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AN INQUIRY INTO THE LEVEL OF TECHNOLOGICAL ADOPTION IN BURUNDI: A CASE STUDY OF RICE IN GIHANGA

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Abstract

The study assessed the determinants of the technological adoption as well as the factors constraining the production of irrigated rice in the western of Burundi. One hundred and twenty rice producers were surveyed for the study. Descriptive statistics and logit models were used in the analyzing data collected. The results revealed that diseases and pests were the most dominant factor limiting the production of rice whereas the model of logit showed land size, dependency ratio, experience and to be a member of an association significantly influence the adoption of new variety of rice V14 while education of conjoint (wife), dependency ratio and off-farm income contribute to the optimal application of urea, the most used inorganic fertilizer in rice production in Gihanga. To improve technological adoption in irrigated rice production, it is recommended that the agricultural policy should more emphasis on the importance of education crop diversification strategy and extension service in order to reduce the incidence of crop diseases and to boost the rice technical adoption.

Key Words: Rice variety, Gihanga, technical adoption, inorganic fertilizer

1. INTRODUCTION

1.1 Rice Production in Burundi and EAC

According to the statistics and population prevision done on 18 November 2009 by the United Nations Population Funds (UNFPA), the population of Burundi is estimated at 8.3 millions of persons. For an area of Km^2 25950, the population density is around 320 persons/Km^2. However, the population forecast of 2050 is projected to 14.8 millions with a population density of 570 persons/Km^2.

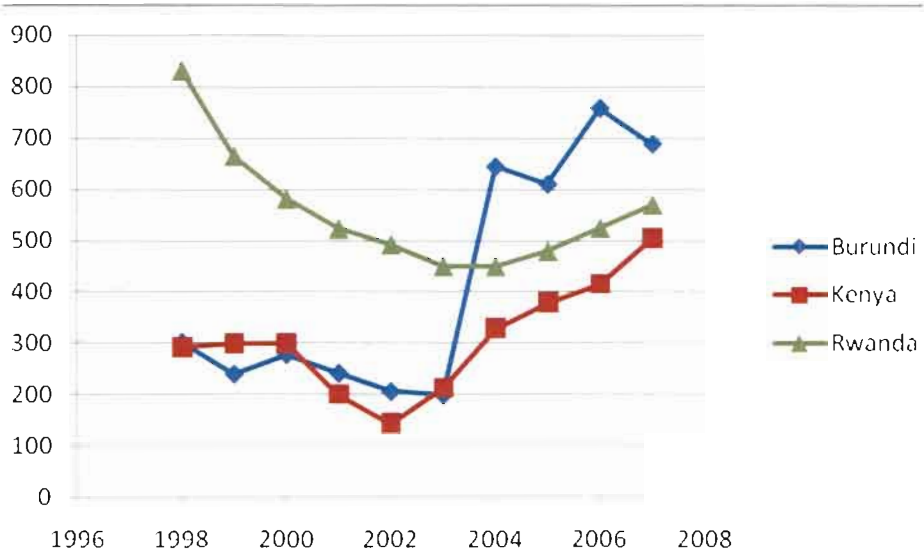
Agriculture plays a pivotal role in addressing current and future issues of Burundians. The Poverty Reduction Strategy Paper-PRSP (IMF, 2007) indicated that agricultural sector is the mainstay of Burundian economy. More than 90% of population is in this sector. The latter provides 90% of food supply and more than 90% exchange revenues. In this context dominated by limited access to land, both PRSP and National Agricultural Strategy 2008-2015 (GoB, 2008) emphasized on the method of agricultural intensification regarded as a cornerstone in contributing to both poverty alleviation and food security.

According to the study on sources of economic growth carried out by World Bank, the rice sector, among others, provides great potentials of food accumulation that is needed to support in order to cover the cereal deficit. The annual rice production is around 70000 tons (ISTEEBU, 2007). Rice is ranked 7th behind sweet potato, cassava, beans, maize, banana and sorghum, It provides 5 to 6% of national food production. Working on identifying agricultural sectors that mostly need to be supported, IFAD (2009) conveyed that the possible growth margins of the productivity through intensification are greatly noteworthy. The annual production yield can move from 2500 Kg/ha for paddy rice to 5000 Kg/ha in irrigated wetland of highland, and from 5000 Kg/ha to 8000 Kg/ha of paddy rice in the areas of lowland. Considering the possible the possibility of cultivating rice twice in the same season, it is no doubt that rice presents high potentials of value added creation.

