Review Articles

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Adoption Drivers and Adopter Categories of Improved Rice Seeds in Northern Ghana

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Abstract

Factors such as education, extension and gender drive farmer adoption of agricultural innovations worldwide, particularly in northern Ghana. Farmers are generally categorized as adopters and non-adopters when they become aware of innovations such as improved rice seeds (IRS). Using a survey data from 385 rice producing households, the study employed logistic regression to analyse drivers of adoption and categorized farmers of IRS into six specific groups of potential adopters. The empirical results revealed six categories of potential adopters: early adopters, late adopters, continuous adopters, temporary disadopters, permanent disadopters, and non-adopters, with a mean adoption level of 51.95%. It is therefore too elementary to categorize potential adopters simply as adopters and non-adopters, irrespective of whether they maintain their adoption decisions over time or not. Outcome of the logistic regression also showed that factors including farmers' awareness of government policies, knowledge of climate change, ownership of mobile phones, and membership in farmer based organizations, positively influenced farmer adoption of IRS in northern Ghana. However, gender and mechanization negatively affected the farmers' adoption decisions. The study recommends that the government collaborates with Non-Governmental and Farmer-Based Organizations to encourage rice farmers to continuously adopt IRS in northern Ghana, via interventions like the Planting for Food and Jobs program. Also, female rice farmers should be encouraged to mechanize and commercialize their rice farms. The findings of this study should serve as a guide to adoption researchers in categorizing adopters of agricultural innovations.

Keywords: Agricultural Innovations, Improved Rice Seeds, Potential Adopters, Northern Ghana

1. Introduction

Besides non-adopters, Rogers (2005) categorized adopters of innovations (technologies) into five main groups, on the basis of their innovativeness. In each adopter category (innovators, early adopters, early majority, late majority and laggards), individuals are similar in terms of their innovativeness [1, 2]. That is, the extent to which individuals in the society adopt new ideas compared to other members of the same system [3]. People randomly choose to reject, adopt or disadopt innovations. Yet, there is a time period within which rejection, adoption or disadoption is deemed to have occurred. Ideally, it takes about three years for farmers to adopt agricultural innovations and a decade or two to disadopt them, due to abstinence [4, 5]. However, not all agricultural innovations get disadopted due to their obstinate nature [6, 7, 1]. Some are disadopted due to their unsustainability or incompatibility with environmental, technological, institutional, sociocultural and socioeconomic conditions of farmers [8, 9, 10]. For example, rice farmers in Ghana and Uganda disadopted Nerica in less than five years after adoption, due to unprofitable and unsustainable nature of producing Nerica, relative to farming other rice varieties [11, 12]. Lamptey (2021) penned that a decade is an ample time to decide if an innovation has actually been rejected, adopted, or disadopted, irrespective of the causes. That is because some non-adopters can later become adopters and some adopters can also become disadopters, within the decade. It is therefore very prudent to fill such a research gab in adoption literature by categorizing potential adopters of ISRS in northern Ghana into early adopters, late adopters, continuous adopters, temporary disadopters, permanent disadopters, and non-adopters. The IRS under study were all technological inventions (innovations) of the Centre for Scientific and Industrial Research (CSIR) of Ghana and her affiliates, promoted for adoption in northern Ghana by 2009. As at 2019, some of these IRS were still being adopted by farmers while others were either rejected or abandoned for diverse reasons [13].

Adoption is the decision of full use of an innovation as the best course of action available while rejection is a decision not to adopt an innovation [9, 10]. Adoption is a binary dependent variable. Many adoption researchers estimate univariate models such as logit, probit or Tobit to analysis adoption [14-17]. This study also estimated a logistic regression model to analyse the drivers of IRS adoption in northern Ghana. The study then categorized the potential adopters into early adopters, late adopters,

continuous adopters, temporary disadopters, permanent disadopters, and non-adopters, using frequencies and percentages. That helped to achieve the purpose of this study, based on Rogers (2005) Innovation Diffusion Theory (IDT).

Theoretical and Empirical Reviews

The Innovation Diffusion Theory:- Mateos and Dadzie (2014) noted that there is no unified "theory" of innovation disadoption because studies on adoption of improved technologies abound but little evidence exists on the continued use of improved technologies. This lack of continued use of technologies leads to disadoption of agricultural innovations or improved technologies. However, Rogers (2005) Innovation Diffusion Theory (IDT) is pivotal in any adoption or disadoption research. Diffusion is the process in which an innovation is communicated through certain channels over time among the members of a social system [3, 9]. Diffusion is a social process that involves interpersonal communication relationships between researchers, communication agents and users of innovations. Diffusion occurs when individuals in the society adopt an innovation. The main purpose of the IDT is to understand the adoption of innovation in terms of four elements, including the innovation, communication channels, time frame and social system.

