__Original Research Article__

Adoption Rates of NERICA Innovation among Rice Farmers in Northern Ghana

ABSTRACT

Adoption rates of the New Rice for Africa (NERICA) have been generally low across Africa, indicating that the innovation has not been well accepted on the African continent, including Ghana. The adoption rates of the innovation were determined in Ghana, and for that matter the study area, to ascertain the extent to which farmers have accepted to grow the 'magic' crop in curbing food insecurity, poverty, unemployment, and rice importation. However, the adoption rates so determined were too low, due to incomplete diffusion. This study sought to determine the adoption rates of NERICA in Northern Ghana from 2015 to 2018, to verify the findings and predictions of previous researchers. Simple random sampling technique was accordingly used to obtain quantitative and qualitative data from 346 rice farmers. The data were analyzed qualitatively and quantitatively using logistic regression and descriptive statistics. The study revealed a low average adoption rate of 25% with a high standard deviation of 44.03%, indicating an uneven spread out of the adoption rates over the period under study. However, the specific adoption rates of the innovation were 91.04%, 3.18%, 2.89% and 2.89% for 2015, 2016, 2017 and 2018 farming seasons respectively, confirming that the rates rose to 91% but fell drastically in subsequent years as predicted by previous researchers. Farmers' educational level, perception of NERICA, household size and primary occupation significantly affected adoption NERICA. The persistent low adoption rates showed that the innovation was unsuccessful in the study area. The Ministry of Food and Agriculture should therefore intensify her innovation dissemination/diffusion campaigns in the study area to revamp its adoption; by providing ready jobs to the youth and market for the commodity through the flagship programs, *Planting for Food and Jobs, and the National Food Buffer Stock Company.*

Keywords: Adoption, adoption rates, dissemination, innovation, NERICA, Northern Ghana

1. INTRODUCTION

Rice is one of the staple foods in Ghana used on many occasions such as festivals, funerals, outdoorings, weddings and marriage ceremonies, installation of chiefs and kings and at social gatherings. It is also one of the main food items found on the menu charts of many institutions like prisons, clinics, hospitals, schools, colleges, and universities, and conspicuous on the menu charts of many restaurants, hotels, ‘chop bars’ and food joints in Ghana. However, much of the rice that is served at these functions are imported [1]. More than 50% of rice consumed in Ghana are imported [1, 2].

Ghana is predominantly an agricultural country with the sector contributing about 30 percent to gross domestic product [3]. There has been a quest for a very good variety of rice for production, similar to what pertained in other African countries such as Benin, the Gambia, Guinea, Mali, Nigeria and Sierra Leone, among others.

The New Rice for Africa (NERICA) was therefore introduced to farmers in Ghana from 2005 to 2010, to demonstrate the Government’s commitment in revamping the local rice sub sector by way of increasing sustainability and food security as well as reducing the importation of rice into the country [4, 5]. An evaluation of the NERICA dissemination project [6] revealed low levels of adoption in Ghana: the highest being 6% at Sekyere-Dumasi and the least was 1% at Tolon/Kumbungu. That study gave 3% average adoption rate of NERICA in Ghana at the time. However, another study by [7] revealed a high adoption rate (68%) of NERICA in Ghana. These inconsistencies in the NERICA adoption rates in Ghana indicate that adoption rates are location specific affected by time and other factors.

The low adoption rates of NERICA were attributed to low awareness levels of the innovation among rice farmers, particularly in the study area [6]. However, there were over twenty improved rice varieties in the study area, including NERICA, Mandee, GR-18, Tox, Togo Marshall, Digang, Agra, Jasmine and Northern Star, all of which had low adoption rates influenced by several factors [8, 9]. NERICA, on other hand, was a unique innovation that came with its complete package of planting methods, fertilizer application, seed and grain production, grain processing and marketing, aimed at boosting its adoption rates. Yet, to no avail.

This research aimed at determining the adoption rates of NERICA among rice farmers in the Northern Ghana, from 2015 to 2018, to verify the findings and predictions of previous researchers. Adoption rate in this context refers to the percentage of NERICA farmers that adopted (cultivated) the rice variety in each year. Since time plays a significant role in the adoption and diffusion processes of an innovation [10], it became expedient to conduct further research on NERICA to help confirm or deny the findings and predictions of previous researchers [6, 7, 11, and 31]. The study by [7], surveyed 200 rice farmers and examined adoption of NERICA and its impact on farmers’ technical efficiency. The study by [7] revealed 68% adoption rate among rice farmers and suggested an average technical efficiency of 69.1%. Similarly, [31] surveyed 378 NERICA farmers in the study area and found an irregular pattern in the adoption rates from 2011 to 2014. The current study therefore employed a sample survey to elicit responses from 346 rice farmers in the study area, to verify the previous findings and predictions, by way of informing policy markers to provide appropriate legislation that would enhance NERICA adoption in this country.

