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Risk Preferences and Risk Perceptions among Smallholder Maize Farmers in Tanzania: Evidence from a Framed Field Experiment

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Abstract

The information on risk preferences and risk perceptions among maize farmers in maize highly growing highlands is limited. Similarly, relationships between socio-demographic factors and risk preferences are not clearly explored. A risk game with pay-offs and a hypothetical scenario in a survey questionnaire were performed to assess the risk preferences of maize farmers in maize-growing regions of the Southern and Northern highlands of Tanzania. Risk ranking was executed during focus group discussions and revealed that risk perceptions of maize farmers varied across gender and location. Cross-sectional data on farmers' and farms' characteristics including risk scenarios from an Agronomic Panel Survey (APS) of the 2016/2017 growing season was collected from 560 Household Heads (HHs), randomly selected within a spatial sampling frame. The study recommends the inclusion of risk preferences and risk perceptions status of farmers in policy-making and the introduction of new agricultural technologies in order to foster a high adoption rate and advancement of agricultural development.

Keywords

Risk Preferences, Risk Perception, Maize Smallholders

1. Introduction

Personal characteristics influence attitudes toward risks. The attitude toward risks of individuals entails the status of their risk preferences (the level of a person's risk affinity or risk aversion) (Binswanger, 1980; Briggs, 2016; Mata et al., 2018; Hertwig et al., 2019) and risk perception (one's sensitivity to risk factors) (Senkondo, 2000; Vitoriano, 2020). A risk-averse individual prefers a sure outcome with a lower pay-off than an uncertain outcome with a higher pay-off. Besides, the risk lover gravitates toward higher payoffs while the risk-neutral leans toward options with potentially indifferent outcomes.

The willingness of farmers to take risks depends on their risk temperaments (Charness et al., 2013; Zou et al., 2020; Arslan et al., 2020) and risk perceptions (Pennings & Leuthold, 2000; Sulewski & Kłoczko-Gajewska, 2014; Arslan et al., 2020). Their risk quotient in turn influences their production decision-making (Bezabih & Sarr, 2012; Mukasa, 2018; Schildberg-Hörisch, 2018). Risk outcomes greatly affect extreme risk-averse farmers compared to risk-neutral and risk-loving farmers (Gardebroek, 2006; Bongole, 2021). Being largely risk-averse (Wik et al., 2004; Clot et al., 2017; Bongole, 2021), African farmers are thought to be hesitant in participating in risky investments.

Likewise, production choices are guided by decision-making power. The decision-making of the farmer is further directed by household objectives, available resources, and other farmers' characteristics including risk attitudes (Senkondo, 2000; Herath & Wijekoon, 2013; Bongole, 2021).

Gender differences do not only impact agricultural productivity (Peterman et al., 2010), but they also determine risk attitudes among smallholders (Arslan et al., 2020; Magnan et al., 2020). Men are more risk-inclined than women. Notably, the types of risks that both genders avoid and prefer to differ (Arslan et al., 2020). In the case of investment, men invest more in risky assets whereas women invest a higher percentage of their wealth in low-risk assets (Eckel & Grossman, 2008a). It is generally true for insurance and currency trading markets where females were also risk-averse (Eckel & Grossman, 2008a).

In addition, farmers' perceptions of risk are important factors in deciding on risk coping and mitigation strategies. Risk perceptions are specific to a given location, group, and time (Senkondo, 2000; Herath & Wijekoon, 2013). The proper measurement of risk perception starts with the identification of important risk elements in the agricultural production process (Pennings & Leuthold, 2000; Sulewski & Kłoczko-Gajewska, 2014).

Maize production in Tanzania is a risk-intensive activity. Risk factors in maize production include weather changes, soil infertility, disease as well as pest challenges (Sulewski & Kłoczko-Gajewska, 2014). The risk management strategies of farmers vary according to their risk tendencies and personal circumstances. Little understanding of farmers' perceptions of maize agricultural risks and their preferences towards risks may affect the utilization and adoption rate of new technologies in crop production, thereby reducing maize yield and farmers' income.

Several risk studies in agricultural production have been conducted in Tanzania. These include risk aversion and income risks for rural farmers in Shinyanga

(Dercon, 1996), risk aversion of fishermen in Lake Victoria (Eggert & Lokina, 2007), risk attitude of agro-forestry smallholder farmers in Babati district (Senkondo, 2000), consumer preferential choices for cassava products against different processing technologies (Theodory et al., 2014), risk exposure and technology adoption among smallholder farmers in Tanzania and Uganda (Mukasa, 2018), and the influence of risk preferences of women and men on the adoption of improved maize varieties (Magnan et al., 2020).

Northern and Southern highlands zones of Tanzania vary in cropping seasons, growing cycles as well as climatic conditions and economic activities. These highlands are producing 10% and 46% of the total national maize production, respectively. Apart from being large producers of maize, the average maize yield in the country is still very low, estimated at 2.2 tons per hectare (URT, 2012). Despite the position of the Southern and Northern highlands of Tanzania as the leading maize-producing regions in the country, there is limited information on risk preferences and risk perceptions among maize farmers in such zones. There is also a paucity of disaggregated information on the relationship between socio-demographic factors such as gender, education level, age, and risk preferences among maize farmers. This paper aims at filling these knowledge gaps.

The results of the analysis can offer ways to integrate maize farmers' risk preferences and perceptions in formulating and implementing new agricultural technologies under risky conditions. Understanding farmers' risk preference status and risk perceptions in the farming environment may enhance technology acceptance which might increase maize yield and enhance farmers' income.

Research questions

1) How do smallholder maize farmers perceive risk factors in maize crop production?

2) How do smallholder maize farmers differ in their risk preferences?