The innovation is the new idea, skill, process, tool, technique, practice, product, invention or project to be adopted (used) by individuals in the society. It may have been invented a long time ago, but if individuals perceive it as new, then it may still be an innovation for them. For example, organic farming is considered as an innovation in Europe while mechanization and the use of synthetic fertilizers or agrochemicals are European indigenous methods of farming. However, the reverse is the case here in Ghana and Africa [18]. Hence, a prominent hindrance to the adoption of innovations is uncertainty. It means adoption and diffusion will occur very well if uncertainty about the innovations and other hindrances are minimized or removed. There is therefore no doubt that the improved rice seeds (IRS) of CSIR and her affiliates fall into the category of new inventions for use by farmers and consumers. The majority of rice farmers in the study area are smallholders who produce rice to feed their families and sell the surpluses for income [19, 20].

The communication channels are the media through which the information about innovation passes to its intended beneficiaries. They include television, radio, telephone, internet, newspaper, magazines, and person to person or group to groups of individuals, among others. The social system is the platform, society, community or the environment in which adoption and diffusion occur. The time frame is the period, usually 10 years, within which adoption and diffusion occur [7, 9]. The time dimension in any diffusion research indicates the reliability of that research. The IDT as well explains five stages in the innovation decision process.

The Innovation Adoption Decision Process

The innovation adoption-decision process involves information-seeking and information-processing activity, where an individual is motivated to reduce uncertainty about the advantages and disadvantages of that technology. As demonstrated by Rogers (2005), the technology adoption-decision process involves five successive steps, namely knowledge, persuasion, decision, implementation and confirmation. The knowledge stage is where individuals learn about the existence of a new technology and seek information about it. The persuasion occurs when an individual has a positive or negative attitude toward the new technology. It does not necessarily lead directly or indirectly to an adoption or rejection of the innovation. The decision stage is where an individual chooses to adopt or reject the new technology while the implementation stage is where the innovation is put into practice. At the confirmation stage, adopters look for affirmations to help them validate their adoption or rejection decisions. The decisions can be reversed if the individuals are exposed to contradictory messages about the innovation or maintained if they get validatory messages.

The Innovation Adoption Decisions/Categories

The innovation adoption decisions are basically acceptance and rejection. The acceptance leads to adoption and continuous adoption or discontinuous adoption while the rejection leads to non-adoption and continuous rejection or later adoption. Those who reject an innovation and continue to reject the innovation never accept or use the innovation and are therefore regarded as non-adopters. However, those who initially reject the innovation and accept it later become adopters. Those who initially accept the innovation, use it and continue to do so are continuous adopters or the real adopters. However, adopters who discontinue their adoption decisions become disadopters. The disadoption decisions can be temporary or permanent [21].

The temporary disadoption decisions can lead to re-adoption decisions when the disadopters regret their disadoption decision possibly due to additional information about the innovation to be discovered later. The permanent disadoption decisions have no regrets whatsoever about any vital or additional information to be realized about the innovation after disadopting it. The individuals therefore live with the consequences of their disadoption decisions, the potential benefits notwithstanding.

It stands to reason that early adopters and later adopters are all considered as adopters of innovations, because they are all aware of the innovation. In this vain, people who are not aware of the innovation cannot be considered as non-adopters.

People who are initially unaware of the innovation but later become aware of it through diffusion and decide to adopt it are considered late/later adopters, not initial adopters, early adopters or laggards. Laggards are potential adopters who intentionally delay their adoption decisions because they are conservatives and risk averse. Therefore, some late adopters can be laggards but not all late adopters are laggards. Hence, initial adopters are innovators and early adopters. Thus, potential adopters can be categorized as early adopters, late/later adopters, continuous adopters, temporary disadopters, permanent disadopters, and non-adopters. These six categorization are synonymous to those of Rogers' innovators, early adopters, early majority, late majority, laggards, and non-adopters. Hence, it is too elementary to

simply categorize potential adopters as adopters and non-adopters, irrespective of whether they maintain their adoption decisions over time or not.

Characteristics of Rice Farmers

Socioeconomic characteristics of farmers such as age of household head, income, group membership, family size, educational level, farm plot size, and number of contacts with agricultural extension agents affect adoption of modern technologies in rice production [4, 19]. These characteristics of farmers need to be taken into consideration in any adoption or disadoption studies.

Most rice farmers in northern Ghana are males, less educated, older, risk averse, have large farm families, small farm sizes, and are prone to unfavourable environmental conditions due to the harmful effects of climate change. Donkoh and Awuni (2011) opined that when the educational levels of farmers are too low, it would take a lot of efforts to introduce modern technologies to them [22]. That is because educated farmers are more prone to adoption and they have the tendency to co-operate favourably with other farmers [23]. Many rice farmers are unable to attend training sessions on innovation dissemination regularly to get latest information on agricultural innovations. Such farmers rely on their fellow (contact) farmers for information on new farming technologies [24].

