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Determinants of Adoption of Agricultural Technology in Cameroon; The case of Improved Rice Variety Adoption in the Upper Nun Valley Areas of the West and North West Regions

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카메룬의 농업 기술 채택 결정 요인 서부 및 북서부 지역의 어퍼 넌 밸리 지역에서 개선된 쌀 품종 채택 사례

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Abstract Fluctuations in the productivity of major cereals in Cameroon have been observed over the past years. The rice productivity in the country is lower than the increasing productivity of this crop in other countries across the continent. This gap has been attributed to the lack of innovative technology development and transfer to rice farmers. The Upper Nun Valley Development Authority (UNVDA) has been implementing state goals in cooperation with development partners aimed at the introduction of improved rice varieties in the area of the present study. Here, we present our results of a survey of 207 rice farmers in some of the major rice growing areas of the north-western and western regions. The survey was conducted to establish the key drivers for the improvement of rice variety adoption. An independent t-test was employed to determine the mean differences in the characteristics of binary-dependent variables. The determinants of adoption were estimated using a Probit regression model with calculated the marginal effects of the variables surveyed. The educational level ($P < 0.02$), farmers' group membership status ($P < 0.000$), the source of seeds ($P < 0.000$), training ($P < 0.002$), extension visits ($P < 0.042$), and the reason for producing ($P < 0.002$) were all identified as factors that statistically increased the probability of making a decision to adopt improved rice varieties. Other statistically significant variables identified to influence negatively the adoption decisions were farmers' farm size and the access to credits. Therefore, farmers should be encouraged to adopt and adhere to improved cultivation techniques to ensure maximum utility of improved cultivation technologies and varieties.

요 약 카메룬의 주요 곡물 생산성은 지난 몇 년 동안 변동 폭을 보였다. 카메룬의 벼 생산성은 아프리카대륙의 다른 국가와 비교했을 때 낮다. 이러한 격차는 국가의 혁신적인 기술 개발과 기술 이전 부족으로 기인한다. 카메룬 농업농촌개발부 산하 UNVDA (Upper Nun Valley Development Authority)는 개발 파트너와 협력하여 벼 개량품종을 국가에 도입하였다. 이 연구는 북서부 및 서부 지역의 주요 벼 재배 지역에서 벼 생산 농가 207명을 대상으로 품종개량 벼 채택에 영향을 미치는 요인을 알아보기 위해 진행하였다. 이항 종속 변수 (Binary dependent variable)의 평균 특성 차이를 식별하기 위해 독립 T-검정을 사용하였다. 채택 결정요인은 조사된 변수의 한계 효과를 계산한 프로빗(Probit) 회귀 모델을 사용하여 추정하였다. 품종개량 벼 채택에 통계적으로 긍정적 영향을 미치는 요인은 최종학력($P<0.02$), 농민단체 가입 여부($P<0.000$), 종자의 출처($P<0.000$), 농민교육($P<0.002$), 현장 기술지도($P<0.042$), 생산 목적($P<0.002$) 으로 나타났다. 반면, 통계적으로 부정적인 영향을 미치는 요인은 농장 규모와 신용 접근성으로 나타났다. 따라서 농가는 개선된 기술로부터 최대한의 효용을 보장하기 위해 개선된 재배 기술을 채택하고 준수할 것을 제안하다.

Keywords : Determinants, Improved Variety, Adoption, Agricultural Technology, Marginal Effects

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1. Introduction

Agriculture remains a key driver of economic development in SSA as problems of food insecurity, poverty alleviation and rural development seems to be addressed through agricultural development interventions. The continent has one of the lowest rate of agricultural productivity despite its vast natural endowment [1]. Average agricultural productivity of most staple food crops across SSA is about 50% less, than that other low and mid-income countries across the globe. This wide discrepancy in agricultural productivity can account for the about 399 million people who are moderately food insecure across Africa [2].