3) To what extent are the risk preferences of maize farmers influenced by socio-demographic factors?

The study measures risk perception through the ranking of risk factors. Risk preferences were measured by using responses to a hypothetical scenario in the Agronomic Panel Survey (APS) and a risk game with pay-offs to the maize farmers in the Southern and Northern highlands of Tanzania.

1.1. Risk Preferences and Risk Perceptions among Farmers

Attitude toward risk is also shaped by socio-economic variables, such as gender, age, and income (Arslan et al., 2020). The study by Dercon (1996) revealed that poor farmers in Tanzania develop a greater aversion to risk when exposed to the financial constraints of credit and insurance. Hence, poverty correlates negatively with risk preference. Furthermore, Kemeze et al. (2020) display heterogeneity in farmers' risk preferences in Ghana when rank-dependent utility and expected utility theories were assumed. Thus, it is very important to identify the risk preferences of the farmer in various circumstances and locations to enhance crop productivity.

Moreover, agricultural risks are ranked differently by farmers based on the peculiarities of their own context and the significance of the risk in question. Sulewski and Kłoczko-Gajewska (2014) elaborated on how farmers from Poland ranked their agricultural risks. They reported that drought was top of the hierarchy of important agricultural risks and this grading was elicited by the farmers' perception of the relative impacts of all the prevailing risk factors on their farming activities. In addition, in the case of cassava farmers in Anambra state, Nigeria, farmers observed flooding/erosion in their farms as a very important risk factor followed by increased rainfall frequency and volume (Emenyonu et al., 2020).

Empirical Model

The study is guided by the Expected Utility Theory (EUT) by Bernoulli (1738). The EUT as later modified by Von Neumann and Morgenstern (1947) is widely used to measure individuals' decision-making under risky conditions. The theory has six assumptions (axioms): preferences are made over possible outcomes, compound lotteries can be reduced to simple lotteries, continuity, substitutability, transitivity, and monotonicity. EUT further narrates the relationship between *acts*, *states* and *outcomes* in studying an individual's attitude toward risk as explained by Briggs (2016) that,

"*The expected utility of an act is the weighted average of the utilities of each of its possible outcomes where the utility of an outcome measures the extent to which that outcome is preferable to the alternatives*".

$$E(U) = P_1 \cdot U(W_1) + P_2 \cdot U(W_2) + \cdots + P_n \cdot U(W_n) \tag{1}$$

$$E(U) = \sum P_i \cdot U(W_i) \tag{2}$$

where:

$U(W_i)$ is the decision maker's utility from ith (1, 2, 3) possible outcome and is expressed as;

$U(W_i) = \sqrt{W_i}$, for a risk-averse individual, $U(W_i) = 2W_i$, *for* risk-neutral individual; and

$U(W_i) = (W_i)^2$, for risk-loving individual.

W_i, is the outcome of the lottery; P_i is a probability of the outcome i and $E(U)$ is the expected utility of a lottery.

In addition, the degree of risk aversion corresponds to the degree of concavity of a utility of wealth function (Jensen, 1967; March, 1988; Von Neumann & Morgenstern, 1947, 2007; Briggs, 2016). The data for risk preferences can be collected through computers (Harrison & Elisabet Rutström, 2008), field experiments, such as games (lotteries/gambles), and hypothetical questions/scenarios with or without pay-offs (Binswanger, 1980, 1981; Deck et al., 2008; Hersch & McDougall, 1997; Kachelmeier & Shehata; 1992; Sanou, 2015; Clot et al., 2017).

Following Herath and Wijekoon (2013), attributes to control behaviour are mainly collected using a Likert scale style of 5- or 7-point scales.

The conceptual framework for this study (**Figure 1**) is modified from Herath and Wijekoon (2013) who studied the attitude and perceptions of organic and inorganic coconut farmers in Sri Lanka. Therefore, this framework has three categories of variables. The first category is agricultural risk factors which were identified by respective farmers in their maize farming conditions. The second category is farmers' attitude factors on decision making, which include farmers' personal characteristics (farmer's characteristics), risk preference status, and risk perception of a given farmer. The third category is decisions on new agricultural technology, such as choosing or not to use inorganic fertilizer or deciding to invest more or less in inorganic fertilizer for maize production.

Personal characteristics of a farmer and socio-demographic factors tend to influence risk preferences and risk perceptions of a farmer in a prevailing riskier condition. Consequently, they affect farmers' uptake of introduced or implemented agricultural technology which might further affect crop production positively or negatively. Moreover, farmers' unpredictable decisions may result in different production outcomes which can have implications for household activities and goals.

1.2. Measurement of Risk Preferences and Coefficient Equations

Risk attitude is generally conceived as a binary proposition. It is mostly viewed as the predisposition to turn toward or away from risk. It is defined in terms of risk aversion or risk preference (Senkondo, 2000). The concept of risk attitude alludes to magnetism in the sense that individuals tend to be attracted to or repelled by risk.

