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Factors Affecting Adoption of Improved Rice Varieties among Small Scale Farmers in Mongu District, Western Province, Zambia.

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Abstract:*Improved rice varieties are important for improving income and food security, however adoption of these varieties has been low in Western Zambia. The objective of this paper was to analyze the factors affecting adoption of improved rice seeds among smallholder farmers in Mongu district of Western Province. Multistage and simple random sampling methods were used to select a sample of 120 smallholder rice farmers across four agricultural camps in Mongu district. A structured questionnaire was used to interview and collect data from the sample households. Data were analyzed using descriptive statistics and a logit regression model to identify determinants of adoption of new improved rice varieties (NIRVs). The results showed that education level of the farmer, extension access, and farm size and farmers' preference for pest and disease resistant rice varieties, have significant positive influence on adoption of improved rice varieties, while, family labour availability negatively influence the adoption. Policy implications are that, farmers' labor availability and their preference for pest and disease resistant rice varieties should be considered in the design of rice development programs. In addition, there is need to enhance access to extension services, literacy programs and farm land among farmers in the study area in order to increase adoption of improved rice varieties.*

Keywords: *Adoption, binary logistic model, farmer perceptions, rice, improved seed varieties, Zambia*

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I. Introduction

In Zambia, rice is produced by small and medium scale producers mostly under rain-fed lowland and to a small extent under rain-fed upland ecosystems. Although, rice is an important food crop which contributes to rural household income and food security, national rice production is below domestic demand. In 2018, Zambia produced about 43,000 tons of paddy rice against the estimated demand of about 60,000 tons (FAO, 2018) and the excess demand was satisfied through importation of rice mostly from Asia. In Zambia, Western Province is the major rice producing area which in 2017 contributed 29% of national rice output (CSO, 2017), followed by Muchinga Province (27.1%), Northern Province (24.7%) and Luapula Province (11.6%).

Rice is produced mainly by small-scale farmers and their national annual average rice yield of 1-2 tons per hectare is below the maximum potential yield of 3-4 tons per hectare. The low rice productivity of smallholder agriculture is a major concern leading to low rice production in the country. To enhance the contribution of rice to food security and reduce reliance on imported rice, Zambia has realized the need to stimulate domestic rice production. To this effect, rice development strategies of 2011 and 2016, have been formulated with the goal of improving food security, wealth and employment creation through rice production. MoA (2016), pointed that the targets of the Second National Rice Development Strategy (SNRDS), are to expand area under rice cultivation by 20%, production by 25% and productivity by 75%. These strategies focus on addressing the issues of low production and productivity among small-scale rice farmers.

The low rice productivity in smallholder agriculture has been attributed to a number of constraints which include: use of low quality and low yield recycled rice seed, non-availability of adequate improved seed varieties with tolerances to drought, cold weather, major pests and diseases (APSSA 2015), and use of traditional farming methods. Since 2013, ZARI has released in Zambia improved rice varieties such as Supa Mg and Kilombero. These varieties are high yielding, with good grain quality and aroma and are highly preferred by consumers and farmers. Other improve varieties released are non- aromatic high yielding varieties such as NERICA 4 and 2 which are upland varieties. The adoption of improved rice varieties has been promoted among small-scale farmers in the rice growing areas through the agricultural extension.

Despite the efforts of Zambia Agricultural Research Institute (ZARI) and development partners in particular JICA (Japan International Development Agency) to develop and release improved varieties of rice e.g. Supa Mg and promoting adoption among smallholder farmers since 2013, adoption levels remain low. Small-scale farmers continue to experience low rice production and productivity due to use of recycled local rice varieties among other factors.The use of recycled seed is common among small scale rice farmers such that improved rice seed have been used by 10% of farmers in Zambia.

