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Risk Preference Responses to Fertilizer Expenditures: A Case of Maize Smallholder Farmers in Iringa and Arusha Regions in Tanzania

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Initiatives have been tested to improve usage and expenditures on inorganic fertilizers; most did not yield the expected results, particularly in highly maize-growing highlands. This study evaluates the usage of inorganic fertilizers and the influence of maize farmers' risk preferences on expenditure in inorganic fertilizers in the Iringa and Arusha regions. Data were adopted from an Agronomic Panel Survey (APS) from 129 maize farmers' household heads (HHs), randomly

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selected within a spatial sampling frame in the maize-growing regions of the Southern and Northern highlands of Tanzania. Data were analyzed using descriptive statistics and Tobit model. Results revealed that the majority of maize farmers (64%) did not apply inorganic fertilizers on maize plots. Results further showed statistical significance for the Arusha region ($p<0.001$), non-schooling ($p<0.05$), primary education (0.01), ordinary secondary education ($p<0.05$), number of plots ($p<0.05$) and size of the maize plot ($p<0.001$) in predicting inorganic fertilizer expenditures when Tobit model was estimated. Nevertheless, risk-preferred maize farmers statistically influenced fertilizer expenditure when both highlands were included. The study recommends a model comprising risk preferences, geographical factors, and household characteristics in studying farmers' decisions on expenditure of inorganic fertilizers in respective regions and districts to uncover the location specificity and improve maize production.

Keywords: Risk preferences; inorganic fertilizer expenditures; inorganic fertilizer use; maize smallholders.

1. INTRODUCTION

Agriculture in Sub-Saharan Africa (SSA) has to cope with large temporal variability in climatic conditions and low inorganic fertilizer use to improve crop yield, production, productivity, and profitability. Inadequate use of inorganic fertilizers in SSA might be due to low purchasing power and variable decisions on the amount spent on purchasing inorganic fertilizers. Farmers' decisions are constrained by uncertainties affecting input investment outcomes Cooper et al. [1]; Charnes et al. [2]; De Brauw and Eozenou [3]; Holden [4]. These decisions are mostly dictated by the personal characteristics and risk preferences of farmers Sanou [5]; Liverpool-Tasie et al. [6]; Mukasa [7]; Liverpool-Tasie et al. [8]; Arslan et al. [9]; Kemeze et al. [10]; Bongole [11]; Mwaijande et al. [12]. A maize farmer's decision on how much to spend on inorganic fertilizer, under variable biophysical crop production conditions, may determine the maize production outcome and later influence the crop production goals.

Smallholder farmers in Tanzania, like in other SSA countries, have limited use of organic and inorganic fertilizers Liverpool-Tasie et al. [6]; Senkoro et al. [13]; Lobullu et al. [14] attributed to low maize yields due to inadequate cash expenditure in inorganic fertilizer Morris [15]; Khan et al. [16]. Magrini and Vigani [17] reported a low percentage of inorganic fertilizer use in maize cultivation among agroecological zones of Tanzania. Some factors contributing to low use and expenditure on fertilizer were the unavailability of extension services, the absence of on-farm trials, and variable rainfall. Variations in fertilizer use and money spent on inorganic fertilizers displayed maize yield variability. In addition, maize smallholder farmers in Tanzania face challenges in making decisions on inorganic fertilizer use and money to be invested in purchasing inorganic fertilizer. Farmers' choices comprise multiple objectives in risky environments prominently determined by household heads [18]. These decisions largely depend on the behavior of risk preference.

This study focuses on the Arusha and Iringa regions as representative of Tanzanias´ Northern and Southern highlands respectively. Northern and Southern highlands zones are the main production areas of maize in the country, with Southern highlands being the largest producer [19,20]. However, the average maize yield in the country is still meager, estimated at 2.2 tonnes per hectare [21]. Nevertheless, there are initiatives tested in previous studies to improve inorganic fertilizer use and expenditures to enhance maize yield in the country; still, low fertilizer expenditure and maize yield are stated. The relationships between maize farmers' risk preferences and expenditures on inorganic fertilizers are scarcely studied in Tanzania, particularly in major maize-growing areas. The present study initially described the soil fertility status of maize in the study regions. It later evaluated the influence of risk preferences of households (HHs) on money invested in inorganic fertilizer. Among the outputs of the study, decision support advice that would contribute to the amendment of microeconomic policies and analytical studies on inorganic fertilizer use and expenditures in boosting the maize subsector in Tanzania will be provided.

1.1 Risk and Maize Production in Tanzania

In Tanzania, agriculture is typically rain-fed and involves smallholder farmers with less than 3 ha per farmer Anandajayasekeram et al. [22,21]. The maize cropping areas frequently have depleted soils with low nutrient contents, negative nutrient balances, and little or no nutrient replenishment. Nutrient depletion leads to low production, food insecurity, and poverty Khan et al. [16]. On top of biophysical constraints, socio-economic factors, such as farmer and farm characteristics, are believed to influence farmers' decisions on crop productivity, but their effects are poorly quantified. Socio-economic factors include the risk preferences of smallholder maize farmers. These preferences may vary among farmers, and they may determine the choice of crop rotations, farm or off-farm income expenditures, and use of improved seeds and fertilizers, hence affecting crop management and productivity.

Since little is known about the decision-making of smallholder farmers under risky conditions, more information on the interaction between maize farmers' risk preferences and farmer and farm resources in respective regions is needed. The importance of the risk aspect in decision-making necessitates this study.