Furthermore, it is important to mention that these actual yields were achieved in the context where the price policy is not initiated by market price signals and could be mostly and probably affected by the signing agreement by Burundi on the Custom Union of East Africa Community (EAC) on July 2009 and common market event to be launched on July 2010.

In fact, as shown in the following figure 1, the income earned from rice by Burundian producer is a source of incentives comparatively to the two other EAC member countries. However, according to IFAD (2009), the uniqueness of the rice sector is above all the existence of two different sub-sectors depending on the identity of the dominant trade agent: around 22000 tons (25% to 40% of national production) are produced by SRDI (Regional Company for Imbo Development).

Table 1: Production Price ($/tonne) in Burundi, Kenya et Rwanda



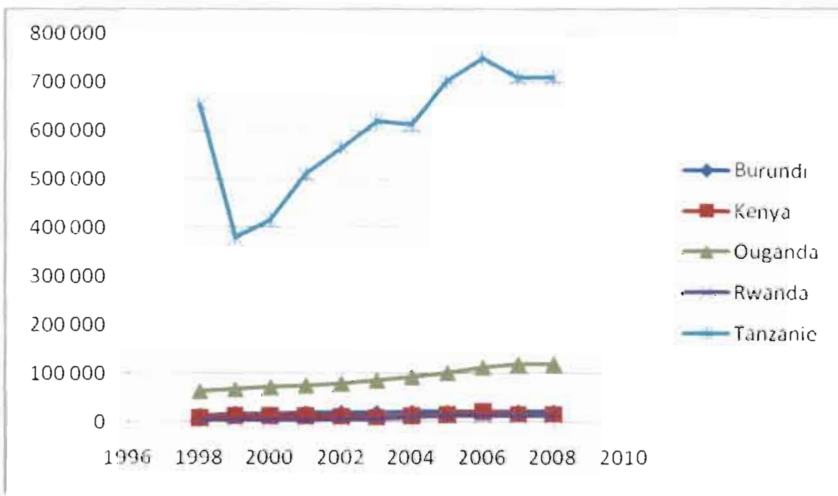
Source : Faostat, 2009

This region covered by SRDI, the production structure, transformation and marketing are linked together to form a particular sub-sector that supplies rice of high quality in all Bujumbura town. Besides, SRDI settles price trend of rice traded in the country.

The probable collusion of rice importation traders against local price and especially price fixed by SRDI is not something new but it is very interesting to note that in 2008-2009 season, this public institution (SRDI) faced serious challenges to sell out rice bought from producers at a price of FBu 585 per Kg while the sector, fully privatized, bought it at FBu 480 per Kg. For countries like

Burundi, Rwanda and Kenya whose areas allocated to rice production remain very limited (figure 2) comparatively to the other competitive and well positioned countries like Uganda and especially Tanzania, the intensification is the only strategy for a sustainable competitiveness in this East region.

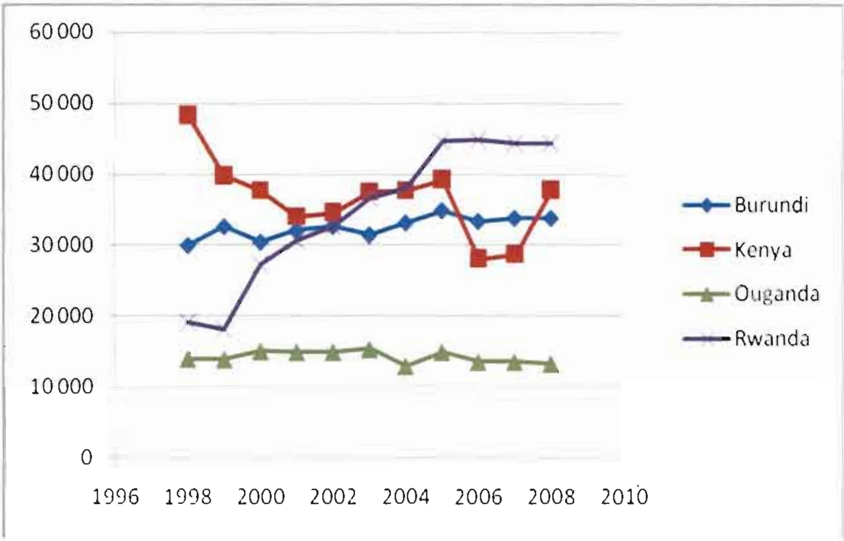
Table 2: Rice Area in EAC Countries



Source : Faostat, 2008

Figure 3 shows that Rwanda has already embraced the intensification strategy as a way to increase rice productivity. However, it is critical to unravel the limits and determinants of the adoption of intensification models on the long run prospects so that Burundi may fall the same pathway. The scope of this research study is to identify two intensification factors: rice variety and inorganic fertilization.