2. LITERATURE REVIEW

Adoption rate refers to the number of farmers in a social system who adopt an innovation in a given time period [10, 14]. The adoption rates are normally expressed in percentages. NERICA is considered a successful innovation but its adoption has not been successful [31, 5] due to low adoption rates [27, 32]. The low rates illustrate a largely unrealized potential adoption rate, unless the entire rice farming population of the African countries are exposed to NERICA varieties and provided access to seed [32]. It means the fact that an innovation has been described as successful does not necessarily mean its adoption would be successful, until appropriate measures are put in place.

Several adoption studies in Africa use the Average Treatment Effect framework to eliminate sample selection biases [5, 7, and 33]. However, adoption rates differ between African countries because adoption is location specific [31, 5]. Certain findings on the determinants of adoption of NERICA show that famers' primary occupation and household sizes have positive impacts while farmers' age and secondary occupation have negative impacts on adoption in Cote d'Ivoire **[**5, 33]. Farmers' participation in extension training programs and involvement in NGO activities also have positive impacts on adoption in Guinea [5, 33]. Similarly, land availability, proximity to NERICA community and positive attributes of NERICA are also important determinants of adoption in Benin [5, 33]. Besides, extension contacts, participation in NERICA dissemination projects, access to credit, and farmers' experience rice farming have positive impacts on adoption of the miracle crop in the Gambia [5, 33].

It means farmers' primary occupation, household size, access to land, credit and extension services, involvement in NGO activities, proximity NERICA villages and participation in NERICA dissemination projects have positive impacts on NERICA adoption in Africa. On the other hand, farmers' age and secondary occupation have negative impacts on adoption in Africa.

Rainfall is another key determinant of NERICA adoption [30]. One more key factor of NERICA adoption is sex of the farmer. About 80% of NERICA farmers across Africa are women who are into subsistent farming [5]. That notwithstanding, NERICA adoption and diffusion have been possible across West Africa, though at a relatively low rate.

The NERICA adoption rate across West Africa in 2011 was 43% but the rate for the same year was much lower in most of the African countries [5]. For example, Ghana recorded 3% in 2011 [6]. The actual and potential adoption rates of NERICA were pecked at 47% and 91% respectively, by [6] but they did not indicate when it would be attained. So, it was not clear in which year the country would record actual and potential NERICA adoption rates at of 47% and 91%. However, including time frame in a diffusion research indicates how strong the study is [10]. That notwithstanding, [7] recorded an actual adoption rate of 68% for Ghana, which needed to be investigated. Hence, it was necessary to determine the actual adoption rates of the innovation in Northern Ghana, and to verify the findings, estimations and predictions of [6], [7] and [31].

3. MATERIAL AND METHODS

3.1 Theoretical and Empirical Frameworks

The term innovation includes not only a new production technology by a smallholder but also a range of other processes, such as the reorganization of marketing strategies by a group of smallholders, the use of new processing techniques by an agro-industrial company [12]. Simply put, the term innovation is an idea or a concept perceived as new by an individual or a unit of adoption in any field of endeavour.

Diffusion is the process in which an innovation is communicated through certain channels over time among the members of a social system. It is a type of communication, in that the messages are concerned with new ideas. The newness of the idea in the message gives diffusion its special character. It therefore means that some degree of uncertainty is involved in diffusion [10]. Hence, there are different categories of adopters based on the perceived risk component and the individual's ability to take such risks. Hence, [10] defined the adopter categories as the classifications of members of a social system based on their innovativeness. This classification includes innovators, early adopters, early majority, late majority, and laggards. In each adopter category, individuals are similar in terms of their innovativeness. Innovativeness is the degree to which an individual or other unit of adoption is relatively earlier in adopting new ideas than other members of a system [10, 13]. Innovativeness can also be considered as a relatively-stable, socially-constructed, innovation-dependent characteristic that indicates an individual's willingness to change his or her familiar practices [13]. In effect, [10] categorizes the adopters based on their innovativeness, as Figure 1 shows.