Risk preference data can be elicited in various approaches including econometric methods (Moscardi & De Janvry, 1977), relative risk premium calculations (Eggert & Lokina, 2007), utility functions (Jensen, 1967; Schmidt, 2004;

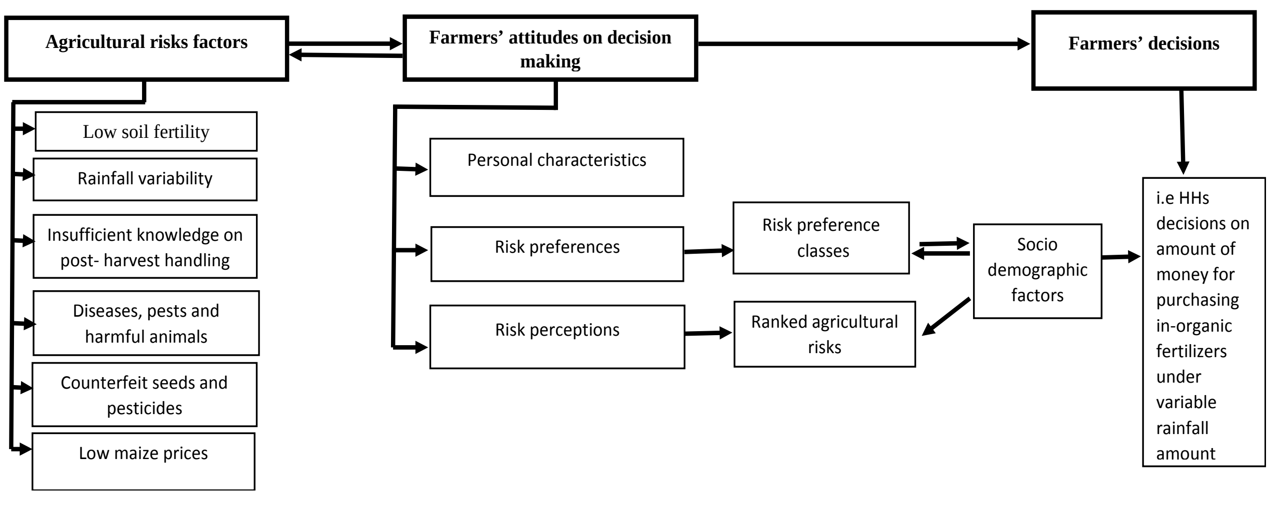

Figure 1. A conceptual framework. Source: Modified from Herath and Wijekoon (2013).

Binswanger, 1980; Von Neumann & Morgenstern, 2007; Yesuf & Bluffstone, 2007; Sanou, 2015; Briggs, 2016), Multiple Price Risk (MPL) designs (Holt & Laury, 2002), Rank Dependent Utility (RDU) (De Brauw & Eozenou, 2014; Kemeze et al., 2020) as well as the latent variable approach (Senkondo, 2000; Deck et al., 2008; Beauchamp et al., 2017). The measurement of risk preferences using utility functions is normally achieved by calculating expected utilities of riskier options and the Coefficient of Relative Risk Aversion (CRRA) and/or the Coefficients of Absolute Risk Aversion (CARA), and Coefficients of Partial Risk Aversion (CPRA). The utility functions used are consistent with Von Neumann-Morgensten theory which is built on Bernoulli's functions (Von Neumann & Morgenstern, 2007; Briggs, 2016). Utility functions usually utilize the expected values of the gamble and their probabilities.

Commonly risk aversion measures used are:

- Absolute risk aversion which describes circumstances where income or gain is fixed and initial wealth is variable (Pratt, 1964);
- Relative risk aversion which explains situations when both income and initial wealth change proportionally (Arrow, 1971); and
- Partial risk aversion $P(Wo, \pi)$ reveals conditions when initial wealth is fixed and income is variable (Menezes & Hanson, 1970).

Alternatively, risk preference degrees can be identified by calculating the Relative Risk Premium (RRP) for each choice (Eggert & Martinsson, 2004; Eggert & Lokina, 2007). This model classifies individuals into:

- Risk neutral (RRP = 0);
- Risk averse (RRP = +ve); and
- Risk taking (RRP = −ve) (Eggert & Martinsson, 2004; Eggert & Lokina, 2007).

RRP of a person is calculated by the difference between the mean revenues of two alternatives, provided that the person is indifferent to the alternatives.

Following Sanou (2015), this study adopted multiple methods to elicit maize farmers' risk preferences. These methods are a hypothetical scenario from the APS and the lottery risk game with pay-offs. The measurement of risk preferences was quantitatively done by calculating the coefficient of relative risk aversion as explained by Pratt (1964) and Arrow (1971) relying on the Von Neumann-Morgensten theory which was built on Bernoulli's utility function (Jensen, 1967; Von Neumann & Morgenstern, 1947, 2007). Initially, expected values, frequencies, percentages, and expected utilities for each gamble/option were calculated. Secondly, the constant relative risk aversion which is mathematically denoted as $R_R(W)$) for each lottery was deduced after calculating the coefficients of absolute risk aversion (mathematically denoted as $R_A(W)$) as per equations below:

Coefficients of absolute risk aversion,

$$R_A(W) = -U(W)/U'(W) \tag{3}$$

and

Constant/coefficients of relative risk aversion,

$$R_R(W) = -WU(W)/U'(W) = W \cdot R_A(W), \quad (4)$$

where: $U(W)$ and $U(W)$ are first and second derivative utility functions.

2. Research Methodology

A combination of Agronomic Panel Survey (APS), focus group discussion and ball risk game with pay-offs were conducted in the Southern and Northern highlands of Tanzania. The surveys involved 25 districts in nine regions (**Figure 2**). These highlands are major producers of maize in the country (Mbululo & Nyirani, 2012; Nkonya, 1998). Southern highland is located between 6˚S - 12˚S and 29˚E - 38˚E while the Northern highland covers an area between 2˚S - 4˚S and 35˚E - 38˚E (Mbululo & Nyihirani, 2012) as shown in **Figure 2**. The Southern