The development of new agricultural technologies plays a critical role in increasing agricultural productivity. From the development of machines, new crop germplasm, fertilizers and pesticides, technology adoption has been and remains a central pillar for the fight against famine as population grows[3]. Agricultural technology innovations not only address the ever growing demand for food and a changing consumer preference but greatly contributes to adapting crop production to climatic changes.

The development and of new rice and wheat varieties accompanied by the development of inorganic fertilizers, machinery and pesticides fueled the green revolution in the 20th century [4]. This seems to have marked the most significant entry point of most agricultural technologies developed to alleviate poverty and ensure food security. Some scholars have been critics to the environmental damages that accompanied the technological development and adoption brought about by the green revolution. These damages cut across the pollution on the soil and water brought about from the use of excessive fertilizers and herbicides, to the damage caused to the insect or wildlife ecosystem from the use of pesticides. That not withstanding, the adoption of the technologies developed greatly addressed the national food security concerns of most developing countries as of then.

Agricultural technology adoption has been defined by several scholars in different contexts applicable to different views. Firstly technology as defined by Bonabana-wabbi consist of tools developed to enable a user work more effectively and efficiently with the objective of improving an existing given status-quo [5]. On the other hand adoption as defined by Levinshn is the integration of a developed (new) or improved technology into an existing practices to improve output [6]. Adoption literature points to rate of adoption and intensity of adoption as being essential to the evaluation of technology adoption. In agriculture, technology adoption is the integration of new crop varieties into a cropping system or the application of a new agronomic practice or machinery by farmers to achieve higher yields or more income. However the prevailing economic, educational and infra structural constraint faced by small-holder farmers in developing countries doesn't promote making use of the constantly developed agricultural technologies [7].

1.1 Rice Production and Technology Adoption in Cameroon

There is an increasing demand for rice in Cameroon in recent years promoted by the changing consumption preference of both rural and urban consumers. Local rice production is far from meeting the demand of local consumption. According to the Ministry of Agriculture and Rural Development, national consumption demand was estimated at 757,112 tons, while local production was 217,280 tons satisfying only 24.3% of the demand in 2021. Rice cultivation activities in the country is dated back to 1940s when the crop was introduced and years later the country attained rice self-sufficiency as the introduced technologies were largely adopted by farmers and productivity was at its best[8]. One major factor that brought about increased productivity was the introduction of different rice varieties in the major production basins in the North and Western highlands. A majority of these varieties came from across Asia and easily adapted to the different agro-ecological zones of the country. Before 2008, most farmers cultivated just the same old varieties introduced many decades ago. The continuous use and re-use of the same seed material by farmers gave room for varietal mixture and low yields. The national rice strategy policy paper developed in 2009 had as on major objective the increase in the productivity of rice through research and extension activities, the maintenance or introduction of high yield and more adaptable rice varieties while re-organizing the local rice sector. This led to the introduction of the New Rice for Africa (NERICA) varieties by the Institute of Agricultural Research and Development (IRAD) in 2009 through a participatory varietal selection approach. Despite the effort made by the government to improve on the quantity and quality of local rice production, the technology adoption rates are still slow and lagging [9].

By definition and considering the context of this study, improved rice varieties refereed to in this study, are the traditional rice varieties (Oryza sativa) that have been cultivated for many years in the study area. These varieties had become mixed with other varieties as such had low yields. This high level of seed mixture not only decreased the yield but brought about a difference in grains maturity timing. These varieties were re-selected, re-cleaned, purified, multiplied and re-introduced to farmers. A rice farmer is considered an adopter of the improved variety if they had cultivated the improved varieties for at least 3 consecutive farming seasons. Therefore agricultural technology adoption in the context of this study is the acceptance and cultivation of improved (variety name: Tox 3145 or Tainan 5) varieties in the study area. Technology adoption is certainly a package with other importance factors (fertilizer, machines, growing techniques etc) included[10]. However this study focused just on the seed adoption component of the entire varietal introduction package.

