Adoption Rates of NERICA Innovation among Rice Farmers in Northern Ghana

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Author’s contribution

The sole author designed, analyzed, interpreted and prepared the manuscript.

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 Northern Ghana 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. The current paper aimed at determining the rates of adoption 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 as well as 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, family size and rice farming significantly affected adoption of 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.

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1. INTRODUCTION

Rice is one of the commonest foods in Ghanaian dishes. Yet, more than 50% of rice consumed in Ghana are imported [1,2,3]. The agricultural sector of Ghana contributes about 30 percent to the country’s gross domestic product [4]. There is therefore the need for an innovation to boost rice production, similar to what pertains in other African countries, and elsewhere [3].

A new rice variety called NERICA was therefore brought to farmers in Ghana from 2005 to 2010, to demonstrate the country’s resolve in revamping the rice industry by way of enhancing food availability and reliability as well as reducing the import in Ghana [5,6,3]. An evaluation of the NERICA dissemination project by [7] indicated low adoption rates in Ghana. The highest rate (6%) was recorded at Sekyere-Dumasi while the lowest (1%) was obtained at Tolon-Kumbungu, with the national average of 3% [3]. However, another study by [8] 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 potential adopters, particularly in Northern Ghana [7,9]. 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 [10,11]. NERICA, on the 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 rates of adoption of the new African rice variety among farmers in Northern Ghana, from 2015 to 2018, to verify the findings and predictions of previous researchers. Adoption rate is the number of farmers who accepted and practiced the innovation each year. Since the spread of innovations is influenced by time [12], it became expedient to embark on further research on NERICA to help confirm or deny the findings and predictions of previous researchers [7,8,9,3]. The study by [8] surveyed 200 rice farmers and examined adoption of NERICA and its impact on farmers’ technical efficiency. The study by [8] revealed 68% adoption rate among rice farmers and suggested an average technical efficiency of 69.1%. Similarly, [3] 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 obtain data from 346 potential adopters, to verify the previous findings and predictions, by way of informing policy makers to provide appropriate legislation that would enhance NERICA adoption in this country.

2. LITERATURE REVIEW

Adoption rate refers to the ratio of farmers in a society who use an innovation at a point in time relative to the potential users [12,13]. The adoption rates are normally expressed in percentages. NERICA is considered a successful innovation but its adoption has not been successful [4,7] due to low adoption rates [14,15]. The low rates show that the majority of potential adopters are yet to use the innovation. Rice farmers in many countries in Africa are aware of the NERICA innovation and managed to provide access to its seeds [3,15], to facilitate its adoption. That presupposes that until appropriate measures are put in place to enhance its usage, adoption of the innovation cannot be termed successful. Rather, a mirage.

Several adoption studies in Africa use the Average Treatment Effect framework to eliminate sample selection biases [6,8,16]. However, adoption rates differ between African countries because adoption is location specific [3,6]. Factors that affect NERICA adoption show that farmers’ primary occupation and household sizes have positive impacts while farmers’ age and secondary occupation have negative impacts on adoption in Cote d’Ivoire [6,3,16]. Farmers’ participation in extension training programs and involvement in NGO activities also have positive impacts on adoption in Guinea [6,16]. Similarly, land availability, proximity to NERICA community and positive attributes of NERICA are also important determinants of adoption in Benin [6,16]. Besides, extension contacts, participation in NERICA dissemination projects, credit access, and farm experience in rice cultivation have positive impacts on adoption of the miracle crop in the Gambia [6,16].
It means farmers’ primary occupation, household size, access to land, credit and extension services, involvement in NGO activities, proximity to 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 NERICA adoption in Africa.

Rainfall is another key determinant of NERICA adoption [17]. 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 [6]. 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 [6]. For example, Ghana recorded 3% in 2011 [7]. The actual and potential adoption rates of NERICA were pecked at 47% and 91% respectively, by [7] 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 of 47% and 91%. However, including time frame in a diffusion research indicates how strong the study is [12]. That notwithstanding, [8] recorded an actual adoption rate of 68% for Ghana, which needed to be investigated. Hence, it was necessary to determine the actual rates of adoption of the innovation in Northern Ghana, and to verify the findings, estimations and predictions of [7,8,3].