Rice farmers' lack of adequate knowledge of agricultural technologies is normally caused by lack of extension visits to farmers' farms [25]. Younger rice farmers are also less likely to disadopt IRS compared with aged farmers (Rogers 2005). This is because young people are zealous to adopt innovations and they have many years ahead of them to maintain their adoption decisions. This gives avenues for extension to specifically concentrate on young farmers and use rice to curb food insecurity in the future. Martey (2013), also posits that married household heads have a tendency of adopting IRS better than unmarried male household heads. The reason is that married male household heads are usually supported by their spouses to produce, process and market rice [26]. Similarly, rice farmers with lager household sizes have the tendency to adopt agricultural innovations because members of their households serve as sources of farm labour.

Study Location and Data

Studied Location, Sample Size and Data Collection:- The study was conducted in northern Ghana, where the improved rice seeds (IRS) were adopted and disadopted. Cluster sampling was used to select four main rice producing zones each in Tolon, Kumbungu and Savelugu Districts but two in Nanton District for the study. Simple random sampling was then employed to select households from each of the selected zones to constitute the total sample.

The vegetation in the area comprises grasslands, shrubs and clusters of perennial trees such as mango, neem, shea, baobab, acacia and other drought tolerant trees. There are two main seasons in a year: rainy and dry seasons. The dry season normally starts from October/November to April/May while the rainy season commences in June and recedes in September/October each year, as a result of variable climatic conditions in recent times. The annual optimal rainfall stands at 1000mm or 35 inches deep [27]. The region alone records about 68,407.25 metric tonnes of paddy rice yearly, and is responsible for about 37% of rice produced in Ghana [28]. The average paddy rice yield in the region stands at 1.32Mt/ha relative to the national average yield of 3.65mt/ha. The map of the study area is as shown in Figure 1.

The study chose a sample size of 385 households from an estimated population of 1,000,000 IRS farmers in northern Ghana, consistent with Krejcie and Morgan [29].

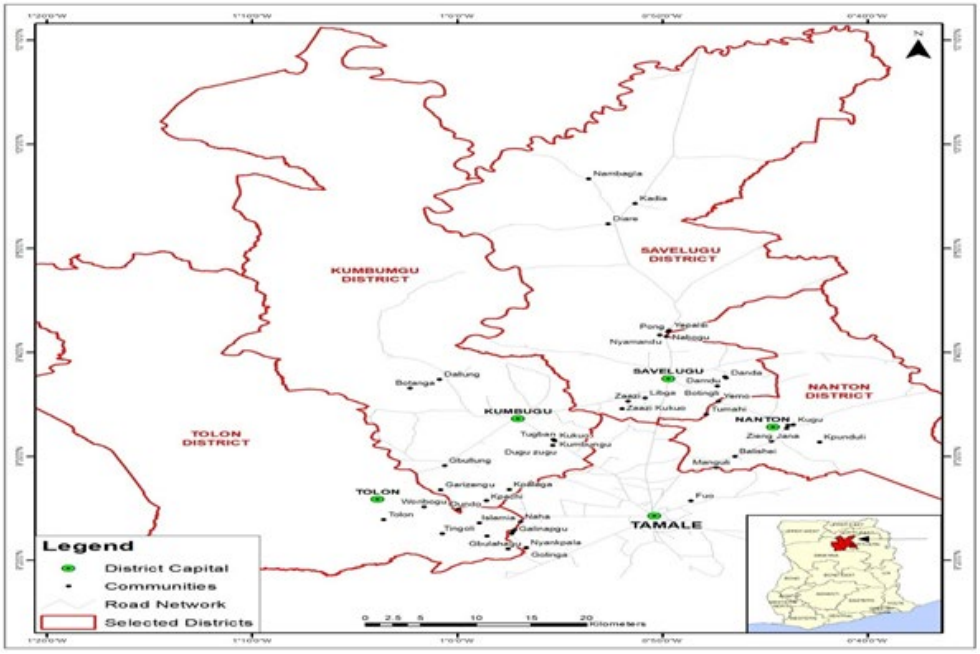

Figure 1: Map of the study area showing the selected districts and communities
Source: Authors' construction, 2020

Statistical Description of Data Collected (Used)

Table 1 shows the socio-demographic features of the sampled improved rice farmers. Descriptive statistics of the rice farmers showed that the mean age of improved rice adopters was 40 years, with those of males and females being 41 and 39 years respectively. It means the male adopters were relatively older than their female counterparts. It was also observed that 30% of the improved rice farmers were literate/educated, with the majority (31%) being males than females (29%). This finding is in tandem with who found that male rice farmers in northern Ghana were more educated than their female counterparts [16, 30, 31]. The likelihood of literate farmers adopting new agricultural innovations such as IRS is higher than the illiterates. This is because the literates are better placed to understand the benefits of the innovation being promoted. Since the illiteracy rate is higher among the farmers, it is very probable that the numbers of the IRS adopters in the region would be lower than expected. Averagely, there were 11 members in male headed farm households and 7 people in female headed farm families, with a mean score of 9 persons per household in the region, corroborating GLSS7 (2019).