1.2 Determinants of agricultural technology adoption

The use of improved farm technologies has been observed to be a major factor in increasing rice productivity. identifying and understanding these key variables is important [11].

The decision by a farmer to adopt or not to adopt a new or improved technology is generally guided by a number of factors. According to McNamara the decision to adopt a technology is surrounding by personal characteristics of the farmer, the institutional incentives and the knowledge on the improved agronomic characteristics of the variety [12]. Factors such as the cost of adopting the technology and the benefits of adoption may play a key role in the decision making process of farmers[13].

There exists an impressive literature on the impact of farm technology adoption across SSA with most scholar detailing out on impacts. Driver of technology adoption has been given some attention too as the studies of Ndiritu and Ogada [14,15].

Despite the well known and proven role that adopting new varieties can play on increasing the productivity of rice in Cameroon, the adoption of farm technologies like certified seeds of improved rice varieties, fertilizers and other agro-chemicals, the rate of farm technology adoption in Cameroon is still low [16].

The choice of explanatory variables used in this study was guided by previous studies such as Kabunga Prica [11,17], among which considered variables related to farmers personal characteristics (age, gender, education, family status, household size, income etc), farming characteristics such as farm size, crop type, farming experience, group membership, etc. The varietal characteristics of rice seeds has been considered for adoption investigation in some of these studies. Such variables covers crop yield, resistance to deceases, and cultivation techniques. The variables surveyed in this study are described on Table 2.

1.3 Importance of the study

Increasing local rice production largely depends on the biophysical and socio-economic environments of production distinguished through different major options. These options could be expanding area of cultivation, increasing cropping intensity and increasing yield (through technology adoption). Adopting improved rice varieties is a purposeful pathway to a transformative local rice industry, enhancing increase in production and farm income generation, [18]. The adoption of improved varieties in the study is deemed best to increase the productivity of rice. This study focus on the adoption of improved varieties of rice existing in the Upper Nun Valley area. With the assumption of being easily adopted by the farmers since it's not a completely new variety re introduced by a cleaned and reselected version of the same old variety with better observables agronomic characteristics. Evaluating the adoption of these varieties in the study areas will guide state and private stakeholders on the designing and implementation of such related projects. This enables clear analytical data to be gotten to enable more farmers have access to the technology. While a few of the available studies on improved rice variety adoption has focused on the impact and constraints of adoption, no previous studies has been done on the factors affecting the adoption of the improved rice varieties (Variety name: Tox 3145 and Tainan 5) in the Upper Nun Valley areas of the North West and West regions. This study therefore could be considered as amongst the first to in the study area.

1.4 Objectives of the study

The main objective of the study was to identify the main factors that guide farmers' decision to adopt or not adopt improved rice varieties in the study area. This study seeks to investigate this objective by;

1. Evaluating the difference in characteristics of adopters and non-adopters of improved rice varieties
2. Identify the key determinants influencing the adoption of improved varieties in the study

As justified above, this study will play a very significant role in understanding technology adoption characteristics in the study area and will equally be very significant at the various levels below;

To farmers, the results gotten will give farmers knowledge on how much different factors affects their decisions to adopt new technologies. This will strengthen their decision making abilities to adopt other technologies introduced in the study area. To non-adopting farmers, the results will clearly show them the increase in yield from the marginal effects of adoption which is enjoyed by adopting farmers. This could encourage them to see the need to adopt the technology as well.

To researchers/extension workers, the extent to which improving several different technologies is useful will be shown from the results of this study. This guide researchers and extension agents on what to pay attention to while disseminating improved technologies within the study area.

To policy markers, especially the Upper Nun Valley Development Authority (UNVDA) and the Project for the Development of Upland and Lowland Rice (PRODERIP) which are the primary state policy implementing agencies in the study area, this study will provide firsthand information or knowledge on the extent to which improved varieties are affected by the decision made by farmers. This will guide the development of training materials, and help identify the key factors to focus on to encourage a broader or wider adoption of improved varieties.