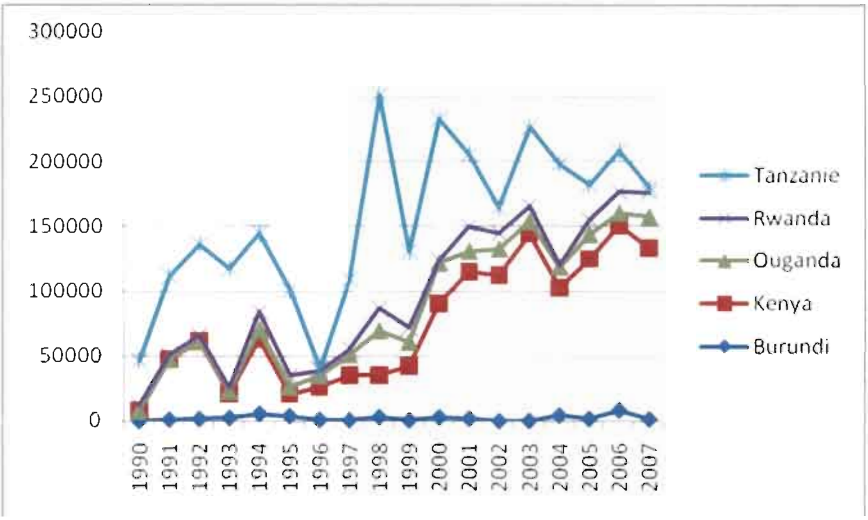
Table 3: Rice Productivity in EAC Countries



Source : Faostat, 2008

The research methodology may be repeated to other EAC countries since the latter are more depending on rice importation as illustrated in the following figure 4.

Table 4: Rice Importation (tonne/an) in EAC Countries



Source : Faostat, 2008

This regional trade deficit (importation greater than exportation) coupled with a long food crises exerted pressure on the consumers' income who hardly overcome the effect of skyrocketed food prices. In fact, it is evident that this upward price trend has been on rise since 2008 and that the rice market has also been the most affected.

1.2 Technological Change: solution to reverse food insecurity trend

Agriculture cannot stay away from adoption of new technologies in farming (Adhikari *et al.*, 2009). Webb (1994) and Lufumpa (2005) asserted that the adoption of improved technology is one of the keys to long-term famine prevention, both through its potential to enhance agricultural productivity. According to Herath and Takeya (2003), many adoption studies distinguished between the rate of adoption (proportion of farmers adopting technology) and the intensity of adoption (defined as the level of adopting the technology initiated). The later will be the one followed in this study. Understanding the intricacies and the pattern of the growth or fall of production efficiency linked to poor technological adoption of rice can only help to promote its sectors and thus boosting the level of competition within the region and also in the world. There are many factors that have to be considered so that one grasps the effects of the determinants of crop adoption at the micro level.

First, there is price factor and political will of the government aiming to assisting the producers. Second, the socio-economic factors that surround the issues of rice adoption must be understood. Lastly, access to and use of inputs coupled with the other exogenous factors may shed light on the production difficulties or success on the bottom of the production chain of rice crop.

The production system is dominated by the agriculture of subsistence in which land is the major factor. Since the only way to increase the agricultural productivity, the production intensification becomes the only solution to alleviate food security that has been pandemic in some regions of Burundi (MINAGRI, 2009). To increase agricultural output, there are three ways: increase the production area, the intensification which consisted of increase use of a combination of production inputs such as labour, capital, and land in order to increase production and use of advanced production techniques in which agricultural output is achieved through a declining or constant resource base (Hayami & Ruttan, 1985). The latter is referred to agricultural productivity.

Under certain assumptions of efficiency, agricultural productivity and technical change are synonymous (Grosskopf, 1993).

