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Assessment of Factors Influencing the Use of Inorganic Fertilizers by Smallholder Farmers in Rwamagana RW-34 Scheme

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Abstract – This study used qualitative and quantitative analysis to assess the factors influencing the use of inorganic fertilizers among small holder farmers. This research was conducted in Eastern province, Rwamagana district, in one of eight irrigated scheme called Rwamagana RW-34. The two stage purposive sampling method was performed to select 200 households' respondents from four sectors as sample size. Descriptive statistics, logistic regression and correlation analysis were used.
Regression results revealed that family size has highly significant effect (p=0.010) on use of inorganic fertilizer and has negative relationship with use of inorganic fertilizer. Education level of household and access to extension service were found significant (p=0.1) with positive relationship. Off farm income of household and cooperative membership of household were found significant (p=0.05) with positive relationship with use of inorganic fertilizer. However distance travelled by household to nearest agro-dealer was found significant (p=0.1) with negative relationship with use of inorganic fertilizer.
Much emphasize should be put in educating rural population, encouraging farmers to create functional cooperatives, promote training and extension services, creating more off farms employment and decentralize the agro dealers to cell level.

Keywords – Fertilizers, Inorganic Fertilizers, Smallholder Farmers.

I.INTRODUCTION

1.1. Background of the study

Fertilizers, if well used, are ones of the most important inputs in enhancing agricultural output. Among the major difficulties the agricultural sector is facing; are achieving food security, mitigating climate change and reducing natural resource deterioration towards achieving Sustainable Development Goals (SDGs) (Prakash Aryal et al., 2021).

The use of fertilizers, particularly chemical fertilizers use, is an important method for increasing farm income by boosting soil fertility. The use of fertile soil improves amendments to supply needed macro and micronutrients in crop productivity. The achievement of the Green Revolution (GR) in the 1960s to improve food production and alleviate global hunger was made possible by the increased usage of inorganic fertilizers (Erisman et al., 2010).

The increased of using inorganic fertilizers combined with irrigation schemes and improved varieties were core to the Government of Rwanda (GR) philosophy that targeted to increase crop yields. Many farmers in Rwanda are unaware of application rate of inorganic fertilizers, they just apply when and where they believe it is necessary. Heavy subsidy related to inorganic fertilizers and the inadequate fertilizers application knowledge has resulted to inadequate application.

II. RESEARCH METHODOLOGY

2.1. Description of the study area

The study was carried out in Rwamagana district in one of eight irrigated scheme called RWAMAGANA RW-34. It is a site that is attached to four sectors namely Gahengeri, Nzige, Mwurire, and Rubona. It is a big irrigated scheme of 215 hectares owned by 400 smallholder farmers. The average land owned by each small farmer is almost 0.5ha. The scheme consists of marshland and upland site. In the marshland, farmers grow vegetables such as tomatoes, chili, and eggplant, french beans, beet roots, and carrot and in the upland site farmers grow mainly maize, climbing beans, banana, cassava, potatoes and soya beans.

2.2. Type and source of data

Both primary and secondary data were used in this study. The primary data was collected through interviewing smallholder farmers who have land in Rwamagana Rw-34 scheme. These factors include household characteristics (age, gender, education level and family size); economic factors (farm size, livestock, off farm income, cooperative membership); institutional factors (access of extension services, access to credit) and farmland characteristics like distance from homestead to nearest agro-dealer. Secondary data was collected from government institutions like MINAGRI, NISR, RAB and reports from website. The secondary data include price of inorganic fertilizers, number of farmers and quantity of inorganic fertilizers used in last seasons.

2.3. Sampling size and technique

Yamane (1967) sample size determination formula was used to determine a sample of 200 representative household heads.

$$n = \frac{N}{1+N(e)2} \qquad (1)$$

Where **n**: is the sample size, **N**: is the population size and **e** is the margin error with a confidence interval of 95%). The sample size is **200** from the total population of 400 households.