3. MATERIALS AND METHODS

3.1 Theoretical and Empirical Frameworks

Innovation comprises a new production technology for producers, new marketing strategies for middlemen and new processing techniques for agro-processers [18]. Innovation is therefore an idea that is considered new by persons in society [12]. Diffusion is the spread of an innovation in society [12]. Therefore, some amount of uncertainty is inherent in the diffusion process [12]. Adopters are therefore categorized based on how the innovation gets to them and how they see it. Hence, adopters are grouped based on how innovative they are. They are grouped into innovators, early adopters, early majority, late majority, and laggards such that persons in each group have similar socio-cultural and demographic features [12,3]. How innovative a person is depends on the rate at which such a person uses an innovation compared to others in the same society [12,19]. How innovative one is can likewise be seen as how stable, socially connected and innovation-driven the person is. This is indicative of the person’s ability to adopt to familiar or unfamiliar practices [19]. In effect, [12] grouped the adopters based on how innovative they are, as Fig. 1.

However, unsuccessful innovations do not constitute these groupings or form the normal curve as shown in Fig. 1 [12]. Rather, they would form a wave-like curve in a serpentine manner, and in some instances, a scattered diagram with an irregular pattern [12,19,3].

For [112], innovators are more capable of experiencing innovations than other persons in the same society. Quite unlike the innovators, early adopters are bound by the norms of the society because they are mostly seen as the custodians of the societal norms and values [12]. They sometimes serve as opinion leaders or contact persons in their respective communities. Such leadership roles place early adopters in the fulcrum of the innovation diffusion process [19]. The innovators, together with early adopters, normally lead all the other groups of adopters when it comes to adoption of innovations in any society. It takes a considerable length of time for laggards to accept innovations, and when they do, they adhere to it long after others have abandoned such innovations. The reason being that laggards are very conservation and risk averse [13,3].

Yet, [20] found a strong relationship between adoption of agricultural innovations and the number of matured male in farm families. This discovery by [20] contradicts the theory of [12] since persons above 18 years of age are considered adults, but not all of them have what it takes to successfully use innovations. That is because adoption is capital intensive and many people below 30 years of age may be eager to adopt innovations but if they do not have adequate resources such as land, labour and capital, it would limit their abilities to adopt.

Persons 60 years and older may have the needed resources to adopt innovations but they may not be strong enough to exert physical pressure or daring enough to risk their resources on new technologies with which they are not well
acquainted. [12,21]. Persons 18 years or younger are zealous to accept innovations yet they lack the requisite experience and necessities to adequately use new technologies relative to persons between ages 30 and 50 years. For [12], early adopters and late adopters are barely the same.

Every innovation diffusion process, campaign or program involves the innovation itself, channels of communication, duration, and the society as a whole [12,19]. Agricultural Extension Agents (AEAs) are the primary promoters of agricultural innovations in Ghana. They use various approaches and styles to get their messages across to farmers [22]. The modes of carrying the new ideas to farmers vary a great deal, depending on the situation, occasion, time, materials and resources at hand, among others [23,24].

It takes a considerable amount of time for an innovation to move from the shelves of researchers to the end users, usually farmers [25]. Innovations are meant to be disseminated, accepted, and used by their target audiences, who in turn spread the information about their usage. Research shows that farmers do not use an innovation as soon as they accept it. Rather, they give it a trial for some time and when they are satisfied with its performance, they gather courage, experience, materials and resources for its wider use [3,12]. It presupposes that adoption has a duration and a medium in which it occurs among various groups of individuals. However, other factors come to play until an innovation gets a widespread acceptance and usage in any community.

The decision to accept and use an innovation is not an event, which occurs on the spot or even overnight. It goes through various stages and processes ranging from awareness through knowledge to usage [12]. There are usually five procedures involved in the decision to use or not to use an innovation [12]. These are knowledge acquisition about the innovation, getting persuaded about its potentials, deciding to accept or not to accept it, implementing the decision to cultivate or not to cultivate it, and finally, confirming the choice they made and leaving with its consequences [3]. Normally, it is at the confirmation stage that one eventually decides whether to continue to use or not to use the innovation, and possibly to discontinue or abandon it after accessing its relative advantages compared to similar innovations.