To ensure food and income security among these small-scale farmers' development and adoption of improved rice varieties and technologies is essential. Further there a need to understand the factors affecting low adoption of improved rice varieties, in order to design policies and programs to support development of the rice sector and increase rice production and productivity small-scale farming households. However, there are no empirical studies which have been conducted to analyze factors affecting adoption of improved rice varieties (Supa Mg and NERICA 2 and 4) in Western Province and other major rice producing parts of Zambia. Therefore, this study attempts to determine the key factors affecting adoption of improved high yielding rice varieties by smallholder farmers in Mongu district of Western Province in Zambia.

A number of empirical studies have assessed the determinants of adoption of agricultural technologies by farmers in developed and developing countries. Although many studies have been done mostly in developing countries, few studies have been conducted in Zambia. The results of various studies confirmed that adoption of a new technology offers opportunities for increasing productivity and production. It is widely recognized that adoption of certified and improved high-yielding crop varieties is important avenue for increasing agricultural productivity and improving the living standard of the farmers in developing countries. The factors considered in adoption studies included: socioeconomicand institutional characteristics and attributes of technology.

Saka and Lawal (2009) examined the status of adoption of improved rice varieties and its impact on rice production among smallholder farmers in southwestern Nigeria using the logit model and stochastic frontier model. The study revealed that adoption resulted in an increase in both yield and production of rice. The significant determinants of farmers' decision to adopt improved rice varieties are land area cultivated to rice, frequency of extension contact and the yield rating of the improved rice varieties. The average technical efficiency score of 78.4% suggests that rice farmers have room to increase their productivity by increasing their farm size, quantity of improved seed and fertilizer.

The study conducted by Kalinda et al. (2014) on adoption of improved maize seed varieties in Southern Zambia using a Tobit regression model indicated that expectations about output price, yield potential, sex of farmer, farm size, wealth status and membership to farmer organizations have positive and significant influence on probability of adoption of improved maize seed varieties.

Ghimire et al. (2015) used a probit model to determine the probability of adopting new improved rice varieties (NIRVs) by smallholder farmers in the hills and tropical plain terrain regions of Central Nepal. They found that education, extension services and seed access, farm size, endowment of favorable land type (e.g. lowlands), and animal power (e.g. oxen) are the key factors influencing the probability of adopting NIRVs. They also indicated that technology specific variables (e.g. yield potential and acceptability) are significant for explaining adoption behavior, implying that it is important to take farmers' preferences to varietal characteristics into consideration in the design of a research and development program.

Olufunmilola, Bamire, and Ogunleye (2017) examined the factors influencing levels and intensity of adoption of New Rice for Africa (NERICA) among rice farmers in Ogun State, Nigeria. Their result indicates that the levels of adoption of NERICA technology is influenced by age, farming experience and quantity of fertilizer used while intensity is influenced number of labour used, farming experience and quantity of fertilizer used. The study concluded that the adoption rate of NERICA technology in Ogun State could be improved by increasing the quantities of seed, number of labour and appropriate use of fertilizer.

Chandio and Yuansheng (2018) examined factors affecting adoption of improved rice varieties by smallholder farmers in Northern Sindh, Pakistan using descriptive statistics and probit regression model. The empirical results showed that years of education, farming experience, soil quality, farm machinery ownership, access to market information and contact with extension agents has significant positive influence on adoption of improved rice variety, while age has significant negative effect.

Thai Thuy Pham et al. (2017) investigated factors influencing the adoption of specialty rice variety among smallholder farmers in the Red River delta of Vietnam. They used a probit model to determine specialty rice adoption and a Tobit model to analyze intensity of adoption. The results revealed that significant determinants of adoption are cultivated land, experience in growing rice, and network size. Tobit model estimates show that group membership (such as in agricultural cooperatives, farmer's union, etc.) and possession of a two-wheel-tractor increase the share of land allocation to specialty rice production.

Hagos et al. (2018) examined factors affecting adoption of upland rice in Tselemti district of Tigray region in northern Ethiopia using a binary logistic regression model and revealed that the level of education, perception on rice yield, access to credit service, participation in off-farm activities, participation on field day and participation in training positively and significantly influence the adoption decision of rice technology. However, market distance has a significant negative influence on rice technology adoption.