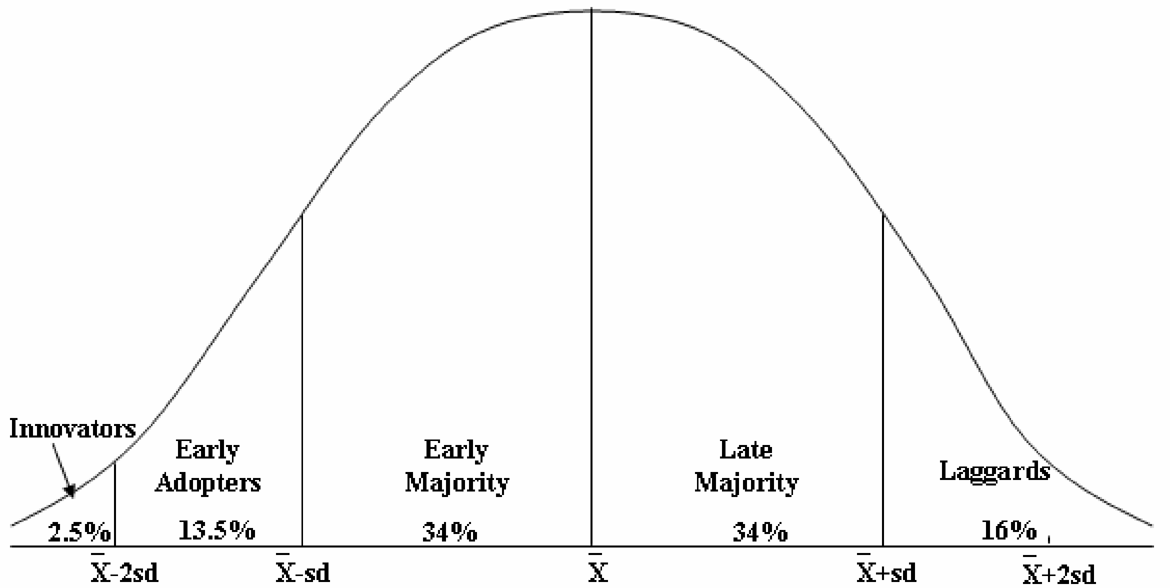

Figure 1: Adopter categorization on the basis of innovativeness
Source: Rogers, 2003

However, incomplete adoption and non-adoption do not form this adopter classification [10]. Only adopters of successful innovations generate this curve over time. In this normal distribution, each category is defined using a standardized percentage of respondents. For instance, the area lying under the left side of the curve and two standard deviations below the mean includes innovators who adopt an innovation as the first 2.5% of the individuals in a system [10, 13].

For [10], *innovators* are more willing to experience new ideas than other members of the social system. Compared to innovators, *early adopters* are more limited by the boundaries of the social system. It is believed that since early adopters are more likely to hold leadership roles in the social system, other members come to them to get advice or information about the innovation [10]. Leaders play a central role at virtually every stage of the innovation process, from initiation to implementation; particularly in deploying the resources that carry innovation forward [13]. Innovators and early adopters therefore tend to lead the *early majority, late majority and laggards* in the adoption of innovations.

Laggards, unlike the others, tend to decide after looking at whether the innovation is successfully adopted by other members of the social system in the past. Due to these characteristics, laggards' innovation-decision period is relatively long [14].

However, according to [15], adoption of agricultural innovations is highly correlated with the number of adult men in the farmer's household. The findings of [15] contradict the assertion of [10] in the sense that "adults" (in the Ghanaian context) are people above age 18 years who have the needed resources and propensity to adopt innovations. The aged (people above 60 years) tend to be slow in adopting innovations [10, 16] because they do not like to take high risks. Younger people (say those below 18 years) are daring but do not have the needed resources to enable them adopt innovations like the middle age adults do. For [10], there is no significant difference between early adopters and late adopters. The four main elements involved in the diffusion process are the innovation, communication channels, time, and the social system. These elements are identifiable in every diffusion research study and every diffusion campaign or program [10, 13].

Agricultural innovations are developed by researchers and communicated to farmers through Agricultural Extension Agents (AEAs), using various methods and materials (print and non-print). The various methods, materials, tools, strategies and styles used by extension practitioners to create situations in which communication can take place between rural people and extension agents are referred to as Extension Teaching Methods (ETMs) [17].

Extension methods of disseminating Agricultural innovations include farm and home visits, result demonstrations, method demonstrations, frontline demonstrations, group discussions, exhibitions, general meetings, campaigns, conducted tours, printed matter (literature), radio, television, motion pictures (movies), agricultural clinic, flag method, peripatic team visits, agricultural games, snake and ladder games [18, 19].

Normally, there is a significant interval between the time an innovation is developed and available in the market, and the time it is widely used by producers [20]. Adoption and diffusion are the processes governing the utilization of innovations. They said studies of adoption behaviour emphasize factors that affect if and when a particular individual will begin using an innovation. That means measures of adoption may indicate both the timing and extent of new technology utilization by individuals. Adoption behaviour may be depicted by more than one variable. It may be depicted by a discrete choice, whether or not to utilize an innovation, or by a continuous variable that indicates to what extent a divisible innovation is used. Diffusion can be interpreted as aggregate adoption.