Factors affecting adoption or diffusion of new farming ideas comprise people’s social, economic, cultural, circumstantial and technical variables. Sex of potential adopters; extension contacts, features of the innovation, institutional and environmental factors as well as societal values [12,26,3]. For [26], it is easy to promote innovations among educated farmers than uneducated farmers.

Fig. 1. Groups of adopters based on how innovative they are [11]
However, age sometimes influence adoption negatively because farmers are relatively young and zealous when it comes to adoption than farmers who are quite older [27]. Yet, leaders of farm families who are married do have the tendency to adopt agricultural innovations than those who are single [28], due to the role of family labour in agrarian communities. In the same way, the size of a farm family normally positively affect farmers’ decision to adopt agricultural innovations since family members contribute in diverse ways to support the farming ventures.

Educated farmers are good team players who tend to adopt innovations better than experienced farmers who sometimes appear doubtful in dealing with people there are not used to [28,3]. Therefore, if one is educated and experienced, one would be a very good adopter than an uneducated and inexperienced farmer. The society as a whole can equally resist the spread of an innovation among its members, for several reasons, particularly societal norms. Farmers would reject any innovations that are not in tandem with values to which they ascribe [26,29]. The assimilation of agricultural innovations in any farming community is heavily dependent on the roles of extension officers, who are the primary promoters of such new farming ideas. Farmers’ frequent contact with extension officers is keenly correlated with the sex of farmers [30].

The expected features of an innovation that facilitate its acceptance and usage comprise how advantageous the idea is relative to other ideas, how compatible it is with other similar ideas in existence, its ability to be tried on a small scale before mass usage, the propensity to observe its performance over a period of time before deciding to adopt it, how complex it is, and whether it can be adapted. These notwithstanding, promotion of agricultural innovations on the African continent has not been very successful, for several reasons. For example, many research proposals are not realistic enough while others are more technical than practical [8,14].

In 2015, the average adoption rate across West Africa was 43%, with a possibility of rising to 63% [6] subject to the availability of NERICA seeds. Bottlenecks in the seed production and distribution limits the spread of NERICA in Africa [6,14]. There are therefore vacuums to be filled in the NERICA adoption rates in Africa and in Ghana. For instance, [7] discovered that the disparity between the real rate of usage and the potential rate of usage was 44%, because the innovation did not spread in the communities as expected. Such vacuums are normally considered adoption gaps in adoption literature [7,30,3].

3.2 Study Area, Sampling and Data

The Northern Region of Ghana is pivotal in providing cereal grains for this nation, accounting for about 37% of national rice production [28,31]. The region is therefore one of the key rice producing areas in this country. Over 80% of dwellers in the study area are full time farmers [31], most of whom produce rice on small scale [28]. Almost all the smallholder rice farmers in the locality have derived benefits from a lot of rice production enhancement ventures tailored towards enhancing rice production and improving farmers’ chances of survival [11,28].

The Tolon district and the Kumbungu district in Northern Ghana were selected for this study to verify the findings of [3]. Tolon is the capital town of the Tolon district while Kumbungu happened to be the administrative seat of the Kumbungu district [3]. Data from the two districts were collected, analyzed and discussed together because the two districts are homogenous in nature.

The Tolon and the Kumbungu districts both lie between latitude 9° 16’ and 9° 34’ North and longitudes 0° 36’ and 0° 57’ west [4,3]. The land mass of the two localities is 2,400km², 70% of which is suitable for crop production, including rice [2,4,3].

The Tolon district is linked to North Gonja (Daboya District) in the west, Kumbungu district in the north, Central Gonja in the south and to Tamale Metropolis in the east [4,3]. The Kumbungu district is likewise linked to Savelugu-Nanton Municipality in the east, Tolon district in the south, North Gonja district in the west, and to Mamprugo and Moaduri districts in the north [4,3].