Similarly, male farm households had larger rice fields (5 acres) than those of females (3 acres), giving a mean farm size of 4 acres in the study area. This is in tandem with Donkoh (2020), MoFA (2017) and Ragasa et al. (2013) finding that most rice producers in Ghana (about 80%) are small-scale farmers, whose farmlands measure less than 2 hectares in size. Besides, 90% of the rice farm household heads were males while 10% were females, corroborating. Most of the household heads (90%) were familiar with government policies for the rice sub sector of the economy of Ghana. Contrary to our expectations, more female (95%) than male (85%) household heads were aware of such policies. In the same way, the results also indicated that equal numbers (90%) of male and female adopters of IRS in the region were able to access both output and input markets respectively. That is unprecedented since females are more market oriented than males [23, 26].

Moreover, an average of 80% farm household heads comprising 79% males and 81% females were able to utilize extension services, and 30% were able to obtain loans to farm rice, corroborating [25]. This is opposed to Doss et al. (2003) who found that female household heads have less access to external inputs, extension services and information due to socio-cultural values. These notwithstanding, an average of 92% farm household heads (91% males and 93% females) were adequately aware of climate change and its devastating effects on rice production in recent times. They were therefore able to employ appropriate climate change adaptation mechanisms like creating fire belts around their farms during the dry seasons and constructing drains/canals in and out of their rice fields during the rainy seasons, corroborating [32, 33]. Then, a mean of 75% adopters (74% males and 76% females) had good transportation systems, equal numbers (50% each) of the male and female adopters were members of farmer based organizations, while 30% of the farm household heads (29% males and 31% females) used mobile phones to get information for their farming and marketing activities. Zakaria (2019) revealed that farmers' membership in groups/associations facilitates their adoption of agricultural innovations, for maximum output.

An optimum percentage (80%) of the respondents, which were made up of 85% males and 75% females, did both ploughing and harrowing before planting/sowing rice, corroborating Lamptey et al. (2022) that modernized rice varieties have high input and labour requirements to give optimum yields. Finally, only 10% of the farm household heads (11% males and 9% females) employed the services of combined harvesters to harvest their rice, chiefly due to constraints with affordability and availability of mechanization services in the region. It means an average of 90% the adopters harvested rice manually using sucks, sickles and tarpaulins, corroborating MoFA (2017) and APS (2015) that majority of rice farmers in Ghana produce rice on small scales using simple farm tools and equipment.

Table 1: Socio-Demographic Features of Improved Rice Seed Adopters

Socio-Demographic Characteristics of Farmers	*Male*	*Female*	*Mean*	*Std. Dev.*
Optimum age of farm household heads (Years)	*41*	*39*	*40*	*11.10*
Percentage of household heads by sex/gender	*90*	*10*	*50*	*0.30*
Percentage of literate/educated household heads	*31*	*29*	*30*	*0.50*
Optimal number of people in farm households	*11*	*7*	*9*	*4.30*
Membership in Farmer-Based-Organization (%)	*50*	*50*	*50*	*0.50*
Household heads having personal mobile phones (%)	*29*	*31*	*30*	*4.30*
Farmers with ability to access input/output markets (%)	*90*	*90*	*90*	*3.40*
Household heads able to obtain loans to farm rice (%)	*25*	*35*	*30*	*0.50*
Ability to utilize agricultural extension services (%)	*79*	*81*	*80*	*0.40*
Maximum acres of rice farm ever cultivated	*5*	*3*	*4*	*4.01*
Awareness of gov't policies for rice sector (%)	*85*	*95*	*90*	*0.34*
Have access to good transportation systems (%)	*74*	*76*	*75*	*0.44*
Farmers practicing ploughing and harrowing (%)	*85*	*75*	*80*	*0.41*

Farmers aware of climate change effects on rice (%)	*91*	*93*	*92*	*0.30*
Use of combined harvester to harvest rice (%)	*11*	*9*	*10*	*0.23*

Source: Field data, 2020.