1.2 Theoretical and Conceptual Framework

Relying on expected utility theory (EUT) Bernoulli [23], von Neumann and Morgenstern [24], von Neumann and Morgenstern [25], Briggs [26], human individuals can be grouped into risk preference classes based on their decision-making abilities as defined by expected utility functions. EUT describes the relationship between *acts*, *states,* and *outcomes* in studying an individual's attitude toward risk as:

'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.

$$E(U) = P_1 .U(W_1) + P_2.U(W_2) + \ldots\ldots\ldots + P_n.U(W_n)\ldots \quad \text{(equation 1)}$$

$$E(U) = \sum P_i . U(W_i)\ldots\ldots\ldots \quad \text{(equation 2)}$$

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

Assuming that the farmer's objective is to maximize expected utility (E(U)) from the crop output under the EUT, the farmer's decision on the amount of money to spend on inorganic fertilizer at non-random inorganic fertilizer prices within variable weather is expected to depend on the farm, farmer characteristics, which include farmer's risk preferences, socio-economic characteristics, and farm biophysical factors.

Most poor farmers are risk-averse and face high uncertainties in crop production compared to wealthier farmers, who are considered to have more assets and are considered risk-preferred. Wealthier farmers are favored not only by risk preferences but also by biophysical and socio-economic conditions. These conditions vary enormously between endowment groups: resource-endowed, intermediate, and resource-constrained [27]. In addition, assets owned by farmers have been reported to increase their risk preferences and positively influence the adoption of new farm technologies.

Similarly, the age and gender of the household head may contribute directly to a better understanding of risks. Likewise, household and farm sizes are theorized to reduce risks and increase the likelihood of expenditures on inorganic fertilizers. The higher the number of people in the household, the more workforce may increase farm production. In conjunction with this, high labor power in the household will reduce labor costs on applying fertilizer, enhancing expenses in inorganic fertilizer for high yield.

In the farm household context (Fig. 1). we conceptualize that, in a riskier environment head farmer is expected to make sensible choices, and the converse is true.

2. MATERIALS AND METHODS

2.1 Study Sites

This study involved Tanzanias´Southern and Northern highlands, represented by two regions, Iringa and Arusha respectively (Fig. 2). Regions were purposively chosen to represent variable ecologies in the maize farming landscape. The studied regions involved six districts: Monduli, Karatu, Arumeru, Iringa Rural, Kilolo, and Mufindi. Particular emphasis was on Karatu and Kilolo districts due to the inclusion of maize farmers from these districts in TAMASA fertilizer-specific trials and payoffs risk game.

In 2017, there was a variable rainfall distribution in the study sites, ranging from mean rainfall of 600 mm – 2600mm in the Kilolo district and 400mm – 1200mm in the Karatu district (Fig. 2). It was also reported by Hamisi [29]; Pima et al. [30], that regions from the Southern Highlands had more reliable rainfall than those located in the Northern Highlands.

2.2 Survey Data

The study used cross-section data from an APS of the year 2017. This survey was conducted in 2016/2017 during the maize harvesting season, precisely from May 2017 to August 2017, by CIMMYT under the TAMASA (Taking Maize Agronomy to Scale in Africa) project. The survey used a stratified spatial sampling frame to identify and select areas covering maize-producing areas across various soil types and agroecologies, as Andrade et al. [31]; Nord et al. [32] explained.

Maize-growing regions and districts were purposively selected from highly maize-growing highlands (Southern and Northern highlands) within a spatial sampling frame, following the Africa Soil Information Service (AfSIS). Each district represents one grid (6 grids for two regions). These grids were then subdivided into 1×1 km cells/villages. There were three cells randomly selected per grid. In each 1x1 km cell, available maize farm households were identified, and eight maize households were randomly selected for enumeration, marking 144 household heads in the list. However, 129 household heads (HHs) were available for the survey. Sampled household heads responded to the APS questionnaire including household and maize focal plots. Soil fertility questions on maize plots were among the responded questions. The responses were recorded and used in the analysis.

2.3 Elicitation of Maize Farmers' Risk Preferences

Data for risk preferences of maize farmers in selected regions were collected as in Mwaijande et al. [12], using the hypothetical question included in the APS questionnaire.

The question had four risk preference choices:

(i) 50% chance of winning 40,000 Tshs and 50% of winning only 1,500Tshs
(ii) 50% chance of winning 25,000 Tshs and 50% chance of winning 5000 Tshs
(iii) 50% chance of winning 17,000 Tshs and 50% chance of winning 8000 Tshs, and
(iv) 100% chance of winning 10,000 Tshs.

Household heads of the selected maize farmers responded to the question by choosing one of the options. Hence, based on the utilities calculated from each option, they group themselves into the risk preference groups, risk-averse and risk-preferred groups,.

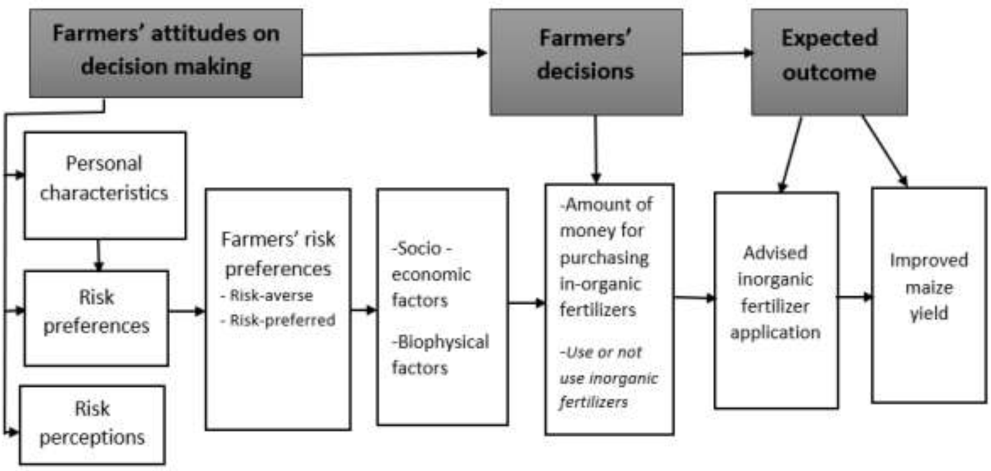

Fig. 1. A conceptual framework
Source: Modified from Herath and Wijekoon [28]