The human population of the Tolon district stands at 72,990. The males are 36,360 while the females are 36,630 [4]. That of the Kumbungu district is 39,341 with the number of males totalling 19,686 being a little more than the number of females, which is 19,655 [4]. None of
the communities in the two districts has more than 5,000 dwellers, rendering them rural [21].

The locality has only one crop growing period per annum, which normally occurs between May and October, and is referred to as the rainy season. On the other hand, irrigation facilities are available at Golinga and Botanga for farmers in the catchment area who could utilize them at subsidized fees for all year round rice cultivation [2,3]. The dry period usually occurs between November and April yearly. The yearly precipitation is optimally about 65-85%, with an uneven distribution of the maximum rainfall being about 1,000mm during the farming period. That sometimes poses a challenge to rice farming and food supply in the region [24,3]. Optimal temperatures are between 22 to 40 degrees Celsius, making the weather unstable in the catchment area. The vegetation cover is predominantly species of dawadawa (Parkiabiglobosa), shea trees (Vitellariaparadoxa), mango (Magniferaindica) and neem dotted around the vicinities.

3.2.1 Sampling and sample size

A sample of 378 NERICA farmers was taken from a population of 6,888 rice farmers [32]:

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

Mathematically;

\[N = \text{the total population of rice farmers}
\]
\[n = \text{Sampled farmers}
\]
\[\infty = \text{the alpha margin of error (0.05^2)}
\]

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

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 used to analyse the social and economic characteristics of the adopters. Non-participant observations, key informants interviews and focus group discussions were carried out in the communities to obtain detailed information in clarifying and enhancing data derived from the questionnaires.

The researcher regularly interacted stakeholders in rice farming throughout the study period to gather information, which helped to clarify and ascertain the validity of data gathered from the questionnaire.

Statistical Package for Social Science (SPSS) was used to analyse the quantitative data, while transcripts from the qualitative data were exported into NVivo 9 qualitative data analysis software and analyzed in line with the study objectives and interpreted as such. The qualitative and quantitative data analyzed formed the basis for interpreting and making inferences, deductions and meanings to address the research questions and objectives.

3.3 The Adoption Model

The dependent variable (DV) in this model is adopted. The Wald Chi-square, also known as F-statistic, is the parameter of determining the significance levels of the independent variables (IVs). A probability value of .000 indicates the significance of the Wald Chi-square, which signifies that the IVs collectively influence farmers’ adoption decision of NERICA. The Pseudo R-squared (R^2), which portrays variations in the farmers’ propensity to adopt NERICA, is explained by the variables used for this research. The other differences are explained by other intervening variables. Institutional variables 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 illustrated with a mathematical formula, with the DV being Y (adopted) and the IVs being X:

\[Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9, X_{10})\]

Where;

\[Y = \text{Adopted innovation (Yes = 1; No =0) (DV)}\]
\[X = \text{Determinants of innovation adoption (IV)}\]
\[X_1 = \text{Farmer’s age in years (Categorical)}\]
\[X_2 = \text{Farmer’s marital status (Dummy: Married =1; Not married = 0)}\]
\[X_3 = \text{Educational level in years (Measured categorically)}\]
$X_4$ = Rice farming experience in years (Measured categorically)
$X_5$ = Range/size of farm families (Measured categorically)
$X_6$ = Rice farming (Dummy: Rice = 1; other = 0)
$X_8$ = Rice perception (Dummy: Better = 1; Poor = 0)
$X_9$ = Credit access (Dummy: Yes = 1; No = 0)
$X_{10}$ = Extension contacts (Dummy: Yes = 1; No = 0)

4. RESULTS AND DISCUSSIONS

4.1 Social and Demographic Features 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 [5] and [3]. Only 28.90% of the farmers received formal education [3,33], 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 the synergy of family labour for their farm operations [3]. 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 [20] and [28] 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 [6,16]. 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 [31]. Most of the farmers (94.22%) had positive perception of the innovation, due to its favourable attributes [8,10]. However, their over dependence 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 [10,21], as shown in Table 1.