The innovation-decision process is described as an information-seeking and information-processing activity, where an individual is motivated to reduce uncertainty about the advantages and disadvantages of an innovation [10]. For [10], the innovation-decision process involves five steps: knowledge, persuasion, decision, implementation, and confirmation.

Knowledge Stage: This the stage at which the individual becomes aware of the innovation, how to use the innovation, and the functioning principles describing how and why an innovation works.

The Persuasion Stage: This is the stage where individual becomes persuaded about the innovation and forms either a negative or positive attitude toward it. The formation of a favourable or unfavourable attitude toward an innovation does not always lead directly or indirectly to an adoption or rejection [10]. That is because the individual shapes his or her attitude after he or she knows about the innovation. So, the persuasion stage follows the knowledge stage in the innovation-decision process.

The Decision Stage: At the decision stage in the innovation-decision process, the individual chooses to adopt or reject the innovation. While adoption refers to full use of an innovation as the best course of action available, rejection means not adopting an innovation [10]. However, rejection is possible in every stage of the innovation-decision process. The implementation stage follows the decision stage.

The Implementation Stage: At the implementation stage, an innovation is put into practice, though with a certain degree of uncertainty about its outcomes. Hence, the implementer may need technical assistance from change agents and others to reduce the degree of uncertainty about the consequences [10, 13]. Reinvention usually happens at the implementation stage, so it is an important part of this stage. Reinforcement is necessary at this stage to enhance confirmation of the decision.

The Confirmation Stage: This is when an innovation-decision has been made, and the individual looks for support for his or her decision. According to [10], this decision can be reversed if the individual is exposed to conflicting messages about the innovation. To stick to the decision, the individual has to stay away from these conflicting messages and seek supportive messages that confirm his or her decision. Thus, attitudes become more crucial at the confirmation stage. Depending on the support for adoption of the innovation and the attitude of the individual, **later adoption or discontinuance happens during this stage**.

Factors affecting adoption and diffusion of agricultural innovations include personal and socio-economic factors; socio-cultural, situational and technological forces; gender; access to extension services**,** characteristics of the innovation, institutional constraints as well as research-extension farmer linkage problems [21]. Among the factors [10] identified, is the social system into which the information is delivered. For [21], when the educational levels of farmers are too low, it would take a lot of effort to introduce modern technologies to them.

However, age is expected to negatively influence adoption because younger farmers are more dynamic with regard to adoption of innovations than older farmers [22]. Yet, household heads that are married also have a higher probability of adoption than their unmarried counterparts [23]. This is because they are normally assisted by their spouses in production, processing and marketing decision making. Similarly, household size is expected to positively influence farmers' adoption of agricultural innovations because members of the households serve as sources of farm labour.

Unlike experienced farmers, educated farmers are more prone to adoption because they tend to co-operate favourably with other farmers [23]. It means educated farmers who are experienced can adopt innovation better than inexperienced educated farmers. Innovations could also meet resistance from socio-cultural, situational and technological forces. The innovation may not be compatible with social norms, values and lifestyle; or may not go well with the economic strata; or be technologically complex, leading to fear of usage, obsolescence and risk [21, 24].

The uptake of new technologies is often influenced by the farmer's contact with extension services, since extension agents provide improved inputs and technical advice. Frequency of contact with extension agents is strongly associated with the gender of the farmer [25]. Perceived characteristics of Innovations that enhance their adoption are relative advantage, compatibility, trialability, observability, complexity, and the possibility of re-invention.

Dissemination of agricultural innovations in Sub-Saharan Africa (SSA) is not an overwhelming success, due to the following: Some research has despite a long history not been translated into ground-proven technologies. Some innovations have simply been technically inappropriate. Others may work in the technical sense but have not been adapted to the place-specific situation [7, 27].

In 2015, the actual adoption rate across West Africa (Benin, Gambia, Ghana, Guinea, Nigeria, Mali and Sierra Leone) was estimated to be about 43%, while the potential adoption rate was estimated at 63% [5]. This 20% gap seems to be due to a lack of both awareness and access to NERICA seed, showing there is still a need to increase investment in NERICA dissemination**.** This is due to the fact that the supply of NERICA seeds has been a major constraint in Uganda and in other African countries [5, 27].

The research by [6] on NERICA in the study and revealed an adoption gap of 44%, due to incomplete diffusion of the innovation. The adoption gap was the difference between the actual adoption rate and the potential adoption rate [6].