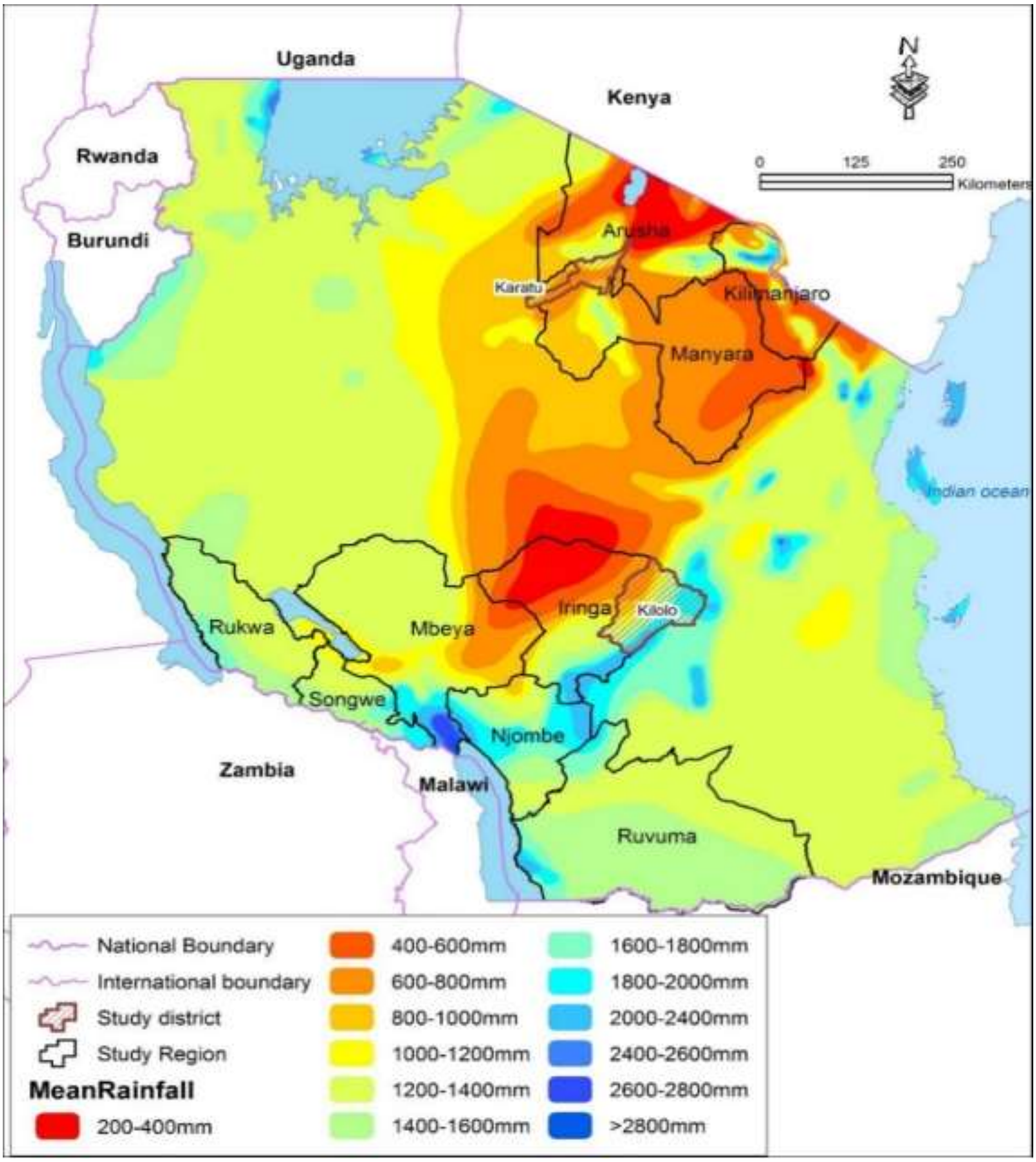

Fig. 2. The schematic representation of the study area and rainfall patterns

2.4 Data Analysis

R statistical packages were used for data analysis. Data collected were checked using cumulative probabilities to reduce the influence of the large variance and skewness in some variables. The data with extreme values were sorted, and the maximum value for the 99% was used for all extreme observations. Important explanatory variables used in the regression analysis were selected using standard regression procedures with the stepwise variable selection method. Initially, a univariate regression between Y and each explanatory variable X was done. Explanatory variables with a p-value less or equal to a significance level of 0.3 were allowed into the regression model. In contrast, a variable with a significance level of 0.35 and above was not included in the model as in Kassile et al. [33]. These significance levels were subjectively chosen to overcome the problem of failing to identify vital explanatory variables in traditional levels (0.05).