2.4. Modelling Specification

Binary Logistic Model

Farmers were classified as "user" or "non-user" based on the dichotomous outcome of the user decision, which characterizes the dependent variables (Y). As a result, a farmer is defined as a "user" when Yi=1 or a "non-user" when Yi=0. For such types of dependent variables, either the Probit or logit models are appropriate, depending on personal preferences .The binary Logit model was used in this research and the specification is given below:

$$\text{Log}[\emptyset(x)] = \log\left(\frac{\emptyset(x)}{1-\emptyset(x)}\right) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \cdots \ldots \ldots \ldots + \beta_{11} x_{11} + e \quad (2)$$

Where:

$\emptyset(x)$ = Probability of use

$1 - \emptyset(x)$ = Probability of no use

α = Constant of the equation

β = Coefficient of the predictor variables

e = The error term

Equation above can be simplified as follow:

$$Y_1 = \ln\left(\frac{P}{1-P}\right) = f(x_1\ x_2\ x_3\ x_4\ x_5\ x_6\ x_7\ x_8\ x_9\ x_{10}\ x_{11}\ ) + e \qquad (3)$$

Where:

Y_1 = Use of inorganic fertilizers (DAP, NKP, UREA)

x_1 = Age of household head

x_2 = Gender of household head

x_3 = Education level of household head

x_4 = Size of the family

x_5 = land size

x_6 = Livestock ownership

x_7 = Off-farm incomes

x_8 = Membership of cooperative

x_9 = Extension service

x_{10} = Access to credit

$x_{11=}$Distance from homestead to nearest agro-dealer

e = Error term

III. RESULTS AND DISCUSSIONS

3.1. Socio-economic characteristics of respondents

3.1.1. Descriptive statistics of continuous variables

Age of respondents

The table below indicates that the youngest respondent was 26 years old and the oldest respondent was 68 years old for inorganic fertilizers use aspect. The mean age of respondent was 40.58.

Young people are less involved in agriculture activities because this sector is still subsistence and not giving enough money, they hence decide to migrate to urban areas for other activities.

Age is a critical factor to consider in farming because it has been shown to influence the use of new technology. According to the findings, the majority of respondents are of working age. The finding is in line with the finding of Adesope et al., (2012) who reported that, the active working age of farmers lies between 41 and 50 years.

Family size of Respondents

Household size also in many families is believed to be one of the sources of labour. This study shows that the average of family size was approximately 4 people. The finding is in line with that one of NISR, (2022) reported that average household size is 4 people in Rwanda population. It was found that minimum number per household was one person whilst the maximum family members was eight person per household. It could signify that households have adequate labour source for agricultural activity.

Education level of respondents

The results in the table below indicates that the mean of education level of households interviewed was 4.31 which means not completed primary school. The lowest education level by household was 0 which means the respondent did not attend any formal class and the highest level of education was twelve years of education, which means completion of secondary school. According to the study, the majority of respondents have a basic formal education that assisted them in their agricultural pursuits. Education

is advantageous in farming activities, particularly when farmers are highly schooled for a certain issue and being implemented by them. People who are well educated try to seek and recognize information easily and they can spread information to other farmers who are less aware. As stated by Ja'afar-Furo, (2007) educated individuals are able to acquire innovation faster, introduce new farming practices and the educated society does not face many challenges.

Farm size

The findings show that the mean value of land owned by respondents is 0.45ha. The results are in line with MINAGRI (2018) demonstrated that total arable land owned by household is less than 0.5ha. In this study, the lowest land size owned by respondent was 0.2ha whilst the biggest land size owned by respondent was 1ha.

Distance travelled from farm to nearest Agro-dealer

The study shows that the average distance travelled by a farmer to nearest agro-dealer is 1.36 km, the lowest distance travelled by household was 1km and the longest distance was 2km.