2. Research methodology

2.1 Study area

The Western highland of the country constitute the second rice production basin in the country. its constitute an agro-ecological zone with a total surface are of 31192 $KM^{2.}$ with an annual rain fall estimated at 1500mm to 2000mm. The Upper Nun Valley area falls within this agro-ecology zone and cuts across the North West region and the West region and all belong to the Western highlands agro ecological zone, The Upper Nun valley areas covers 5 Divisions, (Mezam, Ngoketunjia and Bui of the North West region and 2 Divisions (Noun and Bamboutos) of the West region. Irrigated lowland rice and rain-fed upland rice are the two main ecologies of rice grown in these areas. This study was carried out in the Ngoketunjia and Noun Divisions of the North West and West region respectively. Rice farmers from Monoun area (West region) and from Bamunka and Babungo (North West region) were sampled as will be explained in the section below.

2.2 Sampling Technique and Data collection

Cross sectional data was collected across the study area through the administration of well-structured and pre testes questionnaires. A multi-stage sampling Approach was used to select the areas in which the improved varieties have been introduced. This led to the selection of 3 production zones within study area, which were Upper Bamunka zone and the Babungo zone (in the North West region) and the Monoun zone (West region). The second stage of the sampling saw the random selection from within the rice farming population, those who were either adopters or non-adopters of the technology. In total, 207 rice farmers were examined as distributed on the table below,

Table 1. Distribution of samples

Areas	Number of sampled farmers
Bamunka	100
Babungo	50
Monoun	57

source : author's survey 2022

Survey interview were conducted through a structured questionnaire. the variables surveyed were divided into different sections and as described on the table below.

Table 2. Description of variables with expected signs on adoption decisions of farmers

Variables	Description	Expected signs
Dependent Variable	Binary outcome	
Adoption	If or not a farmer adopts improved varieties, 1 for Adopters and 0 for non-adopters	
Explanatory Variables		
Age	Number of years	+/-
Educational level	Level of formal education achieved	+
Household labor force	Active farming labor force	+
Experience	Number of years spent growing rice	+/-
Income level	Range of monthly income	+
Farm size	Actual farm size use for rice growing(hectares)	+
Farmers' group (dummy)	Farming group membership, 1 for members and 0 for non members.	+
Seed Source (dummy)	Seed source from UNVDA (defined as 1) or other sources (defined as 0)	+
Training (dummy)	Training attendance in the last 2 farming seasons (defined as 1 for Yes and 0 for No)	+
Extension visits (dummy)	If extension workers visited their farms during the growing season (1 for Yes and 0 for No)	+
Credit access (dummy)	If inputs loans were given or not(1 for Yes and 0 for No)	+
Yield	Total quantity (kg/ha) of paddy produced	+
Why Produce	Main reason for growing rice	+/-

source; Field survey, 2022

2.3 Analytical techniques

The first objective of this paper was to evaluate the characteristics differences between adopters and non- adopters of Improved Rice Varieties in the study area. For this evaluation, a 2 sampled independent T- test was used to compare among the explanatory variables of the sampled farmers.

To identify the key factors that influences adoption decision of farmers, Probit regression model was used to analyses the influence of the explanatory variables on the binary dependent variable. The marginal effects of the responses were also calculated as will be shown on Table 4.

2.4 Conceptual framework of model used

As suggested by Gurajt [19], three approaches can be used in qualitative estimation of binary dependent variables. These models are the logistic model, the probit model and the linear probability model (LPM). Among these models, the LPM has been critized for having a partial effect of any explanatory variable used as its assumed to be constant. However, Hill observed that LPM could be used when we desire to keep the choice probability p, within a 0 and 1 interval [20]. The Probit model and the logistic model are very similar and are often used interchangeable in some studies. However, the probit function uses a standard normal probability density function while the logistic model assumes a logistic cumulative distribution function.