Risk preferences data were analyzed using utility and Pratt and Arrow's equations as in Mwaijande et al. [12]. To investigate factors that are associated with an investment in inorganic fertilizer, the Tobit model with a set of explanatory variables was applied in the *R* software version 3.6.3 using the package *VGAM.* Thus, the relationship between observed inorganic fertilizer expenditures and explanatory variables was modeled as follows:

$$y_i^* = X_i\beta + e_i$$

where; $e_i \sim N(0, \sigma^2)$, y is a latent variable that is observed for values greater than τ and censored otherwise.The observed y is defined by $y_i = y^*$ if $y^* > \tau$ τy if $y^* \leq \tau$. In the typical tobit model, we assume that τ = 0 i.e. the data are censored at 0. Thus, we have $y_i = y^*$ if $y^* > 0$ and 0 if $y^* \leq 0$

Whereas;

Y = inorganic fertilizer expenditure (Tzs);
X1 = risk preferences in classes/levels,
X2 = asset values (Tzs),
X3 = income from other sources (land, building rents, gardens, remittances, donations/gifts) (Tzs),
X4 = income from livestock sales (Tzs),
X5 = distance from crop market (km)
X6 = distance to livestock market (km),
X7 = age of the household head (years),
X 8 = gender (male, female)
X9 = household size (numbers),
X10 = children below 10 years (numbers),
X11 = children 10 - 14 years (numbers),
X12 = number of plots (numbers),
X13 = regions (Arusha and Iringa regions)
e = error term

3. RESULTS AND DISCUSSION

3.1 Descriptive Statistics

Out of 129 interviewed household head farmers in Arusha and Iringa regions, 16% were females, and 88% were males. The HHs had an average age of 49 years. Most household heads had primary school education (72.87%), with very few secondary, college, and university graduates (Table 1). Households had an average family size of 5 people , with more adults than children. This is often associated with labor availability for agricultural activities. Adults at production age could positively influence agricultural activities in terms of labor than children below ten years.

These households have an average of 3 plots, with an average area of 1.07 ha for maize plots. The average expenditure of HHs on inorganic fertilizer was 77,000Tzs in the main season (Table 1). Relating expenditures on inorganic fertilizers in the main season and acreage gave an insignificant difference among smallholder maize farmers (*p =0.081*). Thus, when other factors were constant, acreage size did not contribute to the expenditure on inorganic fertilizers in the studied area.

Moreover, maize farmers in the present study owned valuable assets. These include household, farm, and transport assets. Differences in types, amounts, and values of assets owned by household heads could substantiate their farming decisions. In addition, access to institutions and transactions is thought to influence investment in inorganic fertilizer. However, studying maize farmers in Arusha and Iringa regions, inorganic fertilizer investment was independent of the distance to the crop market, extension services, fertilizer sales, and the distance to the livestock market.

Expenditures were captured at the farm level, not from the plot-level data. The value of total assets was calculated using the number of assets owned in 2017 and the value for each asset. The value of total crop sales and livestock sales were calculated using the amount sold, and the price per unit income from business/informal activities was calculated using an estimate of monthly income. (1 dollar = 2200 Tzs in the year 2017).

The study comprised more risk-preferred smallholder maize farmers (58.73%) than risk-averse maize farmers (41.27%) (Table 1). There was a difference of 17.46% between risk-preferred maize farmers and risk-averse maize farmers. The slight difference could result in mixed decisions on money spent on inorganic fertilizers. For the case of improved agricultural technologies, more than 50% of farmers in the study could adopt the technologies expected to have high outputs, leaving behind 40% of maize farmers (risk-averse) who could follow slowly through observing attracting outputs from their fellow farmers.

Comparing Karatu and Kilolo districts (Fig. 3.), maize farmers were in similar risk preference groups. Nevertheless, when their risk preferences were related to inorganic fertilizer expenditure in a univariate regression model, risk-preferred maize farmers were observed to influence positively and significantly the expenditure on inorganic fertilizers at $p < 0.05$ ($p = 0.026$).

Table 1. Descriptive statistics of smallholder maize farmers in Iringa and Arusha regions in Tanzania

Variable	Mean	SD	Sample number (n)
Age of household head (years)	49.57	(13.71)	129
Household family size (n)	5.53	(2.55)	129
Adult household members (n)	3.09	(1.56)	129
Household members aged 10 -14 years (n)	1.18	(1.51)	129
Household members aged below 10 years (n)	1.21	(1.23)	129
Value of total assets (10,000s Tzs)	1024.27	(2606.69)	129
Income from total livestock sales per year (10,000s Tzs)	463.69	(4435.94)	129
Income from donations, gifts, remittances, land, and building rentals per year (10000s Tzs)	56.29	(336.50)	129
Income from informal businesses/ activities per year (10000s Tzs)	220.26	(370.54)	36
No. plots (n)	3.26	(1.53)	129
Area of the maize focal plot (hectare)	1.07	(1.27)	129
Expenditure on inorganic fertilizer in the main season (10,000s Tzs)	7.70	(20.01)	129
Distance from home to a market for farm produce (km)	9.43	(12.91)	129
Distance from home to a market for livestock sales (km)	10.65	(13.16)	129
Distance from home to extension services (km)	3.2	(6.4)	129
Distance to fertilizer sale center (km)	13.48	(14.68)	129
	Percentage (%)		
Gender of the household head	Female = 16.28, Male = 87.72		
HH Non-schooling	15.50		
HH attended Primary education	72.87		
HH attended ordinary secondary school level (Form 1 - 4)	9.30		
HH attended college and University education	2.33		
Risk-preferred – maize farmers	58.73		
Risk-averse – maize farmers	41.27		