3.2 Study Area, Sampling and Data

The Northern Region of Ghana plays an important role in agriculture and is normally described as the grain basket of this country, accounting for about 37% of national rice production [29]. The region is therefore one of the key rice producing areas in this country. More than 80 percent of the inhabitants in the study area are full time farmers [29], most of whom produce rice on small scale. Most of the smallholder rice farmers in the study area have benefited from a lot of development projects aimed at increasing productivity and improving livelihoods [9, 23].

Tolon and Kumbungu Districts in the Northern Region were selected for this study to verify the findings of [31]. Tolon is the capital town of the Tolon District while Kumbungu is the capital of the Kumbungu District. Data from the two districts were collected, analyzed and discussed together because the two districts are homogenous in nature.

The Tolon/Kumbungu district lies between latitude 9^0 16' and 9^0 34' North and longitudes 0^0 36' and 0^0 57' west [3]. The land area of the two districts is 2,400km^2 of which 70% is arable and therefore has potential for agricultural purposes, especially production of cereal crops like rice [3].

The Tolon District shares borders with North Gonja (Daboya District) to the west Kumbungu District to the north, Central Gonja to the south and the east with Tamale Metropolitan [3]. The Kumbungu District also shares boundaries with Savelugu-Nanton Municipal to the east, Tolon District to the south, North Gonja District to the west, and the north with Mamprugo/Moaduri District respectively [3].

According to the Population and Housing Census of 2010, the total human population of the Tolon/Kumbungu District stands at 112,331 comprising 56,046 males and 56,285 females [3]. The total figure constitutes 4.5% of the total population of the Northern Region while the average household size of the two districts is 9 [3].

The total population of the Tolon District is 72,990. Males constitute 36,360 and females, 36, 630 [3]. The total population of the Kumbungu District is 39,341. The number of males (19,686) is slightly higher than the number of females (19,655) [3]. The entire population of the district is classified as rural because all the settlements with 5,000 people or more is considered urban; otherwise it is rural [16].

The local climate has only one cropping season in a year, usually from May to October is considered as the wet season. However, there are irrigation dams at Golinga and Botanga for cultivate rice twice a year [2]. The dry season normally starts from November to April each year. The annual relative humidity ranges from 65-85%, but can be as low as 10% during the dry Harmattan period. Average temperatures range from 22-40 degrees Celsius, whereas annual rainfall is 1,000 millimetres and often unevenly distributed and erratic during the cropping season, thus posing a challenge to crop production and food security in the district [19]. So, the weather fluctuates in the study area. The vegetation is dominated by local tree species such as dawadawa (*Parkiabiglobosa*) and shea nut (*Vitellariaparadoxa*). Exotic plant species such as mango (*Magniferaindica*), and neem are also commonly found around the settlements.

The land area of the Tolon and Kumbungu Districts is 2,400km^2 of which 70% is arable and therefore has potential for agricultural purposes, especially production of cereal crops like rice. More than 70% of the population of the Districts are engaged in one form of agricultural activity or the other [2].

3.2.1 Sampling and sample size

A sample size of 378 NERICA farmers was taken from a population of 6, 888 rice farmers, using [28] formula:

$$\left[n = \frac{N}{1 + N(\infty^2)}\right]$$

Where;

N = Total population

n = Sample size

∞ = Alpha margin of error (0.05^2)

$$\left[n = \frac{6888}{1 + 6888(0.05^2)}\right] \ [n = 378]$$

Sixteen NERICA communities were randomly selected from the study area and purposive sampling was used to collect the data from the farmers, with the help of five agricultural extension officers. However, after data cleansing, 346 questionnaire were found to contain all the necessary information for the data analysis.

3.2.2 Data collection and analysis

A survey was conducted to collect data from three hundred and forty-six rice farmers on the topic, using a semi-structured questionnaire. Logistic regression was employed to analyse the socio-economic characteristics of the adopters. Unstructured interviews were used in this study to elicit detailed information from key informants to clarify and enhance data gathered from the questionnaires. Structured interviews were done at the community level using the interview guide and targeting heads of farm families and leaders of the NERICA farmers.

Non-Participant observations were made in the communities, especially on markets gatherings, cultural occasions, funerals, rice mills and popular food joints to obtain additional information for the research questions and issues. The researcher was physically present at such gatherings to ask questions and to see at first hand the extent to which NERICA was patronized and used, especially in dishes in the study area. The researcher also observed the farmers' farms, grain barns as well as gestures and mannerisms of farmers during interviews, questionnaire administration and focus group discussions to deduce the authenticity of the data being gathered. One Focus Group Discussion (FGD) was held in each community for farmers who answered the questionnaire interview questions. The findings from the FGDs helped the researcher to gain insight and clarify data obtained from the questionnaire.

