Determinants of Inorganic Fertilizer Use by Smallholder Rice Farmers in Mbeya and Morogoro Regions of Tanzania

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ABSTRACT

This study identifies factors that influence smallholder rice farmers to adopt or not adopt inorganic fertilizer. This study employed a cross-sectional design. This study was guided by the Theory of Reasoned Action (TRA) in determining the factors that influence the use of inorganic fertilizer among smallholder farmers. The data was collected using multistage sampling, a two-stage design. To do this, secondary data from the National Sample Census of Agriculture (NSCA) survey of 2019–20 are used to model participation and intensity of use of inorganic fertilizer as separate decisions. The results showed that factors such as farm income, membership in the farmer group, and irrigation influence both participation and intensity of inorganic fertilizer use. Moreover, factors such as distance to the homestead, distance to the nearest road, and improved seed use influence participation decisions, while only extension advice and the price of inorganic fertilizer affect the intensity of inorganic fertilizer use. Furthermore, the study found regional differences in the key factors that influence inorganic fertilizer use. The study recommends various strategies for encouraging and increasing the use of inorganic fertilizer among smallholder rice farmers in Tanzania. These include developments to the rural road network, a decrease in the cost of inorganic fertilizer, encouraging membership in farmer groups, and strengthening the existing extension system. In addition, the designed intervention should take into consideration the regional differences that exist in the regions; thus, policies to increase inorganic fertilizer use might differ among regions. Furthermore, the intervention should account for the regional disparities that exist. Consequently, strategies aimed at promoting the use of inorganic fertilizers may vary among regions.

Keywords: Inorganic Fertilizer, Rice, Sustainability, Yield

I. INTRODUCTION

Smallholder rice farmers play a crucial role in the global agricultural system, contributing significantly to food security and economic development. Globally, there are about 144 million smallholder rice farms, with the majority located in Asia and Sub-Saharan Africa (SSA) (Mather, 2017). These farmers often face numerous challenges, including limited access to inputs such as inorganic fertilizers, which can significantly impact their productivity and livelihoods (Dissanayake et al., 2022; Tadesse, 2021).

Rice is a staple food for more than half of the world's population and plays a vital role in food security and economic development (FAO, 2021). In 2020, global rice production reached 756 million metric tonnes, with Asia being the largest producer and consumer, accounting for about 90% of the world's rice production and consumption (FAO, 2021). However, rice farmers worldwide face various challenges, such as declining soil fertility, water scarcity, and limited access to inputs like inorganic fertilizers (Dissanayake et al., 2022; Tadesse, 2021).

Soil fertility is a critical factor in determining agricultural productivity, and its decline has been identified as a major constraint on crop production in many regions (Eba & Bashargo, 2014). Inorganic fertilizers have been recognised as a key input for improving soil fertility and increasing crop yields (Mensah et al., 2018). The use of inorganic fertilizers has played a significant role in the Green Revolution, which has helped many countries increase agricultural productivity and achieve food security (Dassa, 2022). However, the adoption and use of inorganic fertilizers vary widely across regions and farming systems, influenced by factors such as access to credit, extension services, and market infrastructure (Jamwal et al., 2021).

In Sub-Saharan Africa (SSA), agriculture is the backbone of many economies, employing a significant portion of the population and contributing to food security and poverty reduction (Food and Agriculture Organisation [FAO], 2021). However, the agricultural sector in SSA faces numerous challenges, including low productivity, limited access to inputs, and soil degradation (Tefera et al., 2020). The loss of soil fertility has been identified as a major cause of low agricultural output in the region (Anago et al., 2020). To address this challenge, the use of inorganic fertilizers has

been promoted as a key strategy for improving soil fertility and increasing crop yields (Chinasa et al., 2022). The African Union's Comprehensive Africa's Agriculture Development Programme (CAADP) has also recognised the importance of increasing fertilizer use to address low agricultural production in the region (Makombe et al., 2020).