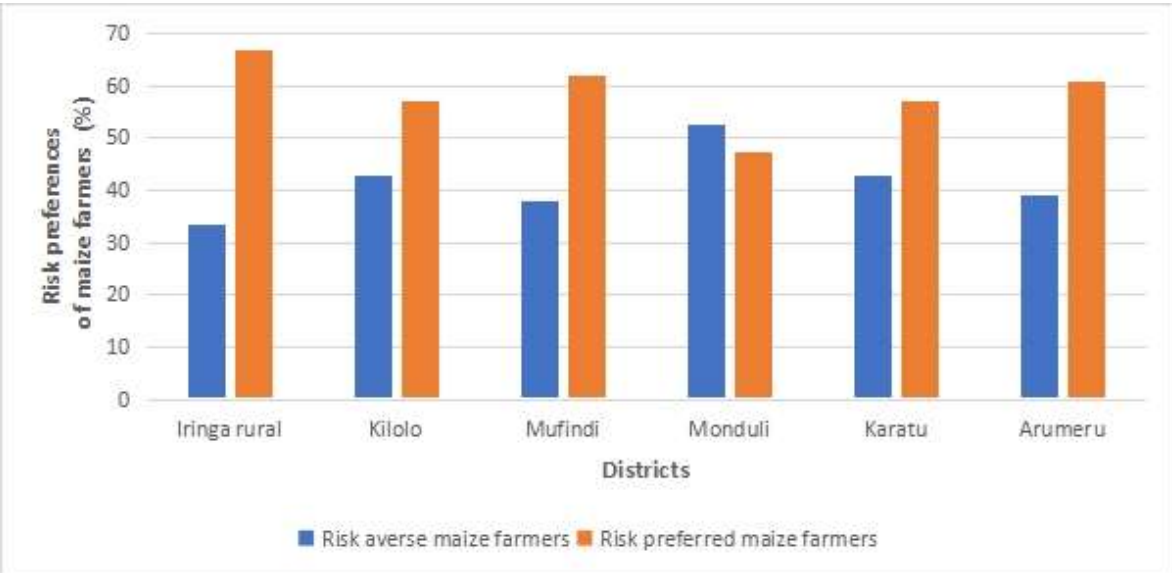

Fig. 3. The status of risk preferences in studied districts

3.2 Soil Fertility Status of Maize Plots

Responding to the soil fertility question, maize farmers from Arusha were recorded to have 'very fertile' maize plots more than those in the Iringa region (Fig. 4). The soil fertility findings in these regions, representing variable features, are similar to those of Ngailo et al. [34]; Senkoro et al. [13].

Very fertile soils might lead to harvest even if there is no addition of inorganic fertilizer, while 'not fertile' soils result in zero harvests if required nutrients are not added at required amounts and time. Growing maize in 'not fertile' soils requires the addition of nutrients especially Nitrogen, Phosphorus, and Potassium, at the right location, type, amount, and time to improve maize crop productivity. Hence, spending money for purchasing inorganic fertilizer is specific for the optimal yield of maize crops based on the soil type. Due to the larger feeding capacity of maize crops than other food and cash crops Holden [4], investment in inorganic fertilizers in maize plots is vital, especially for 'not fertile' soils. However, there are contradicting arguments on the outcomes of inorganic fertilizer investment in maize plots. It was reported by Marenya and Barrett [35]; Suri [36]; Jama et al. [37], that contrary to farmers' expectations of fertilizer investment, in some cases, minimal returns to fertilizer use were noted;| low maize price ratio to high fertilizer price and negative response to fertilizers discourages fertilizer investment. In addition, location-specific factors, as by Palmas and Chamberlin [38] stipulated, might influence agronomic and economic returns to fertilizer expenditures. Nevertheless, , as addressed by Liverpool-Tassie et al. [8]; Nord and Snapp [39], soil testing and site-specific nutrient management techniques on maize plots might reduce farmers' uncertainties.

Two distinct responses were noted for maize household heads: those not using inorganic fertilizers and users of inorganic fertilizers. Most maize household heads (63.73%) did not apply inorganic fertilizers on their plots. Specifically, maize farmers from Karatu district did not use inorganic fertilizers (Fig. 5). Regrettably, zero or low usage of inorganic fertilizers might compound the existing problem of low maize yield if adequate measures are not executed. Besides, there is a strong correlation between maize yield, rainfall, nitrogen, and soil organic carbon Palmas and Chamberlin [38]. The availability of optimal rainfall and soil fertility might influence the inorganic fertilizer use. The findings of low usage of inorganic fertilizers concur with Kihara et al. [40]; Mukasa [7]; Lobullu et al. [14].

Most maize farmers (44.23%), claimed that their soils were fertile enough to support maize production without needing inorganic fertilizers (Fig. 6). Some (27.89%) needed more cash to purchase fertilizers, while 12.5% of maize farmers found inorganic fertilizers too expensive.

Few maize farmers (1.92% and 0.96%) mentioned 'not profitable' and 'low response rate' for not using inorganic fertilizers. Broadly, present study´s findings agree with Mukasa [7].

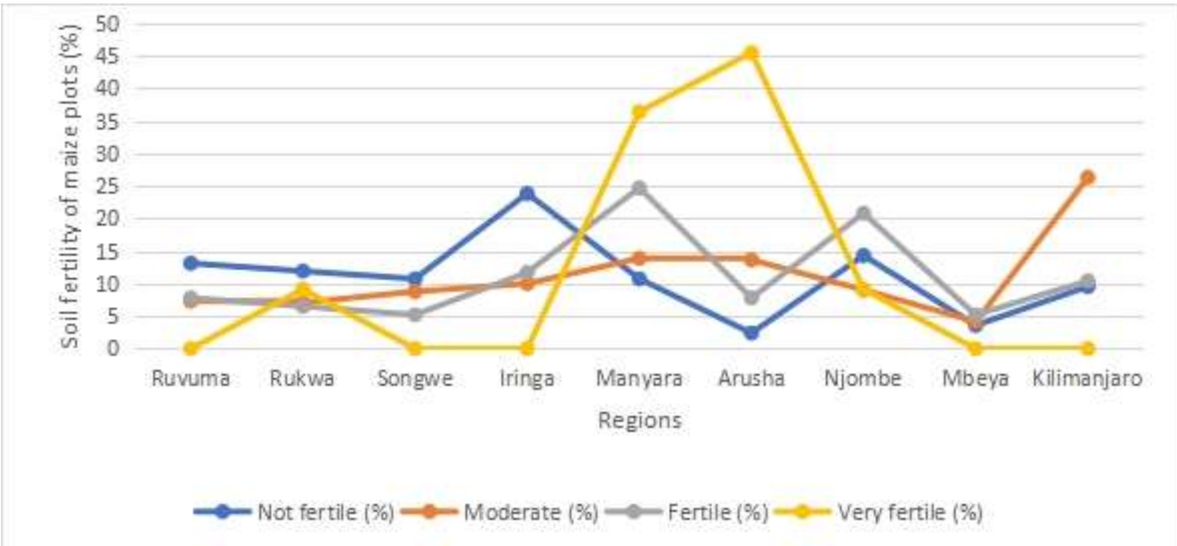

Fig. 4. The soil fertility status of the maize plots in the study regions for the season 2016/2017