The sector of agricultural research has been the field shared among the ISABU, IRAZ and FACAGRO. Though the war affected this sector, there has been a grim of hope when government and many donors re-invested in so that the research centres start to tackle with the issues of food insecurity and rural poverty. There is a great milestone that these centres have achieved in some crops, specifically in cassava and rice. Since 1960, the highly yielding varieties have been distributed to farmers organised in associations and the productivity thereafter got markedly improved. However, no study has been done so far to measure the degree of adoption and the production constraints that have been characterized the rice sector. Moreover, there is a stressing need of knowing the farmers characteristics influencing the technological adoption of the newly introduced crop varieties. Therefore, the prime objective of this study is to assess the factors that hinder the acceptability of the production technology in the rice sector in the lowland areas.

This research is focusing on understanding and measuring of technology adoption of rice as the first step of assessing their production and marketing sector. As other authors covered the aspect of agronomic and crop management of rice production, this study will fill gap through assessing the degree of technology adoption and factors that hinder farmers of SRDI Irrigation Scheme and no-SRDI to attain the production efficiency at the farm level with an econometric tool used to measure the technology adoption. We also tested the degree of adoption of the most used inorganic fertilizer in the same region. The socio-economic determinants of not applying the exact fertilizer rate were found using the same logistic model.

2. RESEARCH METHODOLOGY

2.1 Research Area

This study was carried out in the lowland of Imbo North (in the West of Burundi) and specifically in the district (i.e. commune) of Gihanga. A randomly selection was done to pick some sub-locations that made up the district: Gihanga centre, Vyondo, Ninga, Mugerero, Buringa and Muhombahomba. In each sub-location, both SRDI client and none SRDI client were interviewed with the help of a structured questionnaire. Since the SRDI clients are organized in associations as the first criteria to be serviced by SRDI, we randomly select farmers from the lists of farmers that we gathered from these offices of the associations. The sample size was of 130 farmers which we split into two groups of V14 rice variety adopters and none adopters that we use in the section of logit model.

2.2 Analytical Framework

2.2.1 Productive rice constraints

The first task was to analyze the leading productive constraints in the rice production in study area. We gave a list of seven (7) notorious limiting factors to the rice produced sampled to rank in the ascending order. The 7 productive constraints have been suggested by the official of rice department of ISABU and SRDI. The establishment of scores has been done on those ranks according to the frequencies of each them on the list given to the farmers. At the end, we tested the degree of correlation between frequencies and ranks using the Kendall's tau-b test. This is a nonparametric measure of correlation for ordinal or ranked variables that take ties into account. The sign of the coefficient indicates the direction of the relationship, and its absolute value indicates the strength, with larger absolute values indicating stronger relationships. Possible values range from -1 to 1, but a value of -1 or +1 can only be obtained from square tables.

2.2.2 Technological Adoption in Agriculture

There is a substantial body of research dealing with technology adoption. The adoption model to be developed in this paper stresses on the decision that the farmers, SRDI clients as well as none clients, face at the beginning of the season. The aim of this research is to compare the private sector with the public one (SRDI) as it is known that the private sector is the driver of innovation (Melinda, 2005) The decision to adoption unfamiliar package of technology that goes along with the newly introduced variety of rice involves considerable uncertainty and cannot be analysed through the lens of profit maximizing framework. Apparently, there are two leading econometrical approaches of technology adoption. One is to group technologies into packages and to assume that farmers make a single decision about whether or not to adopt the entire package of technology (Rahm & Hauffman, 1984). A second approach is to assume that farmers make independent decisions about each technology (Fletcher & Terza, 1986 in Bravo-Ureta *et al.*, 2006). The latter has been followed in this study.

2.2.3 Theoretical Model

The choice of an improved crop variety is dictated by the consumer demand from food markets and farmers' consumption requirements on top of the search for the farmers' maximization of utilities (Mafuru *et al.* 2007). In fact, the SDRI procures the improved rice seeds from ISABU on the basis of the consumers' preference and attitudes. Hence, the demand-driven approach is used by SDRI to determine which rice variety to grow each year. As mentioned earlier, the variety V14 was grown because of its intrinsic qualities and productivity potential.