Table 1. Social and demographic features of NERICA farmers

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

Source: Survey data, 2018
4.2 NERICA Adoption Rates in Northern Ghana 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 2015 and 2018.

Table 2 presents the specific rates of NERICA adoption in Northern Ghana from 2015 to 2018. About 91.04% of the farmers adopted NERICA in 2015, which shows that most of the farmers actually adopted the innovation that year, confirming the predictions of [8] and [3]. The adoption rate for 2015, in Northern Ghana, exceeded the estimated value for West Africa as a whole and Northern Ghana in particular, because the farmers anticipated that the gains from the innovation could turn around their fortunes. In 2015, the real average rate of adoption in some West African countries was 43%, with a possibility of rising to 63%. That would have created a gap of 20% in the adoption rates [6]. This is attributed to the fact that NERICA rates of adoption are location specific [6,3]. The rates differ from country to country, especially Benin, the Gambia, and the democratic republic of Ghana, Guinea and the federal republic of Nigeria, as well as Mali and Sierra Leone [6,3]. Researchers therefore estimate average adoption rates for certain geographical areas. For example, the average rate of adoption of the innovation, 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 [3]. The average rate of adoption of the innovation in Northern Ghana, 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 NERICA adoption rates in Northern Ghana dropped from 91.04% in 2015 to 3.18% in 2016 and 2.89% each in 2017 and 2018 respectively, due to incomplete diffusion of the innovation. These findings are consistent with those of [3], indicating that adoption rates of the innovation in the geographic area followed a serpentine order. Though NERICA has its good properties that made it relatively better than similar improved rice varieties in Northern Ghana, an inability of the farmers to have easy market access, 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, corroborating [3].

Hence, though the innovation was considered to be a successful one, its adoption was not successful, because the adoption rates kept rising and falling every four years in the region [3]. Adoption rates increase with time but the rates of NERICA adoption in the region 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 [12,20].

4.3 Factors Affecting NERICA Adoption in Northern Ghana

The factors that influenced adoption of the innovation in the region were analysed using logistic regression. The results of the analysis are as presented in Table 3. The probability of .000 showed the significance that the Wald Chi-square (F-statistic), meaning the independent variables collectively influenced the farmers’ NERICA adoption decision, as [3] observed. The Pseudo R-squared of 0.210 implied that 21% of the variation in the propensity to adopt was explained by determinants employed for the research. In other words, 79% of the variability in the results were explained by other determinants, similar to those in [3].

Farmers’ level of formal educational completed, size of farm families, involvement in rice farming and their rice markedly influenced their use of the innovation. Two (2) out of these 4 statistically significant variables positively influenced farmer use of the innovation.

These show that as farmers’ level of formal educational completed increased, their tendency to adopt the innovation also increased. Thus, the higher the farmers’ level of formal education, the more likely they were to adopt the innovation and vice versa. That was explained by the idea that farmers who are educated are quite receptive to innovation acceptance and usage than farmers who are uneducated [28]. Farmers who are educated are quite innovative and proactive in the farming enterprise and desirous of using
Table 2. NERICA adoption rates in the study area from 2015 to 2018

<table>
<thead>
<tr>
<th>Adoption year</th>
<th>Frequency</th>
<th>Adoption rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015</td>
<td>315</td>
<td>91.04</td>
</tr>
<tr>
<td>2016</td>
<td>11</td>
<td>3.18</td>
</tr>
<tr>
<td>2017</td>
<td>10</td>
<td>2.89</td>
</tr>
<tr>
<td>2018</td>
<td>10</td>
<td>2.89</td>
</tr>
<tr>
<td>Mean adoption rate</td>
<td>25.00</td>
<td></td>
</tr>
<tr>
<td>Standard deviation</td>
<td>44.03</td>
<td></td>
</tr>
</tbody>
</table>