The probit and logistic models are some of the common models used in analyzing surveys with binary outcomes.

Both models assume that the relationship between Pi and Xi is non-linear, as such as the probability approaches zero, x approaches negative infinity. While it approaches one as Xi approaches positive infinity. The probit model has been widely used to study agricultural technology adoption dynamics. This study used the probit model to analysis the determinants of farmers' adoption decision for the improved rice varieties in the study areas. Adoption in this context assumes a binary dependent variable with an error term that is normally distributed [21].

The model estimates the effects of explanatory variables (Xi) on the probability of adoption. This is in the form, $P_i=(Y=1| X)$

The model assumes that the decision to adopt an improved variety by farming household is motivated by utility maximization. This underlying utility function depends on socioeconomic attributes, varietal attributes and institutional attributes with a zero mean error term [22]. This study mirrors the conceptual model of agricultural technology adoption of Uaiene [23]. The probit model is expressed as in the following equations

$$U_{i1}\ (X) = \beta_1 X_i + \varepsilon_{i1} \quad \text{for adoption} \qquad (1)$$

$$U_{i0}\ (X) = \beta_0 X_i + \varepsilon_{i0} \quad \text{for non-adoption} \qquad (2)$$

Considering that utility is random, a farming household will choose to adopt the Improved Rice Variety if only $U_{i1} > U_{i0}$. For the adopting ith household, its probability of adoption will be defined as;

$$P(1) = P(U_{i1} > U_{i0}) \qquad (3)$$

$$P(1) = P(\beta_1 X_i + \varepsilon_{i1} > \beta_0 X_i + \varepsilon_{i0}) \qquad (4)$$

$$P(1) = P(\varepsilon_{i0} - \varepsilon_{i1} < \beta_1 X_i - \beta_0 X_i) \qquad (5)$$

$$P(1) = P(\varepsilon i < \beta X_i) \qquad (6)$$

$$P(1) = \Phi\ (\beta X_i) \qquad (7)$$

where $\Phi(.)$ Is the cumulative distribution function of the standard normal[23]. The model seeks to estimate the impact of vector Xi on adoption decisions, X=nxk considered as the matrix of exogenous variables as will be mentioned later. Considering a normal distribution function, the model can estimate the probability of adoption with the probit model taking a latent form as below;

$$Y^* = \beta_0 + x\beta + \varepsilon \qquad (8)$$

where $\varepsilon \mid x$ is an error term normally distributed. Y^* is an underlying index for the difference in utility derived from adopting the

Improved Rice Varieties (IRV). In order to estimate the marginal effects of the explanatory variables on the adoption of the IRV, the first and second order differentiation was considered [24] as follows;

$$\frac{dp(x)}{dx_j} = \Phi(\beta_0 + x\beta)\beta_j \quad (9)$$

For interpreting the marginal effects, continuous variables (household labor, farm size, etc) are interpreted as a one-unit change in the explanatory variable which results in a change in the predicted probability[20]. Considering the binary explanatory variables (training, extension visits, farmers group, seed source) and the marginal effect is interpreted as the change in the predicted probability if the farmer is considered within that category. Considering the variables used in this study, the probit model can be specified as follows;

$U_i = \beta_0 + \beta_1$ Age+ β_2 Educational level+ β_3 Household labor + β_4 Experience+ β_5 income + β_6 Farm size +

β_7 Farmers' group+ β_8 seed source+ β_9 Training + β_{10} Extension visits + β_{11} Credit access+β_{12} Yield+ β_{13} Why produce +e

The β coefficient represent the influence of the corresponding explanatory variable on the dependent variable (adoption). The model assumes that e1 is independent of the independent variables and has a normal distribution, symmetrically distributed around zero[25].

the variables used in the model are defined as shown on the table below with their expected outcome signs.