In adoption research, the probability models are preferable to the conventional linear regression because according to Amemiya (1981) and Gourieroux (1989), the parameter estimates from the former overcomes most weakness of linear probability models by providing parameter estimates asymptotically consistent and efficient.

In order to know the determinants of the adoption of V14 and optimal fertilizer use, the logit model was preferred to the probit model because of its simplicity and is frequently used in technology adoption assessment (CIMMYT, 1993). However, the dummy models, in general, are proned to the heteroscedasticity variances and multicolliniality problems which lead to inconsistent estimators (Gujarati, 2005). The former constraints is usually overcome by choosing models that require more general estimation (Herath and Takeya, 2003). However, a logit model with a flexible functional form in independent variable can prvail over this problem. The second was solved by applying the Kiel test approach. The general model is binary function involving estimation of probability of adoption of a given practice (Y) as a function of a vector of explanatory variables (X).

$$P\ (Y=1) = f\ (\alpha\ X) \qquad (1)$$

$$P\ (Y=0) = 1 - f\ (\alpha\ X) \qquad (2)$$

Where:

Yi : is the observed response ith observation of the response variable Y (Y=1 for adopter while Y=0 for none adopter);

X: a set of explainable variables which determine the probability of adoption (P);

F: function that can take the form of a normal, logistic, or other probability function. The logic model used in this paper follows a logistic CDF to estimate P in this form:

$$P\ (Y=1) = \frac{e^{\alpha X}}{1+e^{\alpha X}} \qquad (3)$$

$$P\ (Y=0) = 1 - \frac{e^{\alpha X}}{1+e^{\alpha X}} = \frac{1}{1+e^{\alpha X}} \qquad (4)$$

The conditional expectation of Y on X is given by:

$$E\ (Y/X) = 1\ [F\ (\alpha X)] + 0\ [1 - F(\alpha X)] = F\ (\alpha X) \qquad (5)$$

Since the model[116] is no linear, the parameters estimated are not necessary the marginal effects on the various explainable variables. However, the relative effect of each explainable variable

[16] Note : The model cannot be linear because the coefficients will greater than 1 and not appropriate for the dichotomic or dummy variables. The utility of the logistic regression is that it overcomes the weakness of linear probability models.

on the probability adoption can be found by differentiating the equation (3) with respect to X_{ij} and the result is shown in the equation (6):

$$\frac{\Delta P_t}{\Delta X_{jt}} = \left(\frac{e^{\alpha X}}{(1+e^{\alpha X})^2}\right)\alpha = f(\alpha X)\,[1-f(\alpha X)]\,\alpha \qquad (6)$$

We have estimated the model following the maximum likelihood in which each observation is treated as a single draw following the Bernoulli distribution. The end result gives the α, the maximum likelihood estimator. Before reaching the analysis process, we here hypothesize that the farmers are rationale and choose the seed variety and use the recommended fertilizer rate in order to maximize their utility.

There is an overwhelming empirical literature on logistic regression. To mention but the few, adéoti *et al.* (2002) made use of model logit in order to identify factors affecting the adoption of new technologies of *niébé* Vigna unguiculata in West Africa. Household size, education, off-income and extension service were found to positively affect the adoption rate. In addition, qualitative analysis based on the use of logistic regression was carried out by Jayasinghe-Mudalige and Weersink (2004), Herath and Takeya (2003), Bravo-Ureta (2006), Sometenou *et al.* (2008) and Mutai (2005).

As shown by Melinda (2005), the adoption models as powerful econometric tools. Though they bring forth quantitatively the major constraints in technology adoption, the only shortcoming is that the model failed to highlight the role of some crucial factors such as adoption process, information sources, social capital, externalities and the slow payoff time from adoption.

2.2.2 Model Specification

The rate of adoption depends on socio-economic, institutional and technical characteristics, personal factors and communication behaviour. Details review of these factors influencing adoption is given by Feder and Umali (1993). The independent variables for this study included age of household head and wife if the head is married, years of education, social status, sex, and literacy, size of the farm, credit availability, and dependency ratio proxy to labour availability, off-farm income, and extension service. We also add other variables such as experience of the household head, belonging to an association (social participation), access to credit, off-farm income, etc. From the equation (5), we have the following specification of the model (Gujarati, 2005, p. 595):

$$\mathrm{Ln}\,(P_i/(1-P_i)) = X_t\beta + e_i \qquad (6)$$

Where X_t is the index reflecting the combining effect of the independent X variable that prevent or promote the adoption and e_i is the error term. This index can be well interpreted in this detailed model:

$$X_t = \beta_0 + \beta_1 X_1 + \ldots + \beta_n X_n + e_i \qquad (7)$$

The independent variable is the natural log of the probability of adoption, on the one hand rice variety V14 and the recommended rate of application of urea in rice production (P), divided by the probability of not adopting (1-P). The model (6) was estimated using the maximum likelihood method in the most accepted Statistical Package for Social Science (SSPS) software, version 16.