Conceptual and Analytical Frameworks

Conceptual framework: Adoption:-Several factors affect each of these adoption decisions of farmers, to adopt or not to adopt, to continue to adopt or to disadopt, to temporarily disadopt or permanently disadopt [34]. The farmers are also concerned about whether to re-adopt innovations they disadopt or maintain their disadoption decisions for such innovations. Farmers' temporary disadoption decisions lead to re-adoption, when they later regret their actions [21]. The theories of perceived usefulness and perceived ease of use of technology determine farmers' motive to use agricultural innovations whereby the motive to use serves as an intermediary of real innovation adoption [35]. That is because farmers also consume the rice they produce. Farmers' decision to continue to adopt or disadopt an innovation is determined by their need to maximize profit or derive the maximum utility from it. Farmers tend to continue the adoption if the expected utility or gains from persistence use is more than that of abandoning it. The expected satisfaction of a farmer is a matter of both household and farm specific factors [36]. Several other factors affect farmers' early adoption, late adoption, non-adoption, continuous adoption, temporary disadoption (re-adoption), and permanent disadoption decisions. These factors include socioeconomic, demographic, institutional, technological and environmental factors. The complex nature of farmers' adoption decisions can best be explained descriptively, since no econometric model can adequately analyze the entire phenomenon. Hence, this study estimated a univariate binary response model (logit) to analyze the drivers of adoption, and used percentages to categorize the various groups of adopters.

Analytical Framework: The Logistic Regression Model

Logistic (logit) regression model was estimated to analyze adoption drivers of IRS in northern Ghana. The binary response in the model was adoption or non-adoption, where Y denoted a random binary variable that took the value of 0 or 1. The 0 then denoted non-adoption and 1 denoted adoption. □1 represented the socio-economic, demographic, farm level, technological, institutional and environmental characteristics of the farmers relative to adoption of IRS [37, 38]. The logistic model specified the likelihood that Y=1, leading to the values of X1, expressed econometrically as follows:

$$P\left(y_i = \frac{1}{X_i - \beta_i}\right) = \frac{1^{-e^{-x_1\beta}}}{(1-e^{-x_1\beta})} = \frac{e^{-x_1\beta}}{(1+e^{x_1\beta})} \qquad (1)$$

The binary response model, as a regression model, was written as: $y_i = 1 - f(X_i\text{-}\beta) + \varepsilon_i$ with yi as the dependent variable denoting adoption of IRS; X_i as adoption drivers of the IRS and εi as the residue representing the deviation of the binary from its conditional mean. In conformity to Cameron and Trivedi (2010) and Bayard et al. (2006), the empirical model specified to analyze farmers' adoption decisions of IRS was:

$$Log\left\{\frac{P_I}{1-P_I}\right\} = \beta_0 + \beta_1 X_1 \ldots + \varepsilon_i \qquad (2)$$

Where *Pi* represents the likelihood of farmers adopting improved rice varieties and $\{P_i / (1\text{-}P_i)\}$ is the uneven ratio in favour of adoption and X_i denotes the independent variables influencing adoption. ε_i Is the error term and β stands for the logistic coefficient of the independent variables.

Definitions of variables and their a-priori expectations

The Table 2 illustrates the definitions of variables and their a-priori expectations relative to adoption of IRS. Here, adoption is considered as a binary variable and denoted by 1, if a farmer was an adopter and 0, if otherwise. Any farmer who did not cultivate IRS for a minimum of three years, from 2009 to 2019 cropping seasons, was considered a *non-adopter* [39].

Table 2: Adoption Variables and their a-priori Expectations of Improved Rice Farmers

Variable	Description	Measurement	A-priori
Adoption/adopters	Rice farmers who adopted / maintained their adoption decisions of improved rice seeds.	Binary (1) Adopter (0) Non-adopter	N/A
Age	Age of an improved rice farmer at data collection.	Years	+/-
Sex/Gender	Sex of an improved rice farmer.	Dummy: (1) Male (0) Female	+/-
Education	Number of years an improved rice farmer spent attending formal educational institution(s).	Years	+
Family Labour	An improved rice farmer used family members / labourers in rice farm operations.	Number	+/-

Electricity	An improved rice farmer is connected to national electricity.	Dummy: (1) Yes (0) No	+/-
FBOs/ Groups	An improved rice farmer is a members of farmer groups / associations.	Dummy: (1) Yes (0) No	+
Mobile Phone	An improved rice farmer owns a mobile phone for effective communication.	Dummy: (1) Yes (0) No	+
Input/Output Markets	An improved rice farmer has access to input/ output markets in the community/town/village.	Dummy: (1) Yes (0) No	+
Credit Access	An improved rice farmer has access to rice production credit/ loans to farm rice.	Dummy: (1) Yes (0)No	+
Extension Service	An improved rice farmer had access to agricultural extension services in 2019/2020.	Dummy: (1) Yes (0)No	+
Farm Plot Area	Plot area of an improved rice farm land.	Acres	+/-
Rice Policy	An improved rice farmer is aware of government policies in aid of improved rice production.	Dummy: (1) Yes (0)No	+
Field Demonstration	An improved rice farmer participated in rice development projects/ rice field demonstrations.	Dummy: (1) Yes (0) No	+
Road Network	An improved has access to good road network to marketing centers/neighbouring towns.	Dummy: (1) Yes (0) No	+
Mechanization	An improved rice farmer uses tractor for tillage and other farm mechanization services.	Dummy: (1) Yes (0)No	+
Rainfall Perception	An improved rice farmer's perception of rainfall pattern and effects of climate change on rice farms.	Dummy: (1) decreased (0) increased	+
Combine Harvester	An improved rice farmer used combined harvesters in 2019/2020 cropping season.	Dummy: (1) Yes (0)No	+