The few studies reviewed above have highlighted importance of various socio-economic, institutional factors and perceptions toward technology attributes that have been considered in earlier adoption studies, and which may guide the current study in the search for factors affecting adoption of improved rice seed varieties in Mongu district of Zambia.

II. Material and Methods

Study area

The study was conducted in Mongu district in the Western Province of Zambia. Mongu district lies between Longitudes 22°49' and 24°0' east and Latitudes 14°37' and 15°49' south. The district is located 570Km west of Lusaka in the central part of Western province. It covers an area of 10,075 square kilometers and shares boundaries with Kalabo on the west, Luampa on the east, and Limulunga on the north Nalolo on the south. The district is located in the medium rainfall belt of Zambia with an annual precipitation ranging between 800 to 1000mm. The whole landscape of the district is characterized by forest plains and pans, while soils are predominantly Kalahari. The predominant agricultural production areas are Mongu East and the Barotse plains. Agriculture is the major livelihood activity of the majority of people in the district, particularly those in the rural communities. Most people grow maize for consumption and rice to earn cash, livestock has mainly been sold when need arises. Most rural communities are involved in either peasant or subsistence farming growing crops such as rice, cassava, sorghum and millet for both consumption and income generation. Majority of the farmers in the district mainly involved in the cultivation of the staple food maize and cash crop rice. (Mongu Municipal Council and Zambia Environmental Management Agency (ZEMA), 2011).

Sampling procedure and data collection

Multi-stage sampling method was applied to select the sample respondents. First, Mongu was purposively selected due to its rice production potential in western Province. Secondly, out of the six agricultural blocks of Mongu district, two blocks namely Mongu Central and Nalikwanda were selected based on concentration of rice farmers. Thirdly, four rice producing agricultural camps viz. Sefula, Namushakende, and Kaande in Mongu Central Block and Mukangu in Nalikwanda block. Fourthly, in each agricultural camp, 30 farmers comprising of 15 adopters and 15 non-adopters of improved rice seed varieties were randomly selected. In total a sample of 120 households was drawn from the four agricultural camps of Mongu district. The data was collected during February and March in 2018. A structured questionnaire was used to collect information from the sampled respondents. Data obtained were coded and analyzed using SPSS version 20.0.

Methods of data analysis

Data collected were analyzed using descriptive statistics and logit regression. Descriptive statistical analysis involved frequencies, percentages, means and standard deviation. Analysis of presence of statistical differences in selected variables between adopters and non-adopters were done using Chi-square test for categorical or dummy variables and t-test for continuous variables.

The logit econometric model was employed to analyze factors influencing the adoption of rice technology. The model determined the relative influence of various explanatory variables on the dependent variable. The model is chosen because it is computationally easy, it reveals the influence on the probability of adoption. In the logit model, the dependent variable is a dummy variable which take a value of 1 for adopter farmers or 0 otherwise. The logit model is specified as follows:

$$L_i = (P_i / [1 - Pi]) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k + \mu_i \quad (1)$$

Where L_i is the log of odds ratio, is called the logit or logit model. It gives the odds ratio of probability of occurrence of events. X_i is a vector of independent variables; $\beta_o$is the intercept, and β_i, i=1,…n are the coefficients of the independent variables to be estimated; and $\mu_i$is the error term.

The explanatory variables included in the model are listed in Table 1 together with their hypothesized effect on adoption of improved rice varieties.

Prior to executing the logit model a test for multicollinearity among explanatory variables was done and it was found to have no potential influence on estimates from the model. The highest pair-wise correlation was 0.58 whereas multicollinearity is a serious problem if pairwise correlation among regressors is in excess of 0.5 (Gujarati, 2004). Estimates of the variance inflation factor also did not show presence of multicollinearity since none of the VIF values of the variables exceeded 10 (Gujarati, 2002). In fact the mean VIF was 1.67 and the minimum was 1.24 and maximum was 2.47. The econometric software STATA 10 is used to estimate the parameter coefficient and predicted marginal value.