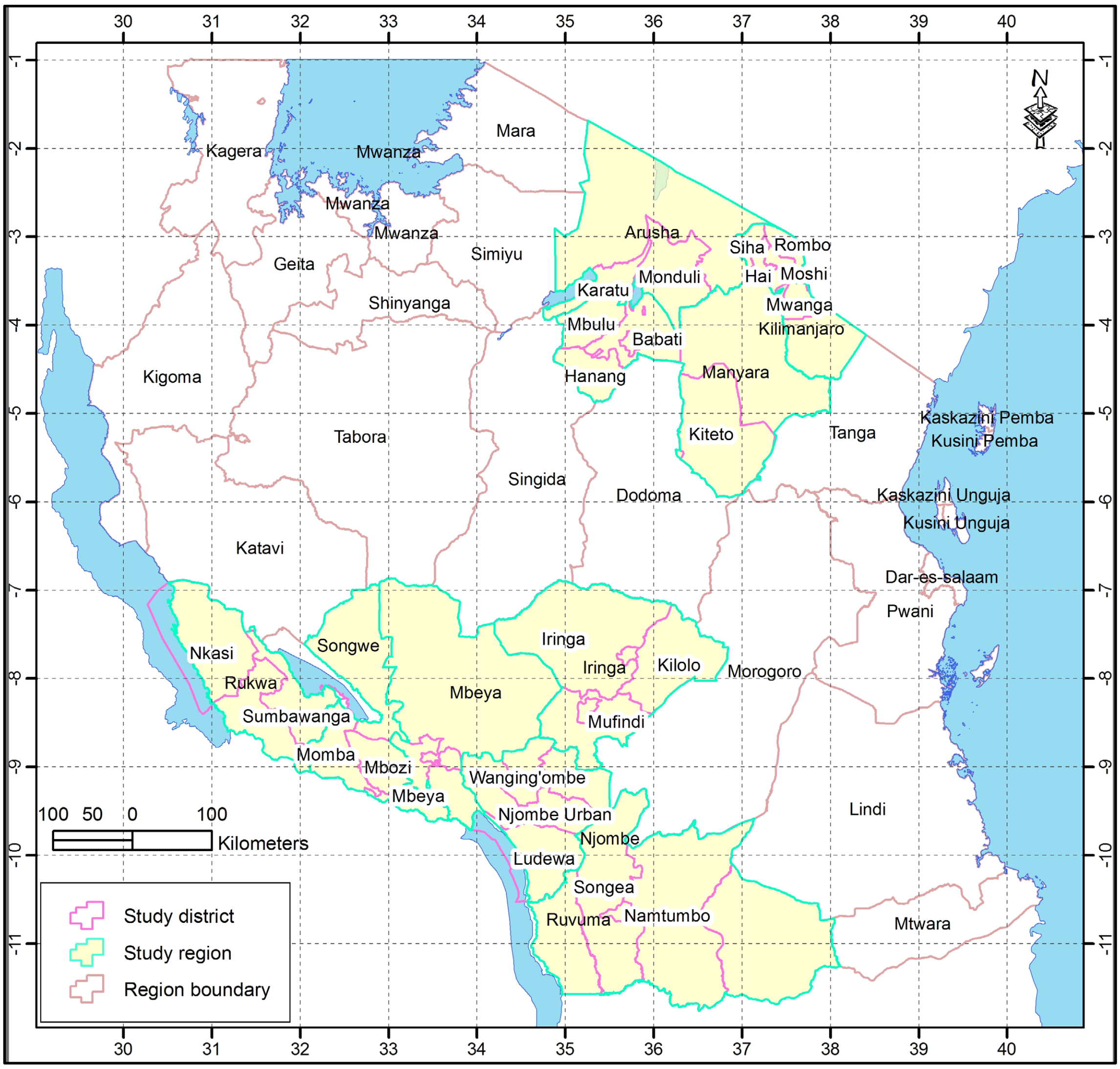

Figure 2. Regions and district covered by the study.

highland is characterized by a unimodal annual rainfall pattern between November and May. The rainfall pattern in the Northern highland is bimodal with a more variable rain season "vuli" between October and December and heavy rainfall "masika" between March and May (Mbululo & Nyihirani, 2012; Tippe et al., 2017).

2.1. Survey Data

The study used cross-section data from an Agronomic Panel Survey (APS) of the year 2017. This survey was conducted in 2016/2017 during maize harvesting season. The survey used the data collection protocol of the TAMASA (Taking Maize Agronomy to Scale in Africa) project as previously explained by Andrade et al. (2019) and Nord et al. (2022). The objective of the project was to upscale maize production and improve the livelihoods of maize smallholder farmers in sub–Saharan Africa, particularly Tanzania, Ethiopia and Nigeria. This research work was based on the theme "*When farming becomes a risky business: How is risk and farmers' attitudes towards risk influence sustainable intensification of smallholder maize farming in Tanzania*?". The APS includes questionnaires (household, community and maize focal plot), crop cuts (maize and biomass) and soil sampling. A total of 600 households (24 households per district) were randomly selected. However, 583 farmers' households with 560 household heads were available for the survey.

2.2. Data Collection

2.2.1. Hypothetical Scenario

Data were collected from the 560 household heads in APS by random selection of households located within a spatial sampling frame, per Africa Soil Information Service (AfSIS) approach (Okoth et al., 2012; Leenaars, 2013). In this approach, each selected district was cited as a grid, totalling 25 grids for 25 study districts. From each grid, three cells (villages) of 1 × 1 km each were selected. In each cell, available maize farm households were identified, and 8 households were selected for enumeration based on the following criteria:

1) Willingness of the household to participate in the survey procedures; and
2) Suitable maize plot for crop cuts.

The risk hypothetical scenario was part of the APS and was posed to heads of the households only. The scenario included four risk preference choices:

1) 50% chance of winning 40,000 Tshs and 50% of winning only 1500 Tshs;
2) 50% chance of winning 25,000 Tshs and 50% chance of winning 5000 Tshs;
3) 50% chance of winning 17,000 Tshs and 50% chance of winning 8000 Tshs,; and
4) 100% chance of winning 10,000 Tshs.