These variables in equation (7) have the impact on the degree of adoption described in the table (see appendix).

3. RESULTS AND DISCUSSION

The following results emphasizes on the production constraints and factors that explained the adoption of both highly yielding rice variety and application of appropriate rate of chemical fertilizer.

3.1 Socio-economic characteristics of sampled respondents

Demography: As it is shown in table 1, Only 72 surveyed farmers (58 percent of sampled farmers) adopted the new rice variety for 2009 season, from which 56 were male and 16 were female. However, the farmers who have applied an optimal quantity of urea in their field, we found only 56 farmers whose 47 were male and 9 were female. There is big disparity between the two genders in rice production. Hence, this indicated the dominance of male as household head. Besides, the adopters of rice variety V14 are older (44 years) than those applying an optimal urea in their field (42). However, the experience in rice production was at par for both adopters (average of 16 years). Either women or men participating in this survey did not go beyond primary school level. The average education reached for both gender was 2 years and 3 years for women and men respectively. It is important to note that farmer education in key factor to adopting productivity-enhancing technologies.

The household size is 6 on average and the farm size was 89 ares (equivalent to 0.89 hectare) for both optimal urea users and high yielding rice variety V14. The farmers surveyed in Gihanga devoted an average of 72 ares (≈ 0.72 hectare) of their land to rice production while for other it was 73 ares. The off-farm income playing a great impact on crop production was to the tune of FBu 287514.29 for rice V14 adopters while for optimal urea users, it is reached an average of FBu 243357.

Table 1: Demographic and socio-economic characteristics of rice V14 and optimal urea application adopters

Characteristics	V14 Adopters Mean	V14 Adopters Standard Deviation	Use Optimal Urea Mean	Use Optimal Urea Standard Deviation
Age of HH head (years)	44.14	11.40	42.63	10.85
Education of HH head if male (years)	3.05	3.05	3.17	3.21
Education of HH if female (years)	2.47	2.51	2.52	2.62
Farm Experience in rice production	16.10	10.45	15.53	10.14
Household size (No)	6.49	2.88	6.51	2.48
Farm size (are)	88.97	51.99	89.32	48.44
Rice (are)	71.86	44.54	73.70	38.19
Off-Income (BIF)	287514.29	681946.80	243357.143	592654.09

	No of farmers	Frequency	No of farmers	Frequency
Genre: **Male**	56	77.8	47	83.9
Female	16	22.2	9	16.1
Extension	48	66.7	32	57.10
Service: **Yes**	24	33.3	24	42.90
No				
Credit access:	55	76.4	39	69.70
Yes	17	23.6	17	30.4
No				
Market Access:	9	12.5	9	16.40
Difficult	35	48.6	30	54.50
Easy	28	38.9	16	29.10
Very Easy				
Member of	64	88.9	45	80.40
Association:	8	11.1	11	19.6
Yes				
No				

Note: HH= Household, BIF = Burundian International Franc (national currency)

Source : Authors' Survey, 2009

Land tenure: Basically, a great part of land for rice production in Gihanga belongs to the State. Through SRDI, the land has been sub-divided among farmers who then became tenants under this condition and sealed a contract with SRDI. The land, a crucial asset and production factor, was acquired in the form of heritage

(70.9 % of them), gift (11.1%) and purchase (18.5%). Farmers, adopters of rice V14, acquired land through heritage (22%), gift (7%) and purchase (7%). The tenants of SRDI have to grow rice and follow rules and regulations that tied them to the landlord, i.e., SRDI. The latter provides them with seeds, fertilizers, pesticides, extension service and other agricultural inputs on credits. The interaction between landlord (SRDI) and tenants (rice producers) has been a source of incentives or des-incentives to farmers from years to years depending on the policy set by SRDI..

Irrigation and cropping systems: The farmers surveyed