Rice is one of the most important crops in SSA, with significant potential to contribute to food security and economic development (Ouattara et al., 2022). SSA is the second-largest rice-producing region after Asia, accounting for about 4% of global rice production (FAO, 2021). However, rice production in SSA faces various challenges, including low productivity, limited use of improved inputs, and poor market access (Aryal et al., 2021). In recent years, the demand for rice in SSA has been increasing due to population growth, urbanisation, and changing dietary preferences (Ouattara et al., 2022). To meet this growing demand, many SSA countries have prioritised rice production and have implemented policies and programmes to increase productivity and self-sufficiency (Jamwal et al., 2021). In this light, this study aims at examining the determinants of inorganic fertilizer use by smallholder rice farmers in the Mbeya and Morogoro regions of Tanzania.

1.1 Statement of the Problem

According to the 2019-20 National Sample Census of Agriculture (NSCA), inadequate soil fertility was recognised as a limiting factor in improving production. Furthermore, the NSCA 2019–20 reports indicate that the use of inorganic fertilizer by smallholder rice farmers is limited, with a mere 23.9% of farmers using it. Moreover, the average application rate in rice production was approximately 104 kg/ha, which is low in comparison to Nakano and Kajisa (2013), who suggested that the optimal range of inorganic fertilizer use in rice cultivation is 125 to 250 kg/ha. Empirical research from the Asia region demonstrates that agricultural output can be enhanced by using inorganic fertilizer (Dittoh et al., 2012). This suggests that a significant contribution to the achievement of the SDGs might be made by increasing the use of inorganic fertilizer.

Studies in SSA have linked different factors, such as age, household size, farm size, improved seeds, distance to market, distance to nearest road, distance from homestead to farm, education, farm income, off-farm activities, extension, farm groups, sex, irrigation, and land ownership, to the use and non-use of inorganic fertilizer (Tadesse, 2021; Mensah et al., 2018; Eba & Bashargo, 2014; Anago et al., 2020; Minot et al., 2000; Akpan et al., 2012; Dabessa et al., 2021; Martey et al., 2013; Mather et al., 2017; Aryal et al., 2021; Tefera et al., 2020; Dassa, 2022). However, the pattern of influence of these factors is often context-specific, depending on location and dynamics. We must update the information to reflect the current technologies that farmers are adopting.

Studies in Tanzania, such as those by Mather et al. (2017), focus on the determinants of commercially priced inorganic fertilizer in maize crops. Furthermore, Boniphace and Fengying (2015) used a probit model to determine the likelihood of inorganic fertilizer adoption in five regions for rice production, whereas Nakano and Kajisa (2013) focused on the role of credit in technology adoption by rice farmers. Until now, Tanzanian studies have not distinguished between participation and intensity of inorganic fertilizer use in rice production.

1.2 Research Objective

This study was undertaken with the main objective of identifying determinants of inorganic fertilizer use by smallholder rice farmers based on participation and intensity of use. Furthermore, the study aims to identify any regional variations in these factors.

1.3 Research Questions

This study aims to address the following research questions: First, what are the factors that influence the participation decision for inorganic fertilizer use among smallholder rice farmers? Second, what are the factors that influence the intensity of inorganic fertilizer use among smallholder rice farmers? Finally, are there differences in the factors that affect inorganic fertilizer use among the regions? These research questions are designed to provide a comprehensive understanding of the determinants of inorganic fertilizer use among smallholder rice farmers in Tanzania, considering both the decision to use fertilizers (participation) and the amount of fertilizer used (intensity). Additionally, the study aims to identify any regional variations in these factors, which can provide valuable insights for policymakers and agricultural extension services to tailor their efforts and interventions to promote sustainable and efficient rice production in different regions of Tanzania.

II. LITERATURE REVIEW

2.1 Theoretical Review

This study is guided by the Theory of Reasoned Action (TRA) in determining the factors that influence the use of inorganic fertilizer among smallholder farmers. This theory was proposed by Fishbein and Ajzen in 1967. The idea centres on identifying the factors that ascertain the behavioural intention of an individual (Dissanayake et al.,

2022). This theory seeks to clarify the interrelationship between attitudes, individual behaviours, and acceptance. In this study, "attitude" refers to an individual's assessment of a technological inorganic fertilizer. Additionally, "acceptance" refers to the outcome of the assessment, whether to adopt or not to adopt inorganic fertilizer. Farmers will participate in rice production if the outcome of adopting inorganic fertilizer results in an increase in rice yield.