The farmer was also allowed to choose "don't understand or don't wish to respond", as the last option.

Farmer's preferences on gamble options were related to their risk preference levels regarding the expected values and values of the expected utilities of gamble options. Differences in risk averseness were described using Arrow-Pratt equations. Farmers' risk preference classes were then regressed to gender, age, education levels, household size, region differences and household dependent children to determine factors associated to risk preferences of maize farmers.

2.2.2. Risk Game and Focus Group Discussion

A total of 80 Household Heads (HHs) participated in eight focus group discussions. These groups were formed in Merera and Bashay villages in Karatu district (Northern highlands) and Image and Masukanzi villages in Kilolo district (Southern highlands). These villages were purposively chosen since they were involved in the then ongoing researcher-managed nitrogen trials (TAMASA project) and they were within TAMASA study area.

20 maize farmers were purposively selected from each village to participate in a focus group discussion and a risk game. Each village formed 2 groups of 10 maize farmers each; one group for females and the other one for males.

Contributions from focus group discussion from female and male farmers were recorded separately in each village. In these groups, the discussion points were:

1) Risk definition;
2) Identification of maize risk factors;
3) Farmers' risk factor ranking; and
4) Proposed risk reduction measures.

A Likert scale of 5 scores was used to rank agricultural risk factors based on their importance. The scores were: 5 = Most important, 4 = Important, 3 = Moderate, 2 = Less important, 1 = Least important. Each farmer was asked to rank all identified agricultural risk factors using coloured stickers. The risk ranking expresses the risk perceptions of maize farmers. The mean Risk Perception Indices (RPIs) were used to assess risk perception diversity between respondents.

An experimental ball risk lottery game with pay-offs modified from Berkeley university (https://www.stat.berkeley.edu) was used as a proxy to study farmers' risk preferences. The ball lottery game was organized in a similar way to the risk game designed by Bateman et al. (2006).

Of the 80 farmers involved in the focus group discussion, 38 male and 40 female maize farmers played the ball risk lottery game. Two male farmers were engaged in other farm activities and were not available for the game. Participants were divided into two groups: 39 from the Northern and 39 from the Southern highlands. Participants were given an initial income of Tshs 5000 (to avoid indecision concerning individual financial status). An explanation of the game was also given.

The study relates farmers' preferences for game phases with their risk aversion levels. The game was in three phases, namely, those who did not go for the fifth round were risk-averse, participants who chose to go for the fifth round and doubled their wealth were risk-loving and those who halved their income in the fifth round were risk-neutrals. Participants filled out a questionnaire on their age, gender and reasons for going/not going to the fifth round. Game pay-offs were grouped in alternatives with low and high pay-off amounts respective to the game phases.

2.3. Data Analysis

Risk perceptions were analyzed using average Risk Perceptions Indices (RPIs) for each identified agricultural risk factor in maize production as in Sulewski and Kłoczko-Gajewska (2014). Risk preferences were analyzed by calculating and comparing the expected utility values and Coefficients of Relative Risk Aversion (CRRA) as explained in Von Neumann and Morgenstein, (2007) and Pratt (1964), Arrow (1971) (Equations (1)-(4)). Observations with "don't understand or don't wish to respond" option were not included in the analysis.

The relationship between risk preferences of household heads and socio- demographic characteristics, such as; age, gender, household size, age groups of dependents, and education level, were assessed using an ordered probit regression model. The ordered probit model equation is presented in the following equation:

$$y_i^* = x_i \beta + \mu_i ,$$

where: y_i^* is a latent variable measuring a degree of risk aversion of the i^{th} decision maker; β = parameter vector; μ_i = stochastic disturbance term and x is a vector of regressors.

It was assumed that the disturbance term has a standard normal distribution resulting in the ordered probit model. However, an ordered logit model could also be assumed. Moreover, content analysis was used to analyse responses from FGDs.

3. Results and Discussion

3.1. Descriptive Statistics

From 560 household heads interviewed, maize was the main crop grown as a sole or intercropped with beans or cowpeas. The majority of farmers had 3.6 plots with a mean size of 2 acres (0.81 ha). Gender-wise, the number of male household heads was six times females (**Table 1**). Predomination of male household heads in agricultural activities is widely reported (Onojah et al., 2013; Mmbando et al., 2015; Cairns et al., 2021).

Households had an average family size of 6 people, comprising more adults than children. Family size is often associated with labour availability in agricultural activities.

Most farmers in the study area (68 percent) have primary education up to standard 8. There are very few college graduates. Elementary education is considered

Table 1. Household and farm characteristics in agronomic panel survey in SHZ and NZ of Tanzania cropping season 2016/2017.

Variable	Year 2017	
	Mean	*SD*
Age of household head (years)	49.12	(14.03)
Household family size	5.6	(3.18)
Adult household members	3.09	(1.56)
Household members aged 10 - 14 years	1.16	(1.37)
Household members aged below 10 years	1.41	(1.48)
Gender of the household head, female = 73, male = 487		
Farm		
No. plots	3.67	(1.8)
Area of the maize focal plot (acres)	2.13	(2.96)
Education level of the household head	Percentage (%)	
HH attended pre-school	11.43	
HH attended primary school (Standard 1 - 7)	78.75	
HH attended ordinary secondary school level (Form 1 - 4)	2.50	
HH attended advanced secondary school level (Form 5)	4.64	
HH attended college and university education	2.68	

sufficient for maize farmers to independently access agricultural information and credits (Mmbando & Baiyegunhi, 2016).