The researcher had informal interactions on regular basis before, during and after administration of the questionnaire to verify non-participant observations made in the communities and also to clarify certain assertions made by the farmers. The researcher also asked salient questions about the facts and figures obtained from the project reports presented to donors and the government of Ghana.

This study therefore used a combination of qualitative and quantitative methods to analyse the data, by employing Statistical Package for Social Science (SPSS). That generated all the necessary tables, charts, descriptive statistics (frequency and percentages) from which the survey results were interpreted. The qualitative data was mainly in the form of narratives and explanations, which helped to describe the information, generated from the SPSS in much detail and made real meanings out of them.

At the same time, data gathered from the FGDs, interviews and key informant stories on the research issues were analyzed daily in the data collection process, which helped to clarify issues and ensure consistent and systematic work. The analyzed qualitative and quantitative data and information processed provided the basis for making interpretations, inferences, deductions and meanings to address the research objectives and questions for the final work.

3.3 The Adoption Model

The dependent variable in this model is adopted. The Wald Chi-square (F- statistic) is the parameter of determining whether an independent variable is significant or insignificant. A probability of .000 indicates that Wald Chi-square is significant and this means that the independent variables jointly influence farmers' decision to adopt NERICA. The Pseudo R-squared (R^2) indicates the variation in the probability of adoption explained by the factors used for the study. The other variations are explained by other factors. Institutional factors such as extension, credit, input market and price of seeds were redundant in explaining farmers' adoption decision, and were therefore removed from the model.
The key determinants of NERICA adoption are represented mathematically as,

Y= *f* (X1, X2, X3, X4, X5, X6, X7, X8, X9, X10)
Where;
Y = NERICA adoption (Yes = 1; No =0) (Dependent Variable)
X = Determinants of NERICA adoption (Independent Variables)
X1 = Age of farmer (In years; Categorical)
X2 = Marital status (Dummy: Married =1; Not married = 0)
X3 = Educational level (In years; Categorical)
X4 = Rice farming experience (In years; Categorical)
X5 = Household size (In ranges; Categorical)
X6 = Rice farming (Dummy: Rice = 1; Other = 0)
X8 = Rice perception (Dummy: Better = 1; Poor = 0)
X9 = Credit access (Dummy: Yes = 1; No = 0)
X10 = Extension contacts (Dummy: Yes = 1; No = 0)

4. RESULTS AND DISCUSSION

4.1 Socio-Demographic Characteristics of NERICA Farmers

Results in Table 1 show that most of the farmers (86.68%) were below 40 years of age, comprising 67.34% males and 17.34% females. It meant that the rice farmers were young and energetic enough to adopt the innovation for many more years, all things being equal. The majority of the farmers (79.77%) were males. The ratio of males to females was approximately 4:1, corroborating [4, 31]. Only 28.90% of the farmers had formal education, implying that formal education was not a basic requirement for NERICA cultivation. Most of the farmers (88.73%) were married and had large household sizes (more than 5 people per household) because they heavily depended on family labour for their farming activities. That helped them to minimize their costs of production, since only a few of them (46.53%) had access to farm credit. All the respondents were rice farmers who took NERICA cultivation as their primary occupation. Many of them (52.02%) however engaged in other occupations as their secondary sources of livelihood, which helped them to diversify risks.

The farmers had smaller farm sizes, with the majority (75.14%) owning about 2 acres or more. Among those who cultivated 2 acres of land were 72.25% males and 2.89% females, corroborating [15] and [23] that women mostly have less access to rice production capital such as land. Only 33.53% of the farmers had regular extension contacts. Inadequate extension contacts could hinder farmers' adoption of the innovation corroborating [5, 33]. Almost all the farmers (98.55%) had access to input and output markets but only 44.51% had government incentives like subsidies on inputs such as seeds, fertilizers, weedicides and herbicides. Farmers had access to those subsidies through the government's flagship program called Planting for Foods and Jobs [29]. Most of the farmers (94.22%) had positive perception of the innovation, due to its favourable attributes [7, 8]. However, their over dependent on rainfall to cultivate rice (86.13%) could limit their ability to fully adopt the innovation, due to the erratic rainfall pattern in recent times [8, 16], as shown in Table 1.