2.2 Empirical review

Several studies have investigated the factors influencing inorganic fertilizer use among smallholder farmers in various contexts. This section reviews the empirical findings of these studies in line with the objectives of the current research.

2.2.1 Participation decision of inorganic fertilizer use

Many studies have explored the factors that influence farmers' decisions to use inorganic fertilizers. Martey et al. (2013) found that factors such as education, extension services, and access to credit positively influenced the adoption of inorganic fertilizers among Ghanaian farmers. Similarly, Eba and Bashargo (2014) reported that farm size, extension services, and access to credit were significant determinants of inorganic fertilizer adoption in Ethiopia. In Nigeria, Akpan et al. (2012) identified farm size, education, and access to credit as key factors influencing farmers' decision to use inorganic fertilizers.

2.2.2 Intensity of inorganic fertilizer use

The intensity of inorganic fertilizer use, or the amount of fertilizer applied, has also been the focus of several studies. Anago et al. (2020) found that factors such as education, farm size, and access to extension services positively influenced the intensity of inorganic fertilizer use among rice farmers in Benin. In Tanzania, Mather et al. (2017) reported that farm size, education, and access to markets were significant determinants of the intensity of inorganic fertilizer use among maize farmers. Minot et al. (2000) also found that farm size and access to markets were positively associated with the intensity of inorganic fertilizer use in Benin, Malawi, and Nigeria.

2.2.3 Regional variations in inorganic fertilizer use

Few studies have explored the regional variations in the factors influencing inorganic fertilizer use. Boniphace and Fengying (2015) investigated the adoption of inorganic fertilizers among rice farmers in five regions of Tanzania using a probit model. They found that the factors influencing adoption varied across regions, with education, farm size, and access to credit being significant in some regions but not others. Dassa (2022) also found regional differences in the factors influencing inorganic fertilizer use among maize farmers in Benin, with education and access to extension services being more important in some regions than others.

The empirical evidence suggests that various socioeconomic, institutional, and farm-level factors influence smallholder farmers' decisions to use inorganic fertilizers and the intensity of their use. However, the relative importance of these factors may vary across different contexts and regions. The current study builds upon this empirical foundation by investigating the determinants of inorganic fertilizer use among smallholder rice farmers in Tanzania, considering both participation and intensity decisions, and exploring regional variations in these factors.

III. METHODOLOGY

3.1 Study Area

This study was conducted in Tanzania targeting smallholder farmers that are engaged in rice production. In addition, regional analysis of the Mbeya and Morogoro region was used to identify regional differences of the factors that affecting inorganic fertilizer use. The regions have been chosen because they account for around 26% of the total harvested area in Tanzania, contribute to the production of around 29% of the country's rice output and had a largest number of households reported to use inorganic fertilizer.

3.2 Data Sources and Sampling Procedure

This study employed cross-sectional design using secondary data obtained from the NSCA 2019-20 dataset provided by the National Bureau of Statistics (NBS). The data was collected using multistage sampling, a two-stage design. The first stage involves identification and selection of urban and rural enumeration areas from 2012 population and housing census frame. The second stage was the identification and inclusion of agricultural farming households from the selected enumeration areas. NSCA 2019/20 is a nationally representative data set including farm-level agricultural statistics. The main purpose of NSCA is to help high-level decision-making bodies plan and create actions by filling the information gap.

3.3 Data Analysis Technique

The study used a Double Hurdle model with the assumption that household farmers make inorganic fertilizer use decision in two steps. First, farmers determine whether to use inorganic fertilizer "participation decision". Secondly, farmer determine amount of inorganic fertilizer use (which might be zero) given his or her circumstance "quantity decision". The specification of the model for the two decisions is given as described by Garcia (2013):

$y_i = z_i\gamma + \mu_i$ participation decision ……. (1)

$I_i = x_i\beta + \epsilon_i$ quantity decision ……. (2)

$\begin{pmatrix}\epsilon_i \\ \mu_i\end{pmatrix} \sim N(0,1)$

Where, y_i is a binary dependent variable representing the decision for each household (i) to adopt fertilizer where a value of 0 indicate non-use, while a value of 1 indicate usage, I_i is a continuous dependent variable of the inorganic fertilizer quantity decision. The error terms of participation and quantity equation are jointly normal and may be correlated. A probit model was used to estimate parameter of household participation decision and truncated regression was used to estimate parameter of quantity decision.