Source: Author's construction, 2022

2. Discussions and Conclusions

Adoption and non-adoption levels of improved rice seeds:- Information on Table 3 shows that the mean adoption level of the improved rice seeds (IRS) in northern Ghana is 51.95%. It means about 48.05% of the farmers in the study area are non-adopters of IRS. That necessitates the use of a binary regression model (logit) in analyzing the drivers of adoption, consistent with Donkoh and Awuni (2011), Bruce et al. (2014), Abdallah (2016), and Lamptey (2022), as shown on Table 4.

Analysis of adoption and disadoption as complex phenomena are discussed in other studies by Lamptey et al. (2021), Azumah et al. (2022), Donkoh (2020), Donkoh et al. (2019) and Azumah (2019); using Generalized Multivariate Regression, descriptive statistics, Endogenous Switching Poison Regression, and Multivariate Probit approaches respectively. Lamptey et al. (2022) also used the Propensity Score Matching (PSM) model to analyze the effect of adoption of improved varieties on rice productivity in the Northern Region of Ghana. They found that adoption of improved rice varieties had a high and positive effect on rice productivity of farm households in the region.

Five different approaches were involved in the PSM model. First, Logistic Regression (logit) was used to analyze factors that affected adoption of improved rice varieties. Secondly, a histogram was employed to check for overlaps and common supports in the propensity score distribution. Thirdly, a test was carried out to analyze the propensity score of the variables in the model, by categorizing adopters and non-adopters respectively as treated and control groups. Then, an overall quality test of factors affecting adoption was conducted both before and after the matching, by treating adopters and non-adopters as unmatched and matched samples in the study. Finally, an Average Treatment Effect (ATE) model was employed to estimate the effect of improved rice varieties adoption on rice output among the farm households. All these tests and models used indicate the robust and complex nature of the phenomenon of adoption (and disadoption). Hence, analyzing adoption as binary requires the use of logit as a univariate model. However, to treat the same subject as multifaceted concept would demand more robust models like Generalized Multivariate Regression, Propensity Score Matching, Endogenous Switching Poison Regression, Multivariate Probit, and Heckman Two-Stage Models, among others, which is not the focus of the present study.

Table 3: Adoption Levels of Improved Rice Seeds in Northern Ghana

Adoption Decisions	*Adoption*		*Non-Adoption*	
Improved Rice Seeds	*Frequency*	*Percentage*	*Frequency*	*Percentage*
Jasmine-85	*308*	*80.00*	*77*	*20.00*
Nerica-1	*192*	*49.87*	*193*	*50.13*
Digang	*203*	*52.73*	*182*	*47.27*
GR-18	*150*	*38.96*	*235*	*61.04*
Nabogu	*161*	*41.82*	*222*	*57.66*
Mandii	*186*	*48.31*	*199*	*51.69*

Source: Field data, 2020. N = 385 Mean adoption level = 51.95

Adoption drivers of improved rice seeds

Improved rice seeds (IRS) modelled in this study are Jasmine-85, Nabogu, Nerica-1, GR-18, Digang and Mandii. Jasmine-85 and Nerica-1 happen to be among the latest to be promoted in the study area while the rest were selected from older varieties under cultivation, corroborating Ragasa et al (2013), MoFA (2017) and Lamptey et al. (2022).

Outcome of the logistic regression analysis in Table 4 showed that age of household head, level of education, household size, access to extension services, access to production credit, and harvesting method did not affect adoption of IRS in northern Ghana. These findings contradict those of Donkoh et al. (2019) and Martey et al. (2013) but are in tandem with Abdallah, (2016) and Bruce et al. (2014). Donkoh et al. (2019) also found an insignificant association between extension service delivery and adoption of agricultural technologies, due to the low extension to farmer ratio in Ghana. However, ownership of mobile phones, membership in farmers based organizations, and access to input markets positively affected adoption of IRS at 1%. Donkoh et al. (2019) also found a positive relationship between farmers' membership in FBOs and adoption of agricultural technologies. Farmers' awareness of climate change (rainfall perception), government policies and total farm plot size also positively affected adoption of the IRS modelled, corroborating Donkoh et al. (2019).

