years ☐
h. Colder than the past 5 years ☐
i. Other (indicate what) ☐
j. No change ☐

16. Have rainfall patterns changed over the last 5 years time?

17. According to you, how has the rainfall changed over the last 5 years?

More rainfall ☐
About the same ☐
Less rainfall ☐

18. If there's more rain, do you mean there are more rainy days or stronger storms than 5 years ago, or both?

More rainy days ☐
Stronger storms ☐
Both ☐

19. Did too much rainfall affect the crops that you grow? Yes ☐; No: ☐
20. How did much rainfall affect your crops?
    a. Crops failed ☐
    b. Yield dropped ☐
    c. Both ☐
21. Have you noticed any change in the cropping seasons in the past 5 years? Yes ☐; No: ☐
22. If so, in what way?
    a. hot seasons are getting longer and cold seasons shorter than they used to
    b. cold seasons are getting longer and hot seasons shorter than they used to
23. Has that changed your cropping practices? Yes ☐; No: ☐
24. How has the change in seasons changed your cropping practices
    a. I changed the crops that I grow in different seasons ☐
    b. I changed the crop varieties that I plant ☐
    c. I changed the planting dates ☐
    d. Others ☐

25. What crops do you grow now?
    a. Maize ☐
    b. Beans ☐
    c. Carrots ☐
    d. Potatoes ☐
    e. Other vegetables (e.g. onions, cabbage)

f. Others ☐ (in QuickTapSurvey we'll have to use complex logic and make this a separate question)

26. If these marbles or bottle caps represent all your crops, please indicate the proportions of each crop
    a. Maize
    b. Beans
    c. Carrots
    d. Potatoes
    e. Other vegetables
    f. Others

27. Did you change your crops or crop varieties over the past few years? Yes: ☐; No: ☐

28. What crops did you grow 5 years ago?
    a. Maize ☐
    b. Beans ☐
    c. Carrots ☐
    d. Potatoes ☐
    e. Other vegetables ☐
    f. Others ☐

29. Please use these marbles/bottle caps to indicate the proportions of each of the crop five years ago?
    g. Maize
    h. Beans
    i. Carrots
    j. Potatoes
    k. Other vegetables
    l. Others

30. If you made changes in the crops you grow compared to five years ago, why did you make those changes?

    a. in response to changes in temperature ☐
    b. in response to changes in rainfall ☐
    c. pest and diseases ☐
    d. higher market demand ☐
    e. Other.

31. If you have not changed the crops or crop variety now compared to five years ago, please indicate if it is because of the following:
    a. I am happy as the crops are now ☐

b. I would like to make some changes ☐
c. I do not know what I can do ☐
d. I cannot afford it ☐
e. I cannot manage it due to insufficient labor ☐
f. I will change very soon or next year ☐

32. Do you use fertilizer on your crops?
    a. If so, how many bags of fertilizer do you buy in a year? _____

33. Have you changed how much fertilizer you buy in the last five years? (yes / no)
    a. If yes, how many bags did you buy in a year five years ago?
    b. If you changed the amount of fertilizer, why?

34. Please list your sources of income:

    a. Off-farm income ☐
    b. Money sent by children/relatives ☐
    c. Crops ☐
    d. Agricultural labor ☐
    e. Livestock ☐
    f. Other ☐

35. Using ten marbles/ bottle caps, please indicate the proportions of the household's income coming from different sources
    a. Off-farm income
    b. Money sent by children/relatives
    c. Crops
    d. Agricultural labor
    e. Livestock
    f. Other

36. Please indicate if you have the following:
    a. Tile roof ☐
    b. Metal roof ☐
    c. Dirt floor ☐
    d. Cement floor ☐
    e. Radio ☐
    f. TV ☐
    g. Bicycle ☐
    h. Motorbike ☐
    i. Mobile phone

Risk perception

For the next questions, please indicate the number that corresponds to how you would answer the following questions.

Information

37. Do you receive any weather forecast? Yes ☐; No ☐

38. Do you get the short-term forecast or seasonal forecast?

    a. Short-term forecast ☐
    b. Seasonal forecast ☐
    c. Both ☐

39. How do you receive information?

    From friends: ☐
    Radio: ☐
    Phone (SMS): ☐
    Local authorities: ☐
    Others: ☐

40. Was the forecast information useful? Yes ☐; No: ☐
41. If the forecast was useful, how was it useful?
    a. I used the forecast to decide when to plant ☐
    b. I used the forecast to decide what to plant ☐

Past Experience

42. Have you ever experienced a flood in your life? Yes: ☐; No: ☐

43. When was your last experience with flood?

    Last year:☐; In the past five years: ☐; Do not remember: ☐

44. How severe were the consequences of the flood? _____

1	2	3	4	5
Extremely severe	Severe	Medium	Not severe	Not severe at all

Perceived control of risk

45. Are floods a threat to your field? Yes ☐; No: ☐
46. How big of a threat are floods to your field/farm?

1	2	3	5	5
Very big	Big	Neutral	Small	Very small

47. How able do you consider yourself to protect your farm(s)/field(s) from floods? _____

1	2	3	5	5
Very able	Able	Neutral	Not able	Not able at all

Trust in public adaptation programs

48. Do you think the Government is doing something to protect you against floods? Yes ☐; No: ☐
49. What do you thing the government is doing to protect you against floods?
    a. The Government is building terraces ☐
    b. Other

50. How safe do Government efforts to protect you against the floods make you feel?_____

1	2	3	5	5
Very safe	Safe	Neutral	Unsafe	Very unsafe

Social factors

51. Are you part of any cooperative or association in your community? Yes: ☐; No: ☐
52. Do you ever discuss preparation for much rainfall or protection against much rainfall? Yes: ☐ No: ☐

53. Do you know if your close friends are concerned with much rainfall? Yes: ☐; No: ☐

54. Do you know if any of your friends or neighbors or community members has done something differently because of too much rainfall? For, changing crops or changing their sources of income? Yes ☐ No: ☐

Risk Attitudes

55. On the piece of paper there are five pairs of numbers. Each pair of numbers represents two possible amounts of money that you will receive for participating in this

interview. You will choose one of the pairs and then we will flip a coin to determine which amount of payment you will get. The possible choices are:

1	2,000 RWF	2,000 RWF	
2	1,5000 RWF	3,000 RWF	
3	1,000 RWF	4,000 RWF	
4	500 RWF	5,000 RWF	
5	0 RWF	6,000 RWF	

So for example, if you choose (2000, 2000), your payment will be RWF 2000 since both numbers are the same and so it doesn't matter if the coin flip comes up heads or tails. If you choose (0,6000), then if the coin flip comes up as heads you will receive no payment, and if the coin flip comes up as tails you will receive RWF 6000.

Please tell me which pair of numbers you choose by ticking next to the pair of your choice.

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