IV. FINDINGS & DISCUSSIONS

4.1 Socioeconomic Characteristics of Rice Farmers

4.1.1 Continuous Independent Variables

Table 1 displays the findings for continuous variables and compares smallholder rice farmers who use inorganic fertilizer to those who do not. In Tanzania the average age of smallholder rice farmers was 49 years. It is important to note that the average age falls within the labor force's age range of 15 to 64 years. Additionally, we found that, the average age of inorganic fertilizer users in the Mbeya region (43 years) was significantly lower than that of non-users (50 years).

Moreover, there was no significant difference between inorganic fertilizer users and non-users in terms of the average farm size for Tanzania. However, rice farmers in the Mbeya region who use inorganic fertilizer have significantly larger farm sizes (0.9 ha) than non-users (0.5 ha). In terms of average household size, there was a significant difference between inorganic fertilizer users and non-users for the whole sample. Farmers who used inorganic fertilizer had an average household size of four members, compared to five for non-users.

Furthermore, there was a significant difference between inorganic fertilizer users and non-users in terms of the number of years spent in school. The average years of schooling for inorganic fertilizer users was six years while that of non-users was five years. There was no significant difference in the Mbeya and Morogoro regions. In addition to that, the average farm income of the inorganic fertilizer users in Mbeya region was TZS 1,948,801, significantly higher than that of non-users, TZS 941,765.

Table 1

Households Characteristics by Use of Inorganic Fertilizer for Continuous Variables

Variables	Full			Mbeya			Morogoro		
	User (n=171)	Non-user (n=804)	t-value	User (n=46)	Non-user (n=73)	t-value	User (n=21)	Non-user (n=163)	t-value
	Mean	Mean		Mean	Mean		Mean	Mean	
Age	49	49.54	-0.421	43.52	50.79	-2.502**	47.57	49.75	-0.657
Farm size	0.729	0.858	-1.201	0.95	0.563	2.262**	0.94	0.93	0.031
Household Size	4.29	5.18	-3.443***	4.48	4.71	-0.513	4.1	4	0.185
Education	6.462	5.572	2.527**	6.59	5.96	0.844	6.48	6.05	0.489
Farm income	1020	1018	0.602	1948	941	2.013**	939	690	1.157

Source: NSCA 2019-20 data. ** and *** Significant at 5% and 10% respectively.

4.1.2 Categorical Independent Variables

Table 2 presents the findings of the categorical variables. We used the chi-square test to demonstrate a statistically significant association between the dummy variables and the use of inorganic fertilizer. A statistically significant association was found between the use of inorganic fertilizer and improved seeds and irrigation, in the country level as well as in the Mbeya and Morogoro regions. The level of significance was 1%. Additionally, the chi-square test shows a significant association between farmers who use inorganic fertilizer and those who reside within 3 km of the closest road at the 10% significance level in the country level.

Furthermore, there was a significant association between the farmers who reside within 3 km of their homestead to the farm and use of inorganic fertilizer at 10% significance level in the country and 5% significance level in Morogoro region. Moreover, the chi-square test shows significant association (at the 1% significance level)

between farmers who do activities off the farm to earn income and the usage of inorganic fertilizer in the country level. Similarly, the statistically significant association was observed between farmers belonging to farm groups and the use of inorganic fertilizer at the 1% level of significance in the country level.