However, gender and mechanization negatively affected adoption at 5%. This implies that female farm household heads have the tendency of adopting agricultural innovations more than their male counterparts, contrary to the findings of Zakaria et al (2019) and Martey et al. (2013). It also means that farmers who do not practice mechanization are more likely to adopt the innovations better than other farmers who practiced mechanization. This is contrary to the a-priori expectations of this study because rice cultivation essentially requires mechanization (tillage). Besides, the nature of soils in the study area is such that no meaningful arable crop farming can take place in the absence of mechanization, except by the means of simple farm tools such as hoes and cutlasses for tillage. This finding confirms the fact that about 30% of rice farmers in northern Ghana cultivate essentially for subsistence purposes (Azumah 2019, APS 2013). It shows that adopters of agricultural innovations in northern Ghana are not necessarily large scale or commercial farmers who have access to adequate mechanization services.

Access to input market positively affected adoption at 10% while that of road network negatively influenced adoption at 10%. These imply that farmers who have access to input market are able to buy IRS, fertilizers and agrochemicals to enhance their adoption decisions. On the other hand, lack of good roads in the region hindered adoption of IRS because access to good roads is an incentive to adoption (MoFA 2017, APS 2015). Finally, the adoption constant was statistically significant at 1%, but negative, meaning the tendency for the farm household heads to reject the IRS was prevalent in the region, due to other extraneous factors.

Table 4: Logistic regression of factors affecting adoption/adopters of improved rice seeds

Variable	*Coeff.*	*Std. Err.*	*P>z*	*Mar. effect*	*Std. Err.*	*P>z*
Age of household head	*-0.014*	*0.012*	*0.217*	*-0.004*	*0.003*	*0.217*
Sex/gender of rice farmer	*-0.866***	*0.432*	*0.045*	*-0.213***	*0.101*	*0.036*
Education attainment	*0.144*	*0.277*	*0 .604*	*0.035*	*0.069*	*0.604*
Farmer's household size	*-0.024*	*0.021*	*0.235*	*-0.006*	*0.005*	*0.235*
Ownership of mobile phone	*1.079****	*0.328*	*0.001*	*0.263****	*0.076*	*0.001*
Total farm plot size	*0.117***	*0.051*	*0.021*	*0.029***	*0.013*	*0.021*
FBO membership	*1.088****	*0.265*	*0.000*	*0.263****	*0.061*	*0.000*
Access to input markets	*2.045****	*0.490*	*0.000*	*0.393****	*0.061*	*0.000*
Access to production credit	*-0.360*	*0.258*	*0.163*	*-0.088*	*0.062*	*0.157*
Access to extension service	*0.347*	*0.311*	*0.264*	*0.084*	*0.073*	*0.253*

Gov't policy awareness	*1.002***	*0.393*	*0.011*	*0.224****	*0.076*	*0.003*
Accessible road network	*-0.493**	*0.289*	*0.088*	*-0.122**	*0.072*	*0.088*
Practice mechanization	*-0.743***	*0.308*	*0.016*	*-0.184***	*0.075*	*0.014*
Rainfall perception	*1.212***	*0.496*	*0.015*	*0.258****	*0.084*	*0.002*
Rice harvesting method	*0.645*	*0.633*	*0.308*	*0.160*	*0.153*	*0.298*
Adoption constant	*-3.155****	*1.032*	*0.002*			
N=385; LR chi2(16)=140.89; Prob>chi2=0.0000; Pseudo R2=0.2529; Log likelihood= -208.154						

*Significant at 10% ** Significant at 5% ***Significant at 1%

Source: Field data, 2020.

Six Adopter Categories of the Improved Rice Seeds

Below was an attempt to categorize potential adopters of IRS in northern Ghana into six groups. Namely; early adopters, late adopters, continuous adopters, temporary disadopters, permanent disadopters, and non-adopters. The reason being that, the general categorization of potential adopters into adopters and non-adopters does not elucidate the diverse shades of real adopters (Lamptey 2021). Farmers are by nature very selective. They pick and choose aspects of innovations that suit them most and they continue to do so as long as they derive satisfaction from those they have chosen to adopt (Mateos and Dadzie 2014, Doss 2006). They disadopt the innovations they are not comfortable with and they may re-adopt them if they later find them useful. They may entirely abandon them for other innovations, if they no longer derive maximum utility from their continuous adoption or usage (Donald and Parker 2012). Hence, this study classified potential adopters into six distinct categories: early adopters, late adopters, continuous adopters, temporary disadopters (re-adopters), permanent disadopters (deserters) and non-adopters, as presented in Table 5.