3.2. Risk Perceptions among Maize Farmers

Maize farmers in both highlands identified nine risk factors. These included low soil fertility, rainfall unpredictability, low crop prices, inefficient crop market, diseases, pests and destructive animals, fake pesticides, counterfeit seeds, lack of awareness of good agricultural practices and post-harvest techniques and insufficient business capital. Though most of the factors were perceived to fall between important and moderate, none was considered unrelated by the maize farmers. Generally, maize farmers in the study were very sensitive to rainfall variability, lack of education on proper agricultural practices and post-harvest techniques, and inadequate working capital. Specifically, maize farmers in Karatu rated risks from diseases pests and harmful animals as a very important one (4.41 rank points), whereas the same risk in Kilolo was regarded as moderately important (3.51 rank points). Likewise, farmers in the Kilolo district considered low soil fertility (4.59 rank points), low crop prices (4.56 rank points), inefficient crop market (4.18 rank points) as the most important risk factors in maize production contrary to Karatu farmers (**Table 2**).

One of the factors that explains differences in risk perceptions across these two districts is regulars encounter with harmful animals like elephants. This is the dominant cause of concern in Northern highlands. During the focus group discussion, maize farmers from Karatu district complained about the losses they

Table 2. Risk Perception Indices (RPIs) of maize farmers in Kilolo and Karatu districts.

Identified agricultural risks	Mean district RPIs		Overall RPIs in districts	Mean gender RPIs	
	Kilolo district	Karatu district		Males	Females
Rainfall variability	4.43	4.43	4.43	4.37	4.5
Low soil fertility	4.59	2.97	3.78	3.58	4.0
Low crop price	4.56	3.41	3.99	3.87	4.10
Inefficient crop market	4.18	3.26	3.72	3.71	3.73
Diseases, pests and harmful animals	3.51	4.41	3.96	4.0	3.93
Counterfeit pesticides	3.36	2.97	3.17	3.21	3.13
Counterfeit seeds	3.72	2.77	3.25	3.13	3.35
Lack of education on proper agricultural practices and post-harvest techniques	4.31	4.26	4.29	4.16	4.40
Insufficient working capital	4.21	4.23	4.22	4.21	4.23

normally experience when elephants invade their maize farms. Most of the farms are near the parks making it difficult to control the invasion of harmful animals. The effects of the invasion of harmful animals were also observed by Mmbaga et al. (2017). Elephants were reported to affect crop yield, specifically maize. More than 95% of farmers within the Rombo area were victims of elephant attacks (Mmbaga et al., 2017).

The other plausible explanation of difference in risk perceptions is highly nutrient depletion of cropped soil observed in Southern highlands. As noted by Ngailo et al. (2016), Southern highlands farmers experience the consequences of low soil fertility in maize farms. This justifies the importance of low soil fertility risk in Southern highlands relative to that of Northern highlands. Farmers in Southern highlands resorted to excessive nutrient mining activities and mono-cropping, resulting in exhausted soils (Ngailo et al., 2016). Besides, fertilizer use in Southern highlands is higher (42%) than in Northern highlands (12%) (Senkoro et al., 2017) but did not solve the soil infertility challenge. Variations of risk perceptions in locations were comparable to Tekeli-Yeşil et al. (2011) and Sulewski and Kłoczko-Gajewska (2014).

Similarly, females perceived low soil fertility, rainfall unpredictability, and low crop prices as more important risk factors; differing from males who regarded rainfall variability, disease, pests, and harmful animals as essential risk factors. For female farmers, farming for family needs and livelihood is the key goal, thus risk factors concerned with dependence on soil fertility, income and prevailing weather are very crucial. Concurring with Hitchcock (2001), females and males differ in perceptions of risks. Moreover, females reported being very delicate with the environment and safety than risks associated with science and technology. Variable education achievements and cultural beliefs among males and females are regarded as the cause of differences. Study findings observe variations between mean RPIs of respondents living in Kilolo and Karatu districts and within their gender, thus, risk perceptions vary across spheres.

During focus group discussions held in Kilolo and Karatu districts, maize farmers proposed the following risk reduction measures: diversification of assets, engaging in off-farm activities, using improved storage facilities, checking the credibility of pesticides and seeds before use, and searching for extension officers' advice on good agricultural practices.

3.3. Risk Preferences of Maize Farmers

Table 3 shows variations in expected values and constant relative risk aversion behaviours in risk options number 1 to number 4. The differences between these aspects specify risk preference classes for each option. The lower the expected value, the higher risk averseness. However, the higher the constant relative risk aversion, the more risk-averse. In addition, the maize farmers were grouped in different risk preference groups, based on the utility functions and coefficients of relative risk aversion for the given risk options.

Expected utility function for a risk-loving/preferred, risk-neutral and risk-averse individual were estimated in risk options of APS scenario and risk game (Equations (1) and (2)). The calculations on expected utility functions for each scenario option met the conditions for the individual risk grouping. Therefore, maize farmers were grouped as risk-loving, risk-neutral and risk-averse groups (Table 4). Since, Options 2 and 3 calculation results were indifferent from Options

Table 3. Risk preference status of maize farmers in the APS hypothetical scenario.

Options	Low pay-offs (Tshs)	High pay-offs (Tshs)	Expected value (Tshs)	The calculated Coefficient Relative Risk Aversion (CRRA)	Risk preference class
1	1500	40,000	20,750	Decreasing $R_R(W)$	Risk loving
2	5000	25,000	15,000	Constant $R_R(W)$)	Risk neutral
3	8000	17,000	12,500	Constant $R_R(W)$	Risk neutral
4	10,000	10,000	10,000	Increasing $R_R(W)$	Risk averse

Table 4. Distribution of risk averting attitude by gender in the risk game and APS hypothetical scenario.