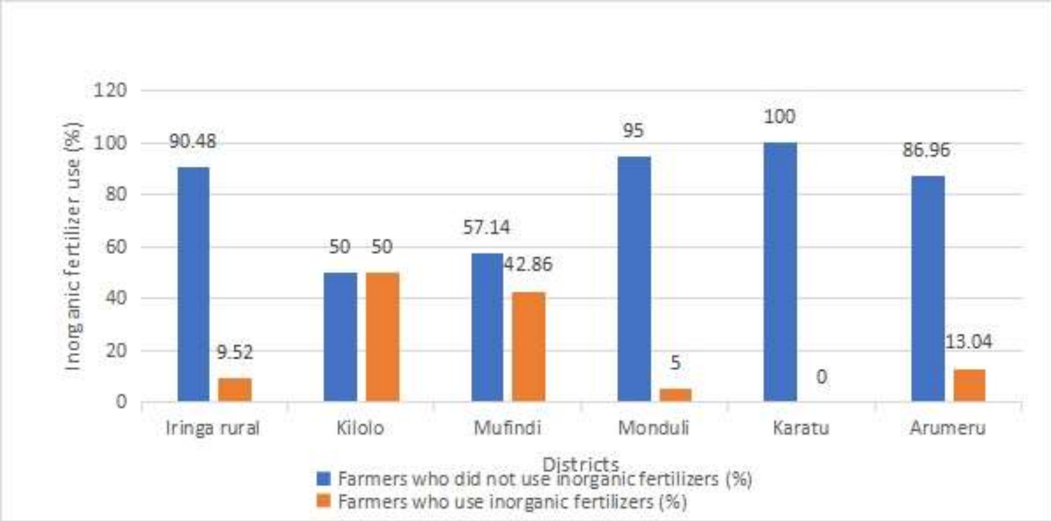

Fig. 5. Use of inorganic fertilizer for the season 2016/2017

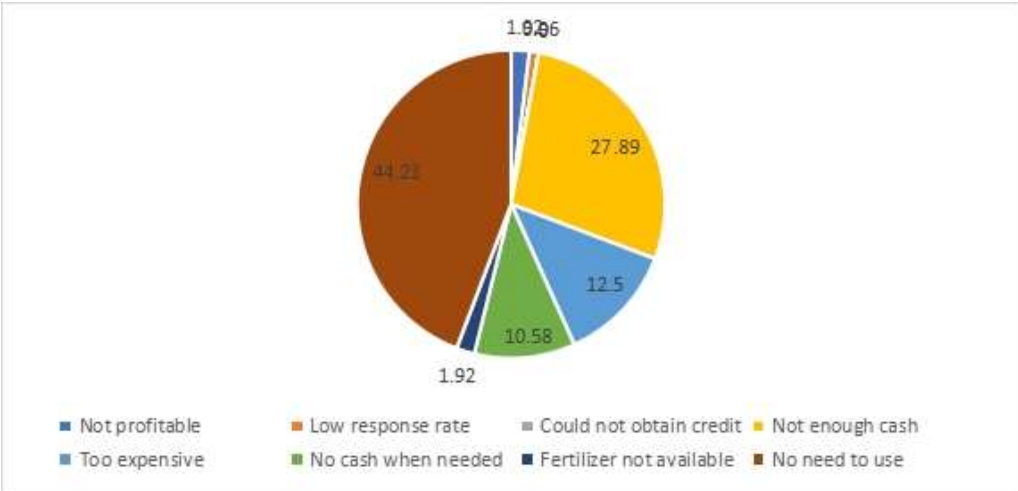

Fig. 6. Farmers' reasons for not using inorganic fertilizers in maize plots

3.3 Modelling Expenditures on Inorganic Fertilizers in Maize Farming

Table 2 presents the findings of modeling expenditures of inorganic fertilizers among maize farmers with variable socio-economic factors. The table showed that the expenditure on inorganic fertilizer for maize farmers in the Iringa and Arusha regions was statistically explained by the education status of household heads: no schooling (p=0.012), primary education (p=0.005), ordinary secondary education (p=0.031), number of plots (p=0.01), area of maize plot (p=2.7e-07) and region factors (p=0.000*).*

Non-schooling to secondary education levels variables related negatively then significantly to inorganic fertilizer expenditure. Maize farmers in these education levels should have spend their income on inorganic fertilizers. This might be due to low awareness of the importance of inorganic fertilizers, the right type, rate and time of application. Xiaoling and Xianrong [41], showed highly educated farmers´ positive contribution to fertilizer application and crop yield. Also, low income to suffice daily needs and purchase of inorganic fertilizers might be a reason. The initiatives should be in place to spread crop production knowledge to farmers, especially inorganic fertilizer use and expenditure. Training farmers could help them improve soil health (Asenso-Okyere and Mekonnen, [42], technical efficiency of inorganic fertilizers Wang et al. [43], and boost crop production and yield Huang et al. [44]. The potential of training farmers on fertilizer management was also seen by Pan and Zhang [45] in rice farming.