Table 2

Household Characteristics by Use of Inorganic Fertilizer for Dummy Explanatory Variables

	Full			Mbeya			Morogoro		
	User (n=171)	Non-user (n=804)	χ^2	User (n = 46)	Non-user (n= 73)	χ^2	User (n=21)	Non-user (n=163)	χ^2
Sex of head	77.7	77.4	0.007	73.9	76.7	0.12	80.9	76.6	0.19
Improved seed	23.3	6.1	50.86***	34.7	5.4	17.3***	20.1	9.2	8.54***
Irrigation	12.8	2.4	38.61***	34.7	6.8	15.1***	9.5	-	15.96***
Extension	2.9	2.2	0.287	2.1	4.1	0.325	-	95	1.07
Market	24.5	18.7	2.96*	21.7	19.1	0.115	14.2	15.3	0.01
Road	49.7	44.9	1.31	43.4	49.3	0.386	66.6	58.2	0.54
Homestead	33.3	40.4	2.97*	23.9	34.2	1.428	23.9	47.2	4.13**
Off farm income	52.6	41.5	7.05***	47.8	43.8	0.181	57.1	47.2	0.73
Farm groups	12.8	5.8	10.55***	10.8	8.2	0.236	4.7	3	0.16
Land ownership	76.6	81.1	1.79	69.5	79.4	1.497	66.6	79.7	1.87

Source: NSCA 2019-20 data. *, ** and *** Significant at 10%, 5% and 1% level respectively. Figures in %

4.2 Participation Decision of Inorganic Fertilizer

The probit estimates in Table 3 show that household size, farm income, farm groups, distance to homestead, distance to the nearest road, improved seed, and irrigation are the key factors that influence the inorganic fertilizer participation decisions of smallholder rice farmers at the country level. The coefficients had expected signs, except for the household size. Farm groups, distance to the nearest road, improved seed use, and irrigation have a statistically significant positive effect on the probability of adopting inorganic fertilizer. In contrast to household size, farm income and distance to the homestead have a statistically significant negative effect on the likelihood of adopting inorganic fertilizer.

Regarding household size, the probability of inorganic fertilizer adoption reduces by 6.5% for every extra member of the farming household head family. This might suggest that extra members of the family increase household expenditure, leaving the household head with an insufficient amount to allocate towards the purchase of inorganic fertilizer. Furthermore, rice farmers are less likely to adopt inorganic fertilizer when farm income increases. An earlier study by Martey et al. (2013) in Ghana found a similar result: farmers used the money they made from selling crops to fulfil other obligations, such as household food expenditure and other social responsibilities. This is likely to explain why Tanzanian rice farmers are less likely to adopt inorganic fertilizer when their farm income goes up.

Additionally, farmers who are part of farm groups are more likely to adopt inorganic fertilizer than farmers who are not part of farm groups. This is in line with the study by Aryal et al. (2021), which found a positive correlation between inorganic fertilizer use and being a part of farm groups. Farm groups serve as the primary resource for farmers seeking to acquire knowledge about inorganic fertilizer technology. Furthermore, rice farmers who use improved seed are more likely, by 23.2%, to adopt inorganic fertilizer compared to those who do not. This finding was statistically significant at the 1% level.

Similarly, rice farmers who use irrigation are more likely to adopt inorganic fertilizer than rice farmers who don't use irrigation. This result was statistically significant at the 1% level. Farming technologies that led to the Green Revolution in Latin America and Asia include improved seeds, irrigation, and inorganic fertilizer (Dittoh et al., 2012). This could help clarify why farmers who use improved seeds and irrigation are more likely to adopt inorganic fertilizer.

In addition to that, rice farmers who reside within 3 km of the closest road are more likely to adopt fertilizer than farmers who live more than 3 km away. This was statistically significant at the 10% level. Having access to roads is often seen as a benefit of adopting inorganic fertilizer because it lowers the transport cost.

This study also found that the key factors that influence participation decisions for inorganic fertilizer by smallholder rice farmers are different depending on the location. At the regional level, age, price of fertilizer, and land ownership are the key factors that influence the participation decisions of inorganic fertilizer. At the country level, however, this wasn't the case.

In the Mbeya region, an additional year for farmers reduces the likelihood of adopting inorganic fertilizer by 0.7%. The findings bear resemblance to those of Anago et al. (2020), where an increase in age influenced negatively

inorganic fertilizer adoption. This might suggest that older rice farmers in the Mbeya region are less likely to adopt inorganic fertilizer.