Table 1. Socio-Demographic Characteristics of NERICA Farmers

Variable	Male		Female		Total	
	Freq.	*%*	*Freq.*	*%*	*Freq.*	*%*
Age (40 years-)	233	67.34	60	17.34	293	86.68
Sex	276	79.77	70	20.23	346	100
Formal education	80	23.12	20	5.78	100	28.90
Married	271	78.32	36	10.40	307	88.73
Rice farming	320	92.49	26	7.51	346	100
Other occupations	110	31.79	70	20.23	180	52.02
Farm exp. (10 yrs+)	250	72.25	50	14.45	300	86.71
Household size (5+)	210	60.69	35	10.12	245	70.81
Farm size (2acres+)	250	72.25	10	2.89	260	75.14
Extension contacts	101	29.19	15	4.34	116	33.53
Credit access	115	33.24	46	13.29	161	46.53
Market access	271	78.32	70	20.23	341	98.55
Gov't incentives	121	34.97	33	9.54	154	44.51
Rice perception	271	78.32	55	15.90	326	94.22
Rainfall dependent	235	67.91	63	18.21	298	86.13

Source: Field Survey, 2018

4.2 Adoption Rates of NERICA in the Study Area from 2015 to 2018

All the respondents in this study were NERICA farmers who willingly adopted the magic crop. The term adoption rates refer to the percentages of farmers that grew and used the crop between from 2015 to 2018.

Table 2 presents the specific adoption rates of NERICA in the study area from 2015 to 2018. About 91.04% of the farmers cultivated NERICA in 2015, meaning most of them adopted the innovation that year, which was consistent with the predictions of [7]. The adoption rate for 2015, in the study area, was higher than what was estimated for West Africa in general and the study area in particular because the farmers anticipated that the gains from the innovation could turn around their fortunes. In 2015, the actual adoption rate across West Africa (Benin, Gambia, Ghana, Guinea, Nigeria, Mali and Sierra Leone) was estimated to be about 43%, while the potential adoption rate was estimated at about 63%, leaving an adoption gap of 20% [5]. This is due to the fact that adoption rates of NERICA are location specific. Researchers therefore estimate average adoption rates for certain geographical areas. For example, the average adoption rate of NERICA, as at the end of the 2010 farming year in Ghana, was 3%. However, the Southern Belt recorded 6%, the Middle Belt recorded 3% and the Northern Belt had 1%, resulting in the average of 3% for the year [6]. The average adoption rate of NERICA in the study area from 2015 to 2018 was 25% with a standard deviation of 44.03%. The fact that the average NERICA adoption rate in the study area was less than 50% shows that adoption of the innovation for the period was very low. The high standard deviation shows the uneven spread out of the adoption rates over the period under study.

The adoption rates of NERICA in the study area dropped from 91.04% in 2015 to 3.18% in both 2016 and 2.89% each in 2017 and 2018 respectively, due to incomplete diffusion of the innovation. Though NERICA has its good properties that made it ‘better’ than other rice varieties in the study area, an inability of the producers to find a ready market for the produce, seed contamination, poor soil fertility, pests and diseases infestation and lack of access to credit facilities resulted in incomplete diffusion of the innovation. Hence, the adoption rates were reduced by climatic, environmental and market forces.

It could therefore be concluded that the fact that an innovation is regarded as successful does not automatically make its adoption to be successful or higher, because NERICA adoption rates declined in the study area. Adoption rates increase with time but the rates of NERICA adoption in the study area decreased drastically in 2016 and plateaued in 2017 and 2018, due to factors beyond the farmers’ control. Such factors normally render agricultural innovations unsustainable, unsuccessful and prone to disadoption [10, 15].

Table 2: NERICA adoption rates in the study area from 2015 to 2018

Adoption year	Adoption rate	
	Frequency	**Percentage**
2015	315	91.04
2016	11	3.18
2017	10	2.89
2018	10	2.89
Mean adoption rate	25.00	
Standard deviation	44.03	

Source: Field Survey, 2018

4.2 Factors Affecting NERICA Adoption in Northern Ghana

The logistic regression analysis was used to analyse these factors and the results presented in Table 3. The probability of .000 indicates that Wald Chi-square (F- statistic) is significant and this means that the independent variables jointly influence farmers' decision to adopt NERICA. The Pseudo R-squared of 0.208 indicates that about 20.8% of the variation in the probability of adoption is explained by the factors used for the study. The remaining 79.20% of the variations are explained by other factors.

Farmers' educational level, household size, primary occupation (rice farming) and their rice perception significantly affected their adoption of the innovation. Out of these 4 statistically significant variables, 2 had a positive effect on NERICA rice technology adoption.

These indicate that as farmers' educational level increases their ability to adopt NERICA also increases. In other words, farmers with a higher level of education have higher probability of adopting the technology than those with lower educational level. This may be attributed educated farmers being more business oriented than their uneducated counterparts. Those who are more business oriented with farming will always want new and improved varieties of crops such as NERICA. In addition, farmers with more years of education are expected to have better information and knowledge about improved technologies than those who are not educated. As a result, the positive sign of education was expected since educated farmers are more prone to adoption because they have tendency to co-operate favourably with other farmers and in turn pass on the innovation to them [23].