Risk aversion classes	Gender in risk game		Gender in APS	
	Female (%)	Male (%)	Female (%)	Male (%)
Risk loving	52.5	39.47	32.86	35.60
Risk neutral	22.5	28.95	28.57	24.36
Risk averse	25	31.58	38.57	40.04
Total	100	100	100	100

1 and 4 (by calculations and ordinal arrangement), they were grouped as risk neutral.

Applying Arrow-Pratt equations (Equations (3) and (4)), the coefficient of relative risk aversion ($R_R(W)$ for risk-averse group in the fourth option was higher than the rest. The CRRA increased down the column, indicating differences in risk aversion levels between alternatives. An individual may be grouped as risk averse if his/her CRRA is greater than zero. Zero and below zero ($R_R(W)$) could be risk-neutral and risk-loving maize farmers. Risk preference grouping was previously done by Binswanger (1980), Wik et al. (2004), Yesuf and Bluffstone (2007) and Sanou (2015), resulting in various individual risk preference classes.

3.4. Distribution of Risk Preferences in the Risk Game and the APS

Results of the risk game show a high percentage of risk-loving household heads (46.15%) as compared to risk-neutral (25.64%) and risk-averse (28.21%) (**Figure 3**). For the APS hypothetical questions, there were slight differences in percentage, risk-loving (35.24%), and risk-averse farmers (39.85%) (**Figure 3**). The variations in percentages of risk preference classes in risk game and APS hypothetical question could be explained by differences in data collection methods as well as the number of samples used in each technique.

From the APS, the study revealed three risk preference classes among maize farmers in Southern and Northern zones of Tanzania. The APS results revealed moderate preferences of risk among maize farmers. The percentage difference between risk-averse and risk-preferred maize farmers was 4.61, which is comparably small. Thus, maize farmers in this study fall within risk-loving and risk-averse group, indicating variability in their decisions when new technologies are introduced. There could be early and slow adopters of technologies among maize

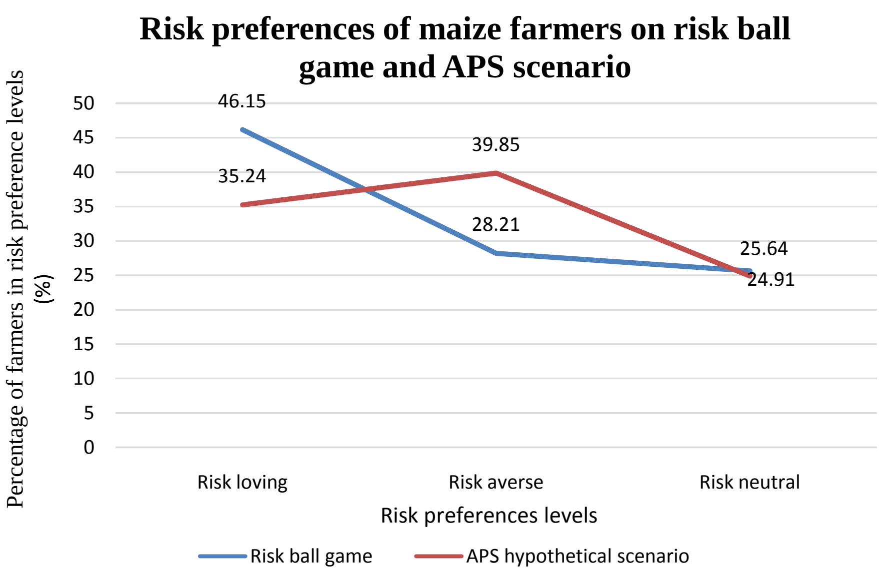

Figure 3. Risk preferences maize farmers in the risk game and the APS.

farmers in this study. This calls for development of diverse techniques of introducing and diffusing agricultural technologies among farmer groups. In comparison, these findings with others worldwide concur with Binswanger (1980) who revealed moderate risk-averse among rural Indian farmers whereas Yesuf and Bluffstone (2007) found high risk-averse status on households in Ethiopia and Senkondo (2000) reported high-risk preferences among individuals in Babati district.

3.5. Risk Preference Status of Maize Farmers in the Study Regions

Descriptive findings of this study revealed variations of risk preferences among regions (**Figure 4**). The majority of farmers were either in the risk-loving or risk-averse categories. Building on the highland economic and geographical differences, maize smallholder farmers in Northern highlands displayed high risk preference behavior (risk loving mean percentage = 36.29%)) to Southern highlands (risk loving mean percentage = 34.27%). Maize farmers with high-risk preferences were observed in Kilimanjaro (38.18%), Songwe (37.78%) and Ruvuma (37.78%) regions. Most maize farmers from Mbeya region fell in the indifferent group (in between high and low risk preference groups). Yet, Rukwa region had a high percentage of risk-averse maize farmers. However, the influence of highlands differences to farmers' risk averseness were not significant but had negative relationship to Northern highlands (**Table 5**). Farming in Northern highlands observed to favor risk preferred maize farmers. Reported soil fertility of Northern highlands might lower the production costs and upsurge the income of maize farmers. Moreover, having various sources of income (from national parks, border businesses and livestock keeping) in Northern highlands predict risk preferred farmers. Similarly, these income sources possibly favored risk-loving maize farmers to adopt new agricultural technologies and benefit from maize farming (**Table 5**). Variations in risk preferences among and within regions were noted by Binswanger (1980), Senkondo (2000) and Yesuf and Bluffstone (2007).