Table 1: Description of the independent variables used in the logistic regression model

Independent Variable	Type	Value	Hypothesis
X_1= Age of farmer	Continuous	Number of years	-
X_2 = Gender of respondent	Discrete	1=male, 0=female	+
X3=Educational level	Discrete	0=none, 1=primary, 2=secondary, 3=tertiary	+
X4=Family labor	Continuous	persons	+
X5=Farm size	Continuous	hectares	+
X6 = Oxen owned	Discrete	1=yes, 0=no	+
X7= Distance to market	Continuous	kilometers	-
X8= Extension contact	Discrete	1=Yes, 0=No	+
X9=FISP access	Discrete	1=Yes, 0=No	+
X10=Perception on pest disease tolerance	Discrete	1=Yes, 0=No	+

III. Resultand Discussion

Characteristics of sample households

In this sample, the male headed households comprised 60 percent of the 120 respondents. The mean age of the farmer was 51.3 years. On average a household had 6 farm family workers, headed by a 51 years-old adult with low level of education (literacy) at primary school level. The farm size was 4.6 hectares (ha) per household and average rice cultivated area of 2.1 hectares. Oxen were a key source of draught power for crop production, and majority (75%) of farmers owned oxen. The farm units were on average located 39 kilometers away from the input and output market center. Majority (93%) of households had access to extension services and about half (53%) accessed Farmer Input Support Program (FISP) which provided selected inputs at a subsidized rate. Most farmers perceived the improved rice varieties to be more pest and disease tolerant (62%), and higher yielding (87%) than local varieties.

Table 2 and 3 presents the comparison of summary statistics of variables expected to influence the adoption of improved rice varieties among sample households. Specifically Table 2 depicts the statistical Chi-square test comparison and Table 3 gives the comparison based on t-test. The descriptive results revealed that there were significant differences between adopters and non-adopters of improved rice varieties in terms of age, education level, family labour, farm size, rice cultivated area, access to extension, access to Farmer Input Support Program (FISP), and perceptions on pest and disease tolerance and yield of improved rice varieties. On the other hand, there were no significant differences between adopters and non-adopters in terms of sex of household head, oxen ownership and distance from market center.

Table 2: Descriptive summary of the continuous variables included in the improved rice variety adoption model

Variable description	Adoption status			*t-value*
	All (mean)	Non-adopters (mean)	Adopters (mean)	
Age of respondent (years)	51.28 (11.83)	56.55 (11.01)	46.02 (10.24)	5.427***
Family labour (persons)	6.18 (2.32)	7.27 (2.43)	5.10 (1.61)	5.75***
Farm size (ha)	4.65 (1.91)	4.22 (1.64)	5.08 (2.07)	2.54**
Rice cropped area (ha)	2.13 (1.05)	1.91 (0.93)	2.35 (1.13)	2.33**
Distance to seed source Km	39.95 (9.12)	39.07 (7.34)	40.83 (10.59)	1.062

***** at 1%, ** at 5% and * at 10% probability level.*
Figures in brackets indicate standard deviations

It is noted that households headed by younger, more educated, with smaller family labor were more of adopters than non-adopters of improved rice varieties in the study area. Improved rice adopters owned larger farm units, cultivated larger rice fields and achieved higher rice yields than non-adopters. With regard to institutional support, more adopters have access to extension services and access to FISP than non-adopters of improved rice varieties. There were differences in perceptions on pest and disease tolerance and yield potential of improved rice varieties relative to local varieties. The result revealed that more adopters than non-adopters perceived improved rice varieties to be pest and disease tolerant and high yielding.