3. Results and Discussions

3.1 Statistical Description of Variables

The sampled results showed that 45.4 % of the farmers adopted improved rice varieties while 54.6% didn't adopt. Male farmers represented 46.9% while females were 53.1%. This suggests that more women are farming household decision makers in the study area. The farmers surveyed got rice seeds from the State institution (UNVDA) by 54.1% while 45.9% got from their neighboring farmers or other sources. In regards to membership into existing farming groups, 60.4% of the farmers didn't belong to any farming group while 39.6% of them belong to groups approved by the state. Farmers in the study areas either produce rice for household consumption, marketing or for both reasons. The results observed that a majority of the farmer (78.7%) produce rice for both household consumption and marketing reasons. This could greatly influence their decisions to adopt improved varieties. A difference too observed between farmers who had access to some financial credits and those who didn't have access to such credits. The results showed that 60.4% of the farmers didn't have access to credits while 39.6% of them had access to such credits. The table below shows in more details, the comparative difference of some key variables between the adopting and non-adopting farmers of improved varieties in the study area.

3.2 Characteristics difference between Adopters and Non-adopters of improved rice varieties

The table below shows the results from the independent sample T-Test.

Comparing the two groups of farmers used in the survey highlighted some major difference in their mean values as shown on the table above. There exists a positive significant difference in the farm size of adopter and non- adopters. The difference in yield between the two groups shows a strong significant difference with adopters of improved varieties producing more paddy rice. This can be attributed to high yielding capacity of the improved varieties and the improved cultivation techniques applied by the farmers. There was a very strong significant difference in the between the adopters and non-adopters for farmers who attended training, received extension visits and the source of seeds. Farmer's membership in farming groups and the main reason for which rice is produced all have a strong significant difference between the two groups of farmers considered in this study.

Table 3. Mean Characteristics of adopter and non-adopters of improved rice variety

variable	Adopters (n=94)	Non-adopters (n=113)	Mean Difference	t-value
Gender	0.43	0.5	-.079	-1.131
Age	2.7	2.85	-.147	-1.097
Educational level	1.98	1.81	.173	1.060
Household labor	3.97	4.35	-.386	-1.554
Income	1.95	2.04	-.089	-.692
Experience	2.96	2.89	.064	.450
Farm size(ha)	0.499	0.398	.10064	2.069*
Yield(kg)	2383	1617	765.5	3.374**
Credit Access(dummy)	0.35	0.43	-.083	-1.212
Extension Visit(dummy)	0.73	0.39	.345	5.257***
Training(dummy)	0.89	0.2	.690	12.28***
Seed source(dummy)	0.95	0.27	.672	11.62***
Farmers' Group(dummy)	0.81	0.05	.755	17.22***
Why produce	2.93	2.58	.350	4.797***

*,**,*** denotes statistical significance at 10%, 5% and 1% respectively
Source, (author's survey 2022)

3.3 Estimation of the Determinants of improved rice variety adoption

The output shows that all the 207 observations of the data set were used in the analysis and using a robust function.

The Wald Chi-Square of 98.38 with a P-value of 0.000 indicates that the model as a whole was statistically significant which means it fits better with the data set than a model with no predictors.

The robust coefficients, standard errors and associated P-values for each of the variables at 95% confidence interval are presented on Table 4 below;

Table 4. Estimation of determinants

Variable	Coefficient (Robust)	Std. Error	P-value	Average Marginal Effect
Age	-.2248	.1667	0.177	-.0227
Education	.3138	.1365	0.022*	.0318
Household labor	-.0626	.0925	0.499	-.0063
Farming Experience	-.0086	.1650	0.958	.0008
Income	-.3018	.1763	0.087	-.0306
Farm size	-5.979	1.771	0.001**	-.6061
Farmer's group	1.870	.4078	0.000***	.1896
Seed source	1.277	.2838	0.000***	.1294
Training	1.027	.3302	0.002**	.1041
Extension Visit	.7345	.3618	0.042*	.0744
Credit Access	-.8775	.3235	0.007**	-.0889
Yield	.0012	.0003	0.001**	.0001
Why produce	.6610	.2183	0.002**	.0670
_cons	-3.015	1.008	0.003**	
Estimation Parameters	Fitness Estimate			
Number of Observations	207			
Wald Chi^2 (13)	98.23			
Prob>chi^2	0.000			
Pseudo R^2	0.7334			
Log Pseudolikelihood	-38.01			