Source: Survey data, 2018

Table 3. Determinants of NERICA adoption: Logistic regression model

<table>
<thead>
<tr>
<th>Variable</th>
<th>Coefficient</th>
<th>Standard Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>-0.170</td>
<td>0.314</td>
</tr>
<tr>
<td>Marital status (married)</td>
<td>1.731</td>
<td>1.560</td>
</tr>
<tr>
<td>Formal education</td>
<td>0.504(^a)</td>
<td>0.110</td>
</tr>
<tr>
<td>Rice farming experience</td>
<td>0.330</td>
<td>0.213</td>
</tr>
<tr>
<td>Household size</td>
<td>-0.350(^b)</td>
<td>0.213</td>
</tr>
<tr>
<td>Rice farming</td>
<td>-1.800(^b)</td>
<td>1.050</td>
</tr>
<tr>
<td>Rice perception</td>
<td>1.880(^a)</td>
<td>0.510</td>
</tr>
</tbody>
</table>

Number of Observations: 346
Probability: 0.000
Pseudo R\(^2\): 0.210

Levels of significance: 1\(\%\) \(^{(*)}\) and 10\(\%\) \(^{(*)}\) Source: Survey data, 2018

newly improved varieties of crop varieties like NERICA [3]. Similarly, the more educated a farmer is, the more informed and knowledgeable he would be in using new farming ideas compared to farmers who are uneducated. Hence, the positive sign associated with farmers’ level of formal education met the a-priori expectations of this research, since educated farmers are more likely to adopt innovations with the tendency of co-operating favourably with other farmers and in turn pass on the innovation to them [28,3].

As expected, farmers in the study area with positive perception of NERICA were more likely to adopt the innovation than farmers who had negative perception of the innovation. Size of farm families negatively influenced NERICA adoption at 10\(\%\) level of significance. The implication is that, a rise in the sizes of farm families had a corresponding decreasing effect on the adoption of the technology. Thus, farm families with fewer members used NERICA more than farm families with numerous members, which seemed to be a contradiction between the a-priori expectations and the outcomes of this research [3]. The features of the technology called for increased numbers of labourers, which favoured the larger farm families. Contrary, the innovation called for more capital investment, which was not favourable to farm families with large numbers. Such households spent more of their farm capital on family upkeep and social obligations, corroborating [3]. Therefore, larger farm families who were deprived of farm credit did not use the innovation relative to farm families with smaller numbers but had access to farm credit and other production capital. These findings confirmed those of [3].

Farmers’ involvement in rice farming exemplified that of [3], which showed 10\(\%\) level of significance but had negative influence their use of the innovation. The negative coefficient sign favoured farmers who were primarily involved in rice production. Those farmers committed much time and other resources to rice production and heavily depended on rice farming for their survival. In effect, they became more interested in using new ideas in conformity to NERICA compared with other farmers who took rice farming as their secondary occupations or hobbies. Such farmers did not pay more attention to their rice farms since their survival did not depend on rice farming. This result met the a-priori expectations of the current study.

Moreover, Table 3 suggested that ages of farmers, their marital statuses and years of experience in rice farming did not affect NERICA
adoption in Northern Ghana, corroborating [3]. It meant that farmers who were older and experienced in rice farming did not use the innovation more than farmers who were younger and inexperienced. This result met the a-priori expectations of the present study since farmers who are more experienced in rice farming normally rely on their store of experience and are quite sceptical in using innovations. That is in tandem with [12], who posited that aged or older farmers are usually laggards who hardly accept innovations. The findings of this research is consistent with [12] and [3] since most of the farmers of NERICA were below 40 years of age and had less experience in rice farming before using the innovation, but opposed to those of [17]. Marital statuses of rice farmers was non-consequential in NERICA adoption since the married farmers did not use the innovation better than those who were unmarried, corroborating [3].

5. CONCLUSION

This research aimed at determining the rates of NERICA adoption 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 locality during the period. 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 NERICA adoption was not successful in the Northern part of this country. 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.

The farmers’ levels of formal education, involvements in rice farming, sizes of farm families, and their rice perception significantly affected their adoption of the innovation. Yet, 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 the use and spread of the innovation in the region.

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.

DISCLAIMER

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 since we do not intend to use these products as a medium for any litigation but the advancement of knowledge. Similarly, the research was not funded by the producing company. It was rather financed by personal efforts of the author.

CONSENT

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

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COMPETING INTERESTS

Author has declared that no competing interests exist.

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