Table 3 Descriptive analysis results for categorical variables

	Percentage between adoption categories			X^2 value
Variable description	**Non-adopter**	**Adopter**	**Total sample**	
Sex of household head				
Female	38.3	41.7	40.0	0.139
Male	61.7	58.3	60.0	
Education level				
None	31.7	8.3	20.0	17.430***
Primary school	63.3	65.0	64.2	
Secondary school	5.0	21.7	13.3	
Tertiary level		5.0	2.5	
Oxen owned				
Yes	75.0	70.0	72.5	0.376
No	25.0	30.0	27.5	
Access to extension				
Yes	88.3	98.3	93.3	4.821**
No	11.7	1.7	6.7	
Access to FISP				
Yes	48.3	66.7	57.5	4.126**
No	51.7	33.3	42.5	
Perceived pest/ disease tolerance				
Yes	26.7	96.7	61.7	62.186***
No	73.3	3.3	38.3	
Perceived yield potential				
Yes	73.3	100.0	86.7	18.462***
No	26.7		13.3	

***, **, and * refers to significant at 1%, 5% and 10% probability level, respectively.

Determinants of adoption of improved rice varieties

In order to identify the variables determining the adoption of improved rice varieties, the binary logistic regression model was estimated using the maximum likelihood procedure. Table 4 presents the empirical model estimates for the factors determining the probability that a farmer will use improved rice seed or not. The model Chi-square value of 104.94 shows that the model was significant at 1% level and best fits the data. The pseudo R square value was 0.631, indicating that the variations in the independent variables explain 63% of the farmer‘s choice to use (adopt) improved rice seed or not.

The results indicate that out of nine independent variables included in the model, five had significant influence on the adoption of improved rice varieties by small-scale farmers in the study area. The significant variables included; education level, family labour availability, farm land size, and access to extension services and farmers perception of farmers toward attributes of pest and disease tolerance of improved rice varieties.

Education level: As expected education level of household head had a positive and significant effect on the probability of adoption of improved rice varieties. The marginal effect showed that a unit increase in the level of education, would increase the probability of adopting improved rice varieties by 0.289 or 28.9%, holding other factors constant. This implies that more educated farmers have a higher chance of adopting improved rice varieties than those with less education. The result suggested that the more educated the farmer is, the more likely he/she will adopt improved rice varieties possibly because he/she can process information more rapidly than others. This result is consistent with findings of Ghimire et al. (2015); Langyintuo and Mungoma, (2008); Kassie et al, (2011), Asfaw et al, 2012) and Dibaba and Goshu (2019).

Table 4: Maximum likelihood estimation of the binary logit model

Variable	Coef.	S.E	z-value	Prob>z	Marginal effects	VIF
Sex of household head (1=male, 0=female)	-0.593	0.943	-0.630	0.529	-0.129	1.65
Education levels	1.349*	0.737	1.830	0.067	0.289	1.75
Family labour (number)	-0.936***	0.268	-3.490	0.000	-0.200	1.72
Rice crop area (hectares)	1.133**	0.455	2.490	0.013	0.242	1.37
Distance to market (km)	0.023	0.037	0.620	0.538	0.005	1.24
Extension access (dummy)	4.566**	2.125	2.150	0.032	0.372	1.37
FISP access (dummy)	0.608	0.844	0.720	0.471	0.127	1.60
Perception on pest and disease resistance	4.261***	0.949	4.490	0.000	0.666	1.55
Ownership of oxen (dummy)	0.432	1.027	0.420	0.674	0.089	1.99
Constant	-8.204**	3.635	-2.260	0.024		
LR Chi-Square	105.48***				Mean	1.37
Log likelihood	-30.435					
Pseudo R Square	0.634					

***, **, and * refers to significant at 1%, 5% and 10% probability level, respectively.

F**amily labour size:** Large family size is assumed as an indicator of labour availability in the family. A household with large working labour force will be in a position to manage the labour intensive agricultural activities. This will increase household's possibility to adopt improved rice varieties production package. The result showed that the number of people available in a family to undertake farm work significantly decreased the likelihood of adopting improved rice varieties. The marginal effect showed that a unit increase in family labour decreased the probability of adopting improved rice varieties by 20%, holding other factors constant. This finding is contrary to studies which found that available family labor significantly increases the likelihood of adopting improved technology (Onyeneke, 2017; Saliu et al. 2016). An explanation for this negative effect of family labour size on adoption of improved rice varieties could be that higher family labor comes from large households. As family size increases the demand for staple food in particular maize to feed the family also increases. In other words, there is competition for family labour between the production maize and rice a cash crop. Since farmers' first priority is to satisfy household food security, they will move family labor away from rice cash crop production to maize staple food production. Therefore increased availability of family labour (or household size) could discourages production and adoption of improved rice varieties in the study area.