Similarly, the price of fertilizer in Morogoro area was statistically significant at 1%, in Morogoro region. An increase in fertilizer price reduces the likelihood of adopting inorganic fertilizer. The Morogoro region had a higher average price per kg for inorganic fertilizer than the Mbeya region. Furthermore, land ownership was a significant factor influencing inorganic fertilizer adoption in the Morogoro region, statistically significant at 10% level. Farmers who own land are less likely to adopt inorganic fertilizer compared to those who do not. This might suggest that landlords didn't have as much of a reason to make their land more profitable as farmers who leased it.

Table 3

Participation Decision Results of Inorganic Fertilizer

Variables	Mbeya		Morogoro		Full	
	Marginal effect	Std. error	Marginal effect	Std. error	Marginal effect	Std. error
Age	-0.007 *	0.004	0.001	0.001	-0.00004	0.001
Sex	-0.15	0.135	0.03	0.043	-0.005	0.029
Household size	-0.024	0.027	0.014	0.009	-0.015 ***	0.005
Education	0.01	0.014	0.002	0.005	0.004	0.003
Farm size	0.048	0.075	0.02	0.002	0.017	0.01
Farm income	0.004	0.013	-0.008	0.007	-0.017 ***	0.005
Off-farm income	-0.074	0.117	0.037	0.040	0.018	0.025
Extensions	-0.102	0.267	n/a	n/a	-0.028	0.068
Farm groups	0.104	0.181	0.006	0.099	0.143 **	0.058
Price of fertilizer	0.035	0.09	-0.083 ***	0.032	0.005	0.018
Distance to market	0.057	0.165	-0.032	0.043	0.039	0.038
Distance to homestead	-0.089	0.144	-0.12 ***	0.043	-0.13 ***	0.317
Distance to road	-0.086	0.153	0.083 **	0.04	0.084 **	0.037
Improved seed use	0.425 ***	0.140	0.354 **	0.172	0.232 ***	0.055
Irrigation	0.322 **	0.147	n/a	n/a	0.285 ***	0.084
Land ownership	0.014	0.135	-0.12 *	0.071	-0.019	0.31
N	119		184		975	
Pseudo R^2	0.21		0.18		0.11	
Log likelihood	-62.218		-52.953		-399.161	
Chi-square	0.000 ***		0.037 **		0.000***	

Source: NSCA 2019-20 data. *, ** and *** Significant at 10%, 5% and 1% level respectively.

4.3 Intensity Use of Inorganic Fertilizer

As presented in Table 4, the study found that, the key factors influence the intensity use of inorganic fertilizer among smallholder rice farmers in Tanzania are farm income, extension, farm groups, price of fertilizer and irrigation. The coefficients estimate had expected signs except for extension. Farm groups and irrigation had a statistically significant positive effect, whereas farm income, extension and price of fertilizer had a statistically significant negative effect.

An increase in farm income results in a decrease in the amount of inorganic fertilizer used by 9 kg/ha. This was statistically significant at the 5% level. This might suggest that income generated from crop sales is not reinvested in inorganic fertilizer purchases. In the Morogoro region, it was found that an increase in farm income resulted in an increase in inorganic fertilizer use. In this case, it might be suggested that the income generated from crop sales be re-invested in the purchase of inorganic fertilizer.

Furthermore, rice farmers who are part of farm groups tend to use more inorganic fertilizer than farmers who are not part of farm groups. The finding was similar to that in the Morogoro region. Moreover, rice farmers who receive extension advice use less fertilizer in comparison to those who do not receive advice. This might suggest that extension services do not inform rice farmers of the benefits of inorganic fertilizer. From the NSCA 2019–20, nearly 83% of the rice farmers receive advice on spacing, use of agrochemicals, soil erosion, use of improved seed, irrigation technology, crop storage, vermin control, and integrated pest management (Dabessa et al., 2021).

Moreover, an increase in the price of inorganic fertilizer results in a decrease in the amount of fertilizer used. This finding is similar to what has been observed in the Morogoro and Mbeya regions. Furthermore, rice farmers who

irrigate tend to use more fertilizer in comparison to those who do not irrigate. This result was statistically significant at the 1% level in the national sample and 5% in the Mbeya region.