As expected, farmers in the study area with positive perception of NERICA have a higher probability of adopting the technology than those who think otherwise. Household size was significant at 10% but had a negative effect on NERICA technology adoption. This implies that as household size increases, the probability of technology adoption reduces. In other words, households with fewer members adopted the technology better than those with more household members, which seem to contradict the expectations of this study. The nature of the NERICA technology required more labour and was favoured by large household size. On the other hand, the technology required higher level of financial commitment such as the acquisition of more and new input and that did not favour households with large members since funds to be used for farming were reduced to settle the high household expenditure. Hence, farmers with large household sizes who lacked funds to farm did not adopt NERICA better than those who had smaller household sizes but had funds and other resources to farm.

Primary occupation was significant at 10% but negatively influences NERICA technology adoption. The negatively sign coefficient favours respondents whose primary economic occupation was crop production. Such farmers have dedicated much of their time to crop production and obtain most of their livelihood from crop farming. As a result, they may be more interested in new and high yielding crop varieties like NERICA than their counterparts who have taken crop production as a secondary occupation and may not give it more attention since it serves as a minor source of livelihood for them. This result was expected and plausible.

Table 3 further suggests that farmer's age, marital status and years of experience in rice cultivation were insignificant and had no effect on NERICA technology adoption. This means that older and experienced farmers did not adopt NERICA technology more than the younger and inexperienced farmers. This result was as expected because the study postulated that farmers who have more experience may rely on their accumulated experience and may be unwilling to adopt new technologies. It confirms [10] position that aged or older farmers tend to be laggards who do not easily accept new technologies. This finding is true because most of the NERICA farmers were young and productive (below 60 years) but inexperienced. This finding contradicts [30] finding that farmers' experience in growing rice has a positive and significant effect on the NERICA yield (adoption) in Uganda. Although majority of the farmers were married, marriage was not a necessity for NERICA adoption because the married farmers did not adopt NERICA more than those who were not married.

Table 3: Logistic regression of factors affecting NERICA adoption

Variable		Coefficient	Standard Error
Age		-0.165	0.314
Marital status (married)		1.731	1.559
Formal education		0.464***	0.106
Rice farming experience		0.326	0.213
Household size		-0.347*	0.213
Rice farming		-1.750*	1.048
Rice perception		1.879***	0.508
Number of Observations	346		
Probability	.000		
Pseudo R^2 0.208			

Note: ***, ** and * implies significance level at 1%, 5% and 10% respectively
Source: Field Survey, 2018

5. CONCLUSION

This study sought to determine the adoption rates of NERICA in Northern Ghana, from 2015 to 2018 so as to verify the predictions and findings of previous researchers. The study revealed a low average adoption rate of 25% with a high standard deviation of 44.03% of NERICA in the study area for the period under review. Meanwhile, the specific adoption rates of the innovation were 91.04%, 3.18%, 2.89% and 2.89% for the 2015, 2016, 2017 and 2018 farming seasons respectively. This study therefore confirmed that NERICA adoption rate rose to 91.04% four years after it was predicted but fell drastically the subsequent years to confirm that adoption of the innovation was not successful in the study area. That is because, the rise and fall in the adoption rates could only produce a wave-like curve but not a normal curve, due to incomplete adoption and non-adoption.

Though farmers' educational level, household size, primary occupation and their rice perception significantly affected their adoption of the innovation, farmers’ inability to find ready market for the produce, seed contamination, poor soil fertility, pests and diseases infestation as well as poor rainfall pattern limited adoption and diffusion of NERICA in the study area.

The Ministry of Food and Agriculture (MoFA) should therefore intensify her innovation dissemination and diffusion campaigns in the study area, especially among educated rice farmers with small household sizes and positive perception of NERICA, to help revamp its dwindled adoption rates. The adoption rates of NERICA would also rise if the government, through MoFA, provides ready market for the commodity through its flagship programmes, *National Food and Buffer Stock Company*, and *Feed the Future initiative.* The problem of seed contamination, poor soil fertility, pests and diseases infestation can likewise be addressed through the *Planting for Food and Jobs* programme of the government, to help boost NERICA adoption rates in Ghana.

CONSENT

As per international standards or university standards, respondents' written consent has been collected and preserved by the author.

COMPETING INTERESTS DISCLAIMER

Author has declared that no competing interests exist. The products used for this research are commonly and predominantly used products in the area of research and country. There is no conflict of interest between the author and producers of the products because we do not intend to use these products as an avenue for any litigation but the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the author.

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