Early adopters are farmers who adopted the IRS as soon as they were released/promoted in the region, particularly from 2010 to 2014. Late adopters are those who accepted and used the seeds later on, especially from 2015 to 2019, through diffusion. Continuous adopters refer to only farmers who utilized the seeds continuously from 2010 to 2019 while non-adopters are farmers who never accepted or used the seeds in that decade. Disadopters refer to farmers who ever adopted the innovations (either from 2010 to 2014 or from 2015 to 2019) but abandoned them along the line, with or without any intentions of adopting them again. Disadoption is therefore abandonment of an innovation after adopting it. Temporary disadopters (re-adopters) on the other hand refer to only farmers who ever adopted the innovations, stopped adopting them for some time, went back to adopt them again and intend doing so until further notice. Permanent disadopters on the other hand are disadopters who have no intentions of ever re-adopting the IRS (Rogers 2003). These classifications are in tandem with Donald and Parker (2012) who found that disadoption can be a permanent or temporary change but the aftermath reaction to it may be positive and reinforcing or negative and regretful.

They opined that temporal disadoption can result in re-adoption when individuals regret their disadoption decisions or when they are able to overcome the challenges associated with continuous adoption. It means there could be temporary disadopters or permanent disadopters. The outcomes of disadoption can therefore be cumulative and involving rather than dichotomous (Mateos and Dadzie 2014, Donald and Parker 2012, Doss 2006).

It is therefore very imperative to re-group potential adopters into early adopters, late adopters, continuous adopters, temporary disadopters (re-adopters), permanent disadopters, and non-adopters. The results as shown in Table 3 reveal that the highest continuous adoption level was about 15%, meaning only about 15% of farmers in the region are continuous adopters of IRS. This is consistent with Lamptey (2022) and Kijima et al. (2011) that adoption rates of agricultural innovations in Ghana and across Africa are generally low. The adoption rates in this sense refer to the numbers (percentages) of farmers who adopted the IRS in the study area during the period under review [40].

Table 5: Six Categories of Improved Rice Seeds Adopters

Adopters**	***Early Adopters***		***Late Adopters***		***Continuous Adopters***		***T.* Dis-Adopters***		***P.* Dis-Adopters***		***Non-Adopters***	
Innovation	***F***	***%***	***F***	***%***	***F***	***%.***	***F***	***%***	***F***	***%***	***F***	***%***
Jasmine-85	*105*	*27.27*	*73*	*18.96*	*57*	*14.81*	*2*	*0.52*	*71*	*19.83*	*77*	*20.00*
Nerica-1	*68*	*17.66*	*25*	*6.49*	*7*	*1.82*	*9*	*2.34*	*83*	*21.56*	*193*	*50.13*
Digang	*57*	*14.81*	*29*	*7.53*	*9*	*2.34*	*9*	*2.34*	*99*	*25.71*	*182*	*47.27*
GR-18	*52*	*13.51*	*39*	*10.13*	*3*	*0.78*	*7*	*1.82*	*49*	*12.73*	*235*	*61.04*
Nabogu	*50*	*12.99*	*56*	*14.55*	*6*	*1.56*	*5*	*1.30*	*44*	*11.43*	*222*	*57.66*
Mendii	*55*	*14.29*	*69*	*17.92*	*10*	*2.60*	*7*	*1.82*	*45*	*11.69*	*206*	*53.51*

N = 385; ** = 100%; T* = Temporary; P* = Permanent; F = Frequency; % = Percentage

Source: Field data, 2020.

3. Summary and Conclusions

This study was carried out to analyze drivers of adoption and categorize potential adopters of improved rice seeds in northern Ghana into six specific groups. Using a survey data collected from 385 rice farm households, the study employed logistic regression to account of the factors that affected adoption of improved rice seeds in northern Ghana and accordingly used frequencies and percentages to categorize the potential adopters into early adopters, late adopters, continuous adopters, temporal disadopters (re-adopters), permanent disadopters, and non-adopters. That categorization helped to specifically group potential adopters into six, rather than the two fundamental groups of adopters and non-adopters, irrespective of whether they maintained their adoption decisions over time or not. The mean level of adoption was 51.95%. Meaning, about 52% of rice farmers in northern Ghana adopted IRS. That had policy implications to ensuring that adoption levels of IRS in northern Ghana rose drastically above average. Outcome of the logistic regression also showed that positive drivers of IRS in the region included farmers' awareness of government policies for rice, knowledge of climate change, ownership of mobile phones, membership in farmer based organizations, total farm plot size, and access to input markets. However, gender, road network, and mechanization negatively affected rice farmers' adoption decisions of IRS northern Ghana. The study recommends that the government collaborates with Non-Governmental and Farmer-Based Organizations to encourage rice farmers to continuously adopt IRS in northern Ghana, via interventions like the Planting for Food and Jobs program. Also, female rice farmers in northern Ghana, should be encouraged to embark on mechanization and commercialization of their farming enterprises. Besides, the government should construct motorable roads to the farming communities. Finally, adoption researchers should use this study as a guide when categorizing adopters of agricultural innovations in Ghana and elsewhere.

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