The study found that the key factors that influence the intensity of use of inorganic fertilizer by smallholder rice farmers vary by region. Age, sex, farm size, distance to the nearest road, land ownership, household size, education, farm income, distance to the nearest market, distance to homestead, and improved seed use had a statistically significant influence on the intensity of the use of inorganic fertilizer in the Morogoro region, whereas that is not the case in the Mbeya region. Furthermore, while irrigation had a significant influence in the Mbeya region, that is not the case in the Morogoro region.

Table 4

Intensity Uses Results of Inorganic Fertilizer

Variables	Mbeya		Morogoro		Full	
	Coefficients	Std. error	Coefficients	Std. error	Coefficients	Std. error
Age	-0.912	2.125	-1.895 ***	0.484	-1.402	1.106
Sex	-2.031	55.685	-159.115 ***	21.738	-18.27	40.073
Household size	7.579	14.781	20.311 ***	3.057	9.635	7.566
Education	2.165	6.562	8.469 ***	1.419	-4.236	3.617
Farm size	-21.134	23.522	-32.59 ***	8.678	8.673	13.942
Farm income	6.287	5.478	15.04 ***	2.534	-9.229 **	4.698
Off-farm income	50.088	55.066	18.146	14.315	-51.971	33.531
Extensions	-173.105	226.895	n/a	n/a	-201.025 *	116.348
Farm groups	-15.933	88.164	208.583 ***	26.012	71.704 *	42.697
Price of fertilizer	-108.205 ***	31.84	-52.098 ***	7.862	-59.722 **	25.865
Distance to market	16.471	82.336	95.432 ***	12.562	34.7	47.369
Distance to homestead	-26.944	83.866	30.551 **	14.718	-18.672	46.275
Distance to road	-61.448	68.861	170.983 ***	12.939	-37.156	45.471
Improved seed	52.04	46.334	47.901 ***	9.769	46.143	37.638
Irrigation	113.03 **	55.96	n/a	n/a	151.2 ***	46.914
Land ownership	-57.533	57.057	-34.538 **	14.633	63.535	40.401
Constant	303.674	191.729	190.885 ***	35.778	295.945	113.549
Log likelihood	-271.377		-83.523		-988.042	
Chi-square	0.049 **		0.000 ***		0.035 **	

Source: NSCA 2019-20 *, ** and *** Significant at 10%, 5% and 1% level respectively.

V. CONCLUSIONS & RECOMMENDATIONS

5.1 Conclusions

This study investigated factors that influence smallholder rice farmers in Tanzania to use inorganic fertilizer, modelling participation and intensity use as separate decisions. The study found that farm groups, distance to the nearest road, improved seeds, household size, farm income, and distance to the homestead all had a significant effect on participation in the in the decision to use inorganic fertilizer. Moreover, the study found that farm groups, irrigation, farm income, extension, and the price of inorganic fertilizer had a statistically significant effect on the intensity of inorganic fertilizer use.

The study found differences in the factors that influence participation and intensity in the use of inorganic fertilizer. For instance, the price of inorganic fertilizer did not significantly influence participation decisions, but it did have a statistically significant effect on the intensity of its use. Furthermore, this study found regional variations in the factors that influence participation and intensity in the in the use of inorganic fertilizer among smallholder rice farmers.

5.2 Recommendations

This study recommends that, in order to effectively target and implement programs that promote the use of inorganic fertilizer, it is crucial that technical personnel involved in program design have a comprehensive understanding of the regional differences. Furthermore, this study suggests that promoting inorganic fertilizer should

go hand in hand with improving access, distribution, and proper use of improved seeds and irrigation infrastructure development. This technology trinity (inorganic fertilizer, improved seed, and irrigation) might result in increased rice productivity, hence achieving the National Rice Development Strategy II (NRDS II) goal of reaching 4 t/ha rice productivity in 2030.

Moreover, extension educators should provide knowledge on the benefits of using inorganic fertilizer, as they do for other technologies. In addition to that, investment in adequate infrastructure, particularly a good rural road network to reduce transportation costs, will lead to a reduction in the price of inorganic fertilizer and increased inorganic fertilizer use among smallholder rice farmers.

Additionally, it is important to encourage smallholder rice farmers to join farm groups. Farm groups provide farmers with production-related services, such as inorganic fertilizer use. Furthermore, grouping smallholder rice farmers geographically dispersed makes it easier for the government to intervene.

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