Table 1: Table showing socio-economic characteristics of respondents for continuous variables

Variables	Sample size	Mean	Min	Max
Age of HHH	200	40.58	26	68
Size of household		4.06	1	8
Education level HHH		4.31	0	12
Farmsize (ha)		0.45	0.2	1
Distance (km)		1.36	1	2

Source: Authors' computation, 2023

3.1.2 Descriptive statistics of categorical variables

Gender of respondents and use of inorganic fertilizers

The findings indicate that 75% of respondents were female headed households and 25% were male headed households. This implies that Rwanda agricultural sector is dominated by females. The results show that gender inequality is significantly dominant and this makes agriculture stagnant therefore this calls upon to promote and mobilize gender equality to enhance sustainable agriculture development. Among respondents of no users of inorganic fertilizers, 22.64% were males whilst users 77.38% were female household heads. Among users of inorganic fertilizers, this study showed that 26.72% were males whilst 73.28% where female household heads.

The results is in line with Kristen (2016) in his study found that gender imbalance in Rwanda agriculture sector is remarkable. He reported that 82% of labors are female and also represent 70% of active labour. According to Ng'ombe et al., (2014) female headed households may be less likely to adopt innovation than male headed households because of financial disparities and cultural issues. Males are well positioned to get extension and training services and hence access to new information about agricultural technologies. Accordingly, Adisa and Okunade, (2005) mentioned that females are backbone of agricultural sector and agricultural production.

Livestock ownership

The finding shows that among 84 households that do not use of inorganic fertilizers, 15.48% do not own any livestock whilst 84.52% own one or more livestock. This might explain that farmers with livestock do not prefer using inorganic fertilizer instead they fertilize their land by using manure got from their livestock. Among 116 households that use inorganic fertilizer, 18.10% do not own any livestock whilst 81.9% own one or more livestock. This implies that, households with livestock use inorganic fertilizers to have high production yields as inorganic fertilizers give a significant yield when combined with manure or compost. The overall percentage shows that 17% of interviewed households do not own any livestock while 83% own one or more livestock.

Off farm income of respondents

The study shows that among 200 households surveyed, 52.5% rely only on farming activities whilst 47.5% have more than one source of income. Among households who do not have any other source of income except farming, 65.48% of them did not use inorganic fertilizers whilst 43.10% use inorganic fertilizers. It implies that farmers without off-farm income may have limited resources to purchase inorganic fertilizers as during interview they all mentioned that inorganic fertilizer is very expensive, few of them can afford and do not use sufficient amount as required due to limited capacity. Among farmers with off-farm incomes, 34.52% did not use inorganic fertilizers whilst 56.90% used inorganic fertilizers in last season. Which shows that farmers with off-farm income may intend to use inorganic fertilizer because they have different source of incomes which can enable them to buy fertilizers. During interview, they mentioned some off-farm activities such as small business, masonry, carpentry, welding and tailoring.

Cooperative membership

The study shows that among 200 households interviewed, 65.5% were cooperative member whilst 34.5% were not member of cooperative. Among 131 households of cooperative member, 99 households used inorganic fertilizers whilst 32 households did not use inorganic fertilizers. Among 69 households who were not cooperative members, only 17 households used inorganic fertilizers whilst 52 did not use inorganic fertilizers. This explains that cooperative membership has a positive influence on farmers to adopt using inorganic fertilizer. During the interview farmers cleared that if a farmer belongs to Gwiza cooperative, it is very easy to get inorganic fertilizer because cooperative can give fertilizer to a farmer and deduct its cost to the produce during harvesting. This has played a vital role to those ones who wanted to use inorganic fertilizers. Gebru et al., (2020) stated that farmer's cooperatives are legal entities owned by farmers. Furthermore, their primary operations are to provide different services and to gain markets of inputs particularly to the rural community.

Access to extension services

The study shows that among 200 households surveyed, 123 households' equals to 61.5% have accessed extension services whilst 77 households' equals to 38.5% did not get extension services. Out of households that received extension services, 93 households have used inorganic fertilizers while remaining 30 households did not use inorganic fertilizers despite extension services provided. The study shows that among 77 households that did not access the extension services; 23 households used inorganic fertilizers while 54 households did not use inorganic fertilizers. However, 15 households have accessed extension services but didn't use any inorganic fertilizer which means only extension service is not sufficient to adopt inorganic fertilizer use but other factors may influence the use of inorganic fertilizer. Also (Kaliba et al., 2000) argued that extension services to households are beneficial in increasing the possibility of selecting agricultural technologies.