Correspondingly, having many plots increase the expenditure on inorganic fertilizers for maize smallholders (Table 2). More plots will allow farmers to rent some and generate income, which will later be invested in purchasing inorganic fertilizers, similar to Chen et al. [46]. According to Chen et al. [46], the large number of cropland areas positively influences the farm´s technical efficiency. It increases the farmer's flexibility to various modifications according to the household goals and needs. Moreover, the maize plot size related negatively to expenditure on inorganic fertilizers in this study. Maize farmers spent less on inorganic fertilizer for large plot sizes, which might lead to insufficient plant nutrient uptake and, later, low crop yield.

Arusha regions displayed statistical significance but were negatively associated with expenditure on inorganic fertilizers. Maize farmers in this region, particularly from Karatu district, did not invest in inorganic fertilizers, claiming to have highly fertile soils for crop production. Furthermore, regions and districts have different agroecological features, such as climate and soil structures, which can be associated with expenditure on inorganic fertilizers. The variable amount of rainfall in selected districts (Fig. 2.), soil fertility variations (Fig. 4.), and inorganic fertilizer use in Karatu district (Fig. 6.) can explain the spotted low farmers' expenditure on inorganic fertilizer in Karatu district (Fig. 7). It was further noted by Olwande et al. [47], that farmers in drier areas have lower fertilizer use than in high-rainfall areas. Thus, farmers in drier areas tend to reduce weather, fertilizer failure risks, and production loss through low investment in inorganic fertilizers. Similarly, when expenditure on inorganic fertilizers was regressed with districts, the Kilolo district emerged a positive predictor of expenditure on inorganic fertilizers (*p=0.004*), contrary to the Karatu district (*p=0.964*). Ideal rainfall amount is paramount to absorbingof nutrients from inorganic fertilizers to plants. Good absorption will lead to positive growth responses and high yield compared to areas experiencing low or variable rainfall amounts and low fertile soils Rusinamhodzi et al. [48].

Risk-preferred maize farmers were positively related but not statistically significant when included in this model. This can also be explained by Fig. 3. and Table 1, that maize farmers dominated the study in two risk preference groups with slightly similar composition. Thus, the influence of the risk preference variable might be overshadowed when more predictors are added to a model. However, the contribution of the risk-preferred maize farmers was seen when a univariate model was assumed between inorganic fertilizer expenditure and risk preferences (*p=0.026*) and when Northern and Southern highlands were included in the model (*p=0.007*) (Table 3). Coinciding with the theoretical framework (Fig. 1.), risk-preferred maize farmers were expected to be intermediate or resource-endowed farmers, who own several assets and have various sources of income to support farming activities. Thus, risk-preferred farmers might choose to put their money into buying inorganic fertilizers aiming at high maize yield at harvest and high profit at crop sale. Also, the resource accumulations of maize farmers who are risk-preferred Household Heads (HHs) could allow the input expenditures to suffice farming requirements, providing a higher outcome. The study findings aling with Bongole [11], who stated that risk-preferred farmers usually embrace costly outcomes.

The age of the household heads was statistically insignificant and negatively associated with the expenditure on inorganic fertilizers (Table 2). Thus, being aged is projected to reduce the amount of money spent on inorganic fertilizers. *Age* is a huge responsibility that requires variable investment to ascertain stable income. Hence, the aged maize farmers might direct their high income to economic activities with higher and faster returns. However, Olwande et al. [47] reported a positive contribution of age to adopting of fertilizers in Kenya. Socioeconomic factors vary with locations and farm and farmers' characteristics, hence, mixed findings.

Economic factors were positively related to expenditure on inorganic fertilizer but were not statistically significant (Table 2). This implies that the differences in mean income from maize farmers' economic activities in these two regions did not influence the expenditure on inorganic fertilizers. Positive association indicates that engagement in economic activities among maize smallholder farmers aligns with expenditures on inorganic fertilizers. Economic activities stimulate acceptance and adoption of introduced agricultural technologies. Thus, injecting money into various economic activities is a risk absorbent for backing capital and investment in numerous activities. Consequently, smallholder maize farmers with several income-generating activities can spend the proposed amount of money on inorganic fertilizers to support crop productivity than those depending solely on agriculture production. The purchasing power is usually related positively to the household head´s income sources. The cash accumulated from livestock sales, crop sales, remittances, renting buildings and lands , and selling vegetables (Table 1) might be used to purchase inputs, such as; inorganic fertilizers, boosting agricultural productivity. These results concur with Duflo et al. [49] who reported low income as a reason for Kenyan rural farmers not purchasing inorganic fertilizers, Haji et al. [50]; Msinde et al. [51], explain the potential of other incomes for purchasing fertilizers in Tanzania. Similarly, these findings relate to the reasons for not using inorganic fertilizers, as narrated in Fig. 6.