*,**,*** denotes statistical significance at 10%, 5% and 1% respectively
Source, (author's survey 2022)

From the results above, the educational level of the farmers was positively and statistically significant at 10%. This indicated that the more educated a farmer is, the better he can appreciate, analyzed and interpreted the advantages of growing a new variety and the better his comprehension of training materials on the improved cultivation techniques of the improved variety. Hence this explains the positive and significant impact on their adoption decision. This results are in-line with the findings of Tiamiyu, Kijima and Sserunkuuma, [26,27] who observed that education enabled farmers to better analyzed and interpret information about improved varieties and hence helps adoption positively. The estimated average marginal effect of educational level on adoption indicated that an additional year or level of education achieved by a farmer increases the probability of adoption of improved rice varieties by 0.031. In a study on the adoption of NERICA varieties in Uganda, Kijima and Sserunkuuma found that education had a positive and significant influence on the new rice variety adoption.

Farm size affected adoption negatively (at 5% statistical significance) implying that as the size of the farms increases, the likelihood to adopt the improved rice varieties decrease. This mean that a unit increased in the size of farm land reduces the probability of adoption by 0.606. These results are contrary to the prior expectation sign (on Table 2). These findings are equally contrary to that of Jonas and Hiroshi who both found that farm size affected adoption of improved rice and maize varieties in Northern Ghana and Northern Nigeria respectively [28,29]. However in the context of this study, these results could be explained by the fact that adopting new technologies is costly and increasing farm size will increase cost of production hence given that the descriptive statistical results showed most farmers within the minimum income range, farmers may lack the financial ability to adopt improved varieties on larger farm area.

Belonging to a farming group approved by UNVDA showed a positive and statistically significant (at 1%) influence on the decision to adopt the improved rice varieties. As farmers join these existing farming groups, their probability of adoption increases by 0.189. This can be justified by the fact that farming groups approved are eligible to input loans, trainings and other services that accompany any new technology introduced within the study area. This results are consistent with the findings of Verteeg and Jonas [29,30] who observed that group membership of farmers had a positive and significant impact on technology adoption decision of farmers in Benin and Nigeria.

The source from where farmers get improved seeds equally showed a positive and statistically significant effect on the adoption decision made by the farmers. The availability and accessibility of improved seed increases the probability of adoption by 0.129. This can be explained by the fact that the only reliable seed multiplier for the improved varieties in the study area is UNVDA and as such access to improved certified seeds by the farmers guaranteed their acceptance of adoption. These results agree with the findings of Raju Ghimire [31] who observed that the accessibility of improved seeds by farmers in Nepal positively influenced their adoption of improved rice varieties.

Attending training on rice cultivation prior to the growing season showed a positive and statistical significant (at 5%) effect on the adoption of improved varieties. Attending training increased the probability of adoption by 0.104. This result can be explained by the fact that training gives farmers the opportunity to clearly understand the techniques by which the improved variety should be cultivated and as such motivates their willingness to adopt the varieties.

Extension visit to farmers' field by extension agents from UNVDA or from the delegation of agriculture and rural development showed a positive and significant influence on adoption. Extension visits increases the probability of adoption by 0.074. This is explained by the fact that such visits provide practical field observations and guidance to the farmers as such improves their production outcome. Better guidance encourages better yield and hence the desire to want to adopt the improved variety. One other key fact on this variable is that adopting the new variety indirectly guarantees extension visits during the cultivation seasons. These findings are consistent with that of [31-33] who all found that training and extension visit to farmers' fields during growing seasons had a positive and significant effect on the adoption of new improved rice varieties.