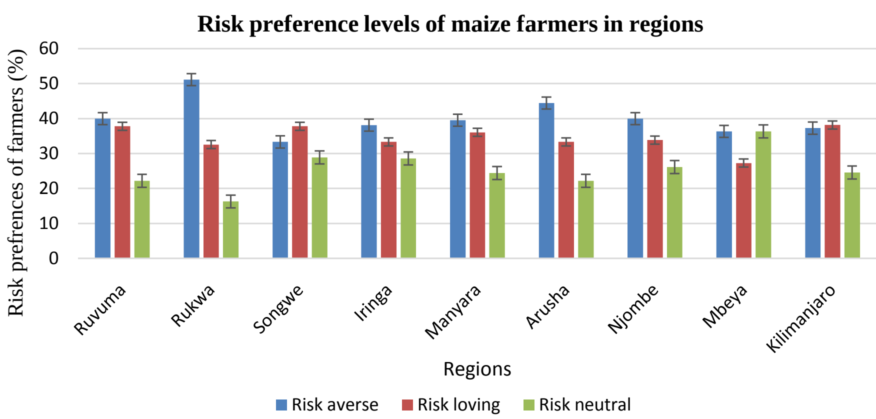

Figure 4. Risk preference status of maize farmers in study regions.

3.6. Socio-Demographic Determinants of Risk Preferences

Socio-demographic attributes that determine risk preferences were determined. More than fifty percent of female-headed households who played a risk game were risk preferred as compared to males (39.47%), contrary to the findings from the APS hypothetical scenario. The percentage of male and female-headed households in the risk-loving class in APS was quite comparable even though the male composition of the sample was higher than females (**Table 4**). The results from the risk game showed the changes in gender behavior of farmers with time. Nowadays, females are engaging in various income-earning activities more than before. Females are less afraid of risks in earning income for their families. However, their enthusiasm in risk preference cannot outperform their male counterparts. Hence, risk averseness was positively related with female maize farmers in the APS hypothetical scenario (**Table 5**).

Male and aged maize farmers were negatively related to decreasing their risk preferences. However, age was statistically significant ($p = 0.029$) (**Table 5**). The significant result is dissimilar to Yesuf and Bluffstone (2007), Dohmen et al. (2011), and Albert and Duffy (2012). It can be assumed that, under constant factors, elderly farmers are more experienced in the economic activities, agriculture in particular, and with high accumulation of assets, they could embrace risks to generate more income for their generations. Whereas, young maize farmers

Table 5. Ordered probit regression output of socio-demographic determinants of risk preferences for maize farmers.

Variables	Risk preferences of maize farmers		
	Coefficient values	*t*-value	*P*-value
Household size	0.033	0.194	0.846
No schooling	−1.022	−0.965	0.334
Primary education	−0.503	−0.481	0.631
Ordinary secondary education	−0.008	−0.007	0.994
College and university education	0.219	0.201	0.841
Number of children 10 - 14 years	−0.028	−0.151	0.879
Number of children below 10 years	0.012	0.072	0.942
Number of adults	−0.026	−0.138	0.891
Age	−0.008	−2.182	0.029*
Gender: Male	−0.276	−1.794	0.073
Northern highlands	−0.008	−0.084	0.933
Risk averse: risk loving	−1.354	−1.232	0.218
Risk loving: risk neutral	−0.379	−0.346	0.729
Reference group	Risk averse		
Cragg – Uhler R^2	0.069		

Significance levels: "***" 0.001, "**" 0.01, "*" 0.05.

are risk averse; running away from riskier options in maize farming. Young maize farmers are afraid of losing, hence, invest in activities with sure outcomes. In addition, the inverse relationship between being a female household head and risk loving was similar to the findings of Peterman et al. (2010), and Eckel and Grossman (2008a, 2008b).

In this study, literacy had a mixed effect in terms of farmers' risk preferences. Maize farmers with primary and ordinary secondary education had a higher likelihood of displaying risk preference attitude. Graduates of college and university degrees were positively associated with the risk-averse group (**Table 5**). The reverse relationship between higher education and risk preference coincides with high composition of pre- and primary school graduates (90.18%) (**Table 1**). Hence, higher education achievement was not important to the sampled farmers. In addition, highly educated farmers seem to be very conscious of calculated risks, hence running away from riskier choices.

Having small household size could lead to a greater tendency for risk preference among maize farmers. Yet, having dependents aged 10 - 14 years associates negatively with risk-averse farmers. Households that have children of this age group engage in riskier choices to cover family needs such as education and food. Nevertheless, the household with high number of children aged 10 - 14 years and adults are thought to have enough manpower to support farming activities: hence, they are able to venture into riskier activities. These findings are in agreement with Yesuf and Bluffstone (2007).

4. Conclusion

Maize farmers' risk perceptions reflect geographical heterogeneity and gender differences. Understanding the reality of agricultural risks as they are perceived by maize farmers is key to developing risk reduction strategies and designing suitable maize technology adoption plans that suit a particular context and gender.

Similarly, the findings disaggregate the risk preference behaviors of farmers and confirm the hypothesis that farmers exhibit divergence in risk aversion. Different groups of risk preferences predict the farmers' decisions on the adoption and utilization of new agricultural technologies. A high percentage of risk-averse and risk-loving maize farmers means high variability in decisions and outcomes concerning maize production. Thus, consideration of risk preferences of maize farmers should be taken into account during the introduction of new agricultural technologies and the planning of agricultural programs.

Socio and demographic characteristics determined the risk preferences of maize farmers. A persistent gender difference in risk preferences could explain different labour consequences and savings behavior observed in males and females. Moreover, a huge population of modestly educated, aged maize farmers is likely to result in a more conventional group of farmers which could influence macro-economic performance, intensify resistance to reforms, and interrupt modifications of risky policies.

There is a need to understand the risk preferences of farmers in developing countries. Insights on the risk landscape will result in a better rate of adoption of improved technologies and improvement of crop production in rural areas. There is room to illuminate the extent of risk preferences in affecting technology adoption in crop farming in Tanzania.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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