Access to Credits

Credit can play a vital role in farming activity as it helps farmers to buy agricultural inputs and can pay for extension services which help them to increase productivity (Berger et al., 2017). The study shows that among 200 households interviewed, 93 (46.5%) households do not have access to credit because of different reasons including but not limited to lack of collateral, high interest rate, and lack of information whilst 107 (53.5) have tried credit services. Among farmers who did not try credit services; 58 (69.05%) households did not use inorganic fertilizers whilst 35 (30.17%) households used inorganic fertilizers. It also shows that among households accessed credit services only 26 (30.95%) households did not use inorganic fertilizers whilst 81 (69.83) households used inorganic fertilizers. Farmers rely on land as their primary asset which can be served as collateral to obtain financial services including acquiring credit (Ding & Kinnucan, 2011). During interview with participants, they pointed out that in many situations, they do not have legal titles for their land which makes it difficult for them to obtain credit. Furthermore, participants in the focus group discussion claimed that the lack of lending institutions, high interest rates, and delay of service and lack of collateral affect farmer's access to loan. In some instances, local financial institutions (IKIMINA) are present but not be relied on because they cannot provide enough money required to purchase all required inputs. However, formal institutions have been reported to have high interest rate which is a main key challenge which prevents farmers from acquiring loans since they are afraid of failing.

Table 2: Table showing Socio-economic characteristics of respondents for categorical variables

Variables (categorical)	Category	Users	Non users	Frequency	Percentage
Gender	**Male**	31	19	50	25
	Female	85	65	150	75
Livestock Ownership	**Yes**	95	71	166	83
	No	21	13	34	17
Off farm income	**Yes**	71	24	95	47.5
	No	58	47	105	52.5
Cooperative Membership	**Yes**	99	32	131	65.5
	No	17	52	69	34.5
Access to Extension	**Yes**	93	30	123	61.5
	No	23	54	77	38.5
Access to Credit	**yes**	81	26	107	53.5
	No	35	58	93	46.5

Source: Authors' computation, 2023

3.2. Logistic regression model on factor influencing the use of inorganic fertilizers by smallholder farmers

The maximum likelihood estimates of the multinomial logistic regression model for factors influencing the use of inorganic fertilizers by smallholder farmers suggest that the fit of the model was satisfactory. The estimated coefficients for likelihood ratio chi-square were significant (**P<0.000),** with chi-square value of 105.49 and the model accounted Pseudo R^2 of 0.38 which indicates 38% variation in the level of using inorganic fertilizers is explained by households variables, economic variables, institution variables and farmland variable under this study. In the logistic regression model, the explanation of the variance of the independent variables on the usage of inorganic fertilizers by smallholder farmers was dependent on variables whose p-value became significant at 1%, 5% and 10%. Variables with p-values are believed to be inconsequential were not used to justify the variance between the explained and explanatory variables. Out of the eleven variables included in the model, only six variables were significant where one was significant at 1%, two were significant at 5% and three were significant at 10% on the inorganic fertilizer use.

Family size was significant at 1% and had negative impact on the use of inorganic fertilizers. The negative sign on marginal effect implies that if the household number increases by one person, the likelihood of using inorganic fertilizer decreases by 15.9%. It indicates that adoption of using inorganic fertilizer was high among smaller households with less family members. It might indicate that because larger family size places a higher value on food security than small family size, thus will relocate few resources to the use of inorganic fertilizer. This finding is in line Shiferaw, (1988) reported that household with larger members notice larger risk of not getting food compared to those with less family member and hence if they failed to get yields because of unfavorable climate, households with bigger family size can suffer a lot and could therefore become less interested to use inorganic fertilizers.

Education was significant at 10%, and the marginal effect was positive which means that if household head increases his education level by one year, the probability of using inorganic fertilizers will be increased by 4.3%. The idea is that an increase in education level is connected with a lot of information about good agricultural practices, land management expertise, productivity and conservation measures. The result is supported by finding of Kebede et al., (1990) has found a positive relationship between education level and the use of technology.