The access to credit by farmers showed a negative effect on adoption of the improved rice varieties. This means that as farmers get credits in the forms of farm inputs, the likelihood to adopt the improved varieties decrease. An increase in the ability to get credits reduces the probability of adoption by 0.088. This result is contrary to the prior expected sign (on Table 2) and in the context of this study, it can be justified by the fear of creditors give out loans to farmers to invest in new technologies to invest in new technologies by farmers.

Total yield of paddy harvested had positive and statistically significant influence on the adoption of the improved rice varieties in the study area. For every one kg of increase in the yield of paddy, the probability to adopt the improved rice varieties increases by 0.0001. For whatever reasons farmers may grow rice, an increase in the yield of a variety motivates them to adopt the variety. These results agree with the findings of Langyintuo and Mungoma,[34] who found that adoption is positively influenced by farmers' perception of the potential yield of an improved variety over an existing or low yield variety.

The main reasons for which farmers grow rice either for household consumption or both marketing and self -consumption plays a positive and significant impact on the adoption of improved rice varieties. Once a new variety is perceived to be palatable and accepted by consumers, adoption of such a variety by farmers will increase. As shown on the results table above, the reasons for producing rice increase the probability to adoption by 0.067. This is consistent with the findings of Raju et al, 2015 who observed that farmers in the Nepal adopted high yielding varieties for the purpose of producing more to market and self-consumption.

4. Conclusion and Policy Recommendations

This study sought to identify the key determinants of improved rice variety adoption in the West and North West region of Cameroon. Adoption a new variety or farm technology is often hindered by personal or institutional challenges faced by farmers. From the results presented in the previous sections, this study identified key determinants of improved rice variety adoption in the study area. These determinants can be classified into different categories such as farmers' personal characteristics, Institutional factors and Varietal characteristics of the improved variety.

4.1 Farmers' Personal Characteristics

The findings of this study showed that some personal characteristics of rice farmers in the study area positively or negatively influenced their decisions to adopt improved rice varieties. These key determinants are the educational level of the farmer, membership in a farming group, their main reasons for growing rice and their land area cultivated. Except for land area cultivated which showed a negative influence on adopting improved varieties, the rest of these characteristics had a positive influence on the adoption decision of the farmers. Farmers are therefore recommended to belong to registered and approved farmer's organizations through which access to some incentives could be easily attained.

4.2 Institutional 'pull or push' Factors

Institutional factors could either pull farmers into accepting and adopting a new technology or push them away from accepting the said technology. The findings of this study showed that the source of improved variety seeds positively affected farmers' decision to adopt the variety. This study recommends that accessibility to improved seeds be improved for better adoption of the improved variety. This could be done by multiplying more seeds and distributing in small farming communities to encourage adoption of the technology. Farmers' exposures to trainings and field follow up trough extension visits by extension workers plays a positive role in ensuring that farmers adhere to improved cultivation techniques. It is therefore recommended that more trainings and extension visits be financed and encouraged by the state and other development partners to increase the rate of adoption of improved varieties in the study area.

4.3 Varietal characteristics

The improved rice varieties considered in this study is reported to have potential yield of 3-5 tons/ha higher than the 2 to 3.5 tons potential yield of the old varieties. This is factor is observed to have a positive influence on the adoption decisions of farmers. It is therefore recommended that researchers and breeders continuously help to maintain the quality and yield of the improved varieties to encourage more farmers to adopt the variety over time. Ensuring that the improved varieties remain pure and not mixed with other varieties which could affect its genetic yielding potential, required a collective strategy from the farmers, researchers, extension workers and other development stakeholders.

Conclusively, this study highlighted the key determinants of agricultural technology adoption in the upper Nun valley areas of the North West and West region of Cameroon. Future research on the adoption rate and intensity of adoption of improved varieties in the study area is recommended to fully understand the dynamism of rice production in the study area.

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