Rice land size (crop area): Farm size or rice crop area was found to influence the use of improved rice varieties positively at 5% significance level. The positive and significant sign on farm size indicated that as farm size increases, the likelihood of adopting improved rice varieties increases. The marginal effects showed that a unit increase in farm land holding of the household increases the likelihood to adopt improved rice varieties by 24.2%, holding other factors constant. This result is consistent with findings of Kassie et al. (2011); Ghimire et al. (2015), Dibaba et al. (2019, and Mariano et al (2012), Kalinda et al. (2014). This result is contrary to the findings of Aidoo et al. (2014) that increase in farm size reduces the probability of a farmer adopting improved seeds and that farmers with large rice fields are likely to spend more on seeds if they are to use the so-called 'expensive' certified seeds for rice production such farmers are likely to opt for a cheaper source of seed which is the recycled farmer-saved seed.

Extension contact: As expected extension contact had a significant positive effect on the probability of adoption of improved rice varieties. Farmers with extension access are 43.6% more likely to adopt improved rice varieties than farmers without extension contact, all other factors held constant. This finding concurs with some earlier studies that found that availability of extension services significantly increases the adoption of technology such as improved rice varieties among farm households (Aidoo et al. (2014), Abebaw and Belay (2001), Ghimire et al. (2015), Feleke and Zegeye (2006), and Saka et al. (2005). This underlines the importance of extension contact in promoting uptake of improved seed varieties among farmers.

Perception on pest and disease tolerance: The result indicated that farmers' perception toward pest and disease resistance of improved rice varieties has a significant positive effect on adoption of improve rice varieties. The marginal effect of perceiving that improved rice varieties have better pest and disease resistance, increases the likelihood of adopting improved rice varieties by 66.6%, holding other factors constant. This finding suggests that the probability of adopting improved rice varieties will increase once a farmer perceives that the pest and disease of the given variety is higher than that of the existing local ones. This finding is consistent with earlier

studies by Adesina and Zinnah (1993), Langyintuo et al. (2008), Kalinda et al. (2014) and (Ghimire et al. 2015), that farmers' perception on variety attributes such as yield potential and pest and disease resistance and consumer preference or acceptability of the grain in the market, play an important role in technology adoption.
The other variables which were expected to influence the adoption of improved rice varieties like gender, oxen ownership, and distance to market center and access to FISP were not significant at 10% even though they had the expected signs. In the case of distance it had the unexpected sign and had no significant effect on adoption of improved rice varieties.

IV. Conclusion

Adoption of improved rice seed varieties has benefits of increasing yield, total rice production, farm income and household food security. This study using the cross-sectional data and the logit model examined the factors affecting the adoption of improved rice varieties (NIRVs) by smallholder farmers in Mongu district of Western Province in Zambia. Descriptive analysis revealed that there were no significant differences between adopters and non-adopters of improve rice varieties in terms of gender, oxen ownership and distance to the market center. However, there were significant differences in age, education, family labour, farm size, extension contact, FISP access and perceptions on yield potential and pest and disease resistance of improved rice varieties between adopters and non-adopters of improved rice varieties. The study found that factors influencing the probability of adoption are education, family labour availability, farm size, and extension contact and farmers' perception toward pest and diseases resistance of rice varieties.

The findings imply that it is important to consider farmers labor availability and preferred varietal attributes in particular pest and disease resistance of rice varieties in the design of rice development programs. Since extension access, education level and farm size play significant roles in adoption, there is need to strengthen provision of extension services, offer literacy programs and improve access to farm land among farmers in the study area.

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