Cooperative membership was found to be significant at 5% and with positive sign of marginal effect which indicates, being a cooperative member increases the probability of using inorganic fertilizers by 22.7%. The membership of a cooperative empowers access to information on available technologies, inputs of technologies like inorganic fertilizers as well as loans for buying input to be used (Jamilu et al., 2015).

Off-farm income as expected was seen to be significant at 5% and positively related with inorganic fertilizer use. A positive marginal effect for off-farm income proposes that the bigger the income earned from non-farming activities, the greater the probability to 18.7% of using inorganic fertilizer. The argument is that off farm income may facilitate the liquidity constraint required for soil amendment or buying of soil fertility- enhancing inputs (Shiferaw, 2011).

Access to extension services was found to be significant at 10% with positive marginal effect. This implies that using inorganic fertilizer increases with greater extension services provided to farmers. If the farmer got an extension service there is a probability of 18% to use inorganic fertilizer. Extension services accelerate farmers to get available information and hence stimulate the adoption of technology (Abate et al., 2015).

Distance traveled by households to nearest agro-dealer was found significant at 10% and with negative sign of marginal effect. This shows that the increase of one kilometer from household to agro dealer, there is a probability of 19% to do not use inorganic fertilizer by farmers. The longer distance travelled by household to agro-dealer, the lesser household adopts to use inorganic fertilizers. This might be due to the fact that the household is discouraged by kilometers he must travel to reach agro-dealer and hence decide to do not use inorganic fertilizer. This is supported by the study of Mango et al., (2018) who reported that distance travelled by smallholder to nearest inputs suppliers was found to be negatively affect the adoption of using irrigation technologies.

Table 1: Logistic Regression model of the factors influencing the use of inorganic fertilizers

Use of inorganic fertilizer	dy/dx	Std. Err.	z	P>|z|	Significance
Gender HHH	-0.0938487	0.10733	-0.87	0.382	
Family size HH	-0.1596319	0.05331	-2.99	0.003	***
Age HHH	0.0005844	0.00899	0.07	0.948	
Education HHH	0.0435236	0.0261	1.67	0.095	*
Land size HH	0.6045294	0.58796	1.03	0.304	
Livestock HH	-0.0697863	0.11812	-0.59	0.555	
Off farm income	0.1878696	0.09523	1.97	0.049	**
Access credit	0.0310136	0.10777	0.29	0.774	
Cooperative membership	0.2275151	0.11109	2.05	0.041	**
Access extension	0.1988323	0.10849	1.83	0.067	*
Distance to agro dealer	-0.198502	0.1084	-1.83	0.067	*

***: significant at 1% (P<.01), **: significant at 5% (P<.05), *: significant at 10% (P<.1)

Source: Authors' computation, 2023

IV: CONCLUSION AND RECOMMENDATIONS

4.1. Conclusion

This study used the methods of analyzing data by using SPSS for frequencies and STATA software applied to analyze the binary output of using inorganic fertilizers by smallholder farmers. The findings of the study show that the family size, cooperative membership, off farm income, education level, access to extension service and distance travelled by household to nearest agro dealer influenced the use of inorganic fertilizers.

5.2. Recommendation

Education was found to be significant, much emphasize should be in encouraging young people to attend school to acquire basic knowledge which will help to access information and adopt technology so easily. Off-farm job was also found to influence the use of inorganic fertilizer, creation of more off-farm jobs is very important so that smallholder farmers will have enough money to purchase inputs. Cooperative membership was found to influence the use of inorganic fertilizer, thus facilitating farmers to be in cooperative increases the use of inorganic fertilizers. Providing adequate extension and training services to smallholder farmers as it increases the awareness about new technologies among smallholder farmers should also be taken into consideration. Diffuse agro dealers at village/cell level as it is found that the more a farmer travels a very long distance to agro dealer discourages him to buy the fertilizer.

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CONFLIT OF INTEREST

The author of this article declares that there is no conflict of interest related to this publication manuscript.

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