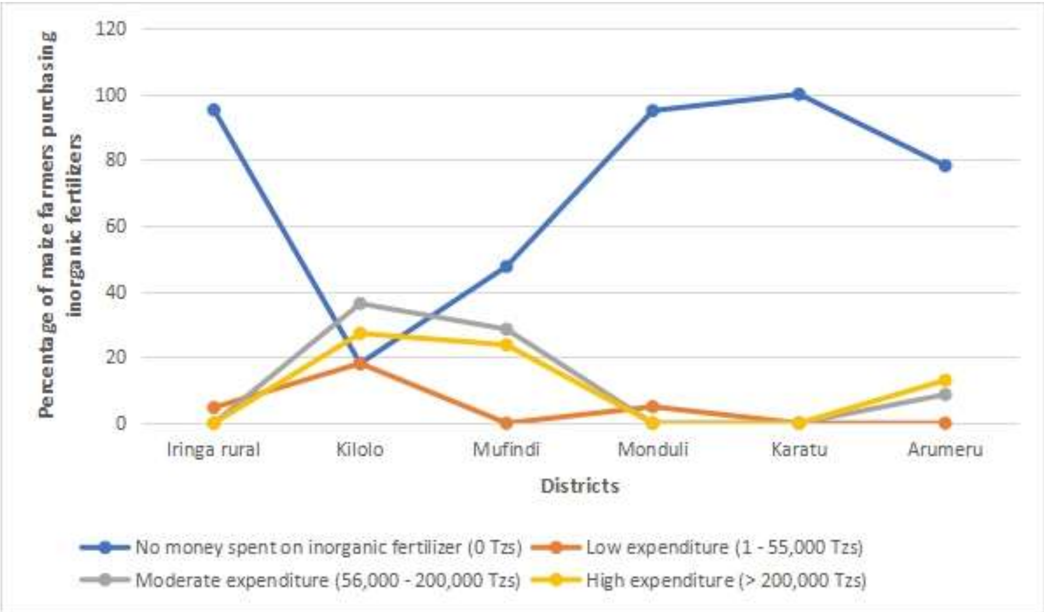

Fig. 7. The expenditure on in-organic fertilizers in the study area

Table 2. Tobit regression output explaining the expenditure on inorganic fertilizer in Iringa and Arusha regions

Variable	Coefficients	P- values
Intercept: 1	$3.64e^{05}$	0.256
Intercept: 2	$1.27e^{01}$	$<2e^{-16}$ ***
Age of household head	$-7.75e^{02}$	0.834
Household size	$5.79e^{03}$	0.747
Household heads – no schooling	$-6.91e^{05}$	0.012*
Primary education of household heads	$-6.20e^{05}$	0.005**
Ordinary secondary education of a household head	$-5.39e^{05}$	0.031*
Risk preference of household head: Risk preferred	$5.17e^{04}$	0.606
Assets of the household heads	$2.33e^{-03}$	0.105
Income from other sources	$1.65e^{-02}$	0.121
Number of plots	$9.44e^{04}$	0.001**
Area of maize plot	$-2.42e^{05}$	2.7e-07***
Region: Arusha	$-3.47e^{05}$	0.000***

Names of linear predictors: mu, loglink (sd) Vr
Log-likelihood: -538.39 on 239 degrees of freedom
Number of Fisher scoring iterations: 18
No Hauck-Donner effect found in any of the estimates
Dependent variable: expenditure in inorganic fertilizer (Tzs)
*Significance levels: '***' 0.001 '**' 0.01 '*' 0.05*

Table 3. Tobit regression output explaining the expenditure on inorganic fertilizer in both highlands

Variable	Coefficients	P- values
Intercept: 1	$-2.45e^{05}$	0.129
Intercept: 2	$1.32e^{01}$	$<2e^{-16}$ ***
Age of household head	$7.55e^{02}$	0.726
Gender: Male	$5.56\ e^{04}$	0.506
Household size	$-2.84e^{04}$	0.099
Children aged 10 – 14 years	$7.32e^{04}$	0.018*
Risk preference of household head: Risk preferred	$1.53e^{05}$	0.007**
Asset values of the household heads	$4.07e-^{04}$	0.002**
Income from other sources	$2.28e-^{02}$	0.000***
Number of plots	$4.22e^{04}$	0.005**
Highlands: Northern	$-5.92e^{05}$	< 2e-16***

Names of linear predictors: mu, loglink (sd)
Log-likelihood: -3677.864 on 1048 degrees of freedom
Number of Fisher scoring iterations: 6
No Hauck-Donner effect was found in any of the estimates
Dependent variable: expenditure in inorganic fertilizer (Tzs)
*Significance levels: '***' 0.001 '**' 0.01 '*' 0.05*

Comparing regression outputs from two regions (Table 2) and in both highlands (Table 3), risk-preferred maize farmers, asset values, and highlands were seen to predict expenditure on inorganic fertilizers when Southern and Northern highlands were enclosed in a model. This explains the contrasting behavior of maize farmers when locality is considered. Some factors can be associated with location coverage in studying risks and fertilizer expenditure. Considering farmers in this distinctness can play a significant role in improving crop productivity [52].

4. CONCLUSION

The study presented the importance of studying farmers' risk preferences and their influence on crop production through expenditures on inorganic fertilizers. Advocating and implementing policies like offering credits with affordable requirements and interests, inorganic fertilizer subsidies, and weather insurance programs will improve farmers' capacity to cope with risks and prefer risky but productive decisions. These initiatives may also foster investment in inorganic fertilizers, specifically for risk-averse farmers who depend much on farming as their sole source of income and living. In addition, proper mechanisms should be in place to train maize farmers on production: Good Agricultural Practices (GAPs), mainly inorganic fertilizer use, and the importance of purchasing and applying inorganic fertilizers on their plots since most of them seem to have insufficient maize production knowledge and fail to tap benefits attached with.

This study contributes to current research on risk preferences and inorganic fertilizer investment. However, there is no clear evidence of the influence of the marginal return of inorganic fertilizers on fertilizer investment among maize smallholders in Tanzania. Soil testing and specific site nutrient management practices should be considered while advocating inorganic fertilizer use and the importance of purchasing these fertilizers.

The specificity of farmers' risk preferences, their farms, and farmers' characteristics, as well as their agronomic and economic attributes, should be considered in crop improvement programs to improve crop production and farmers' livelihoods. The heterogeneity of soil, climate, and socioeconomic factors of maize farms and farmers should not be generalized in agroecological highlands; instead, the uniqueness of their locations must be considered in inquiring about input findings in specific regions and districts. This study is a foundation for regional and district risk studies to uncover the uniqueness of the maize smallholders' risk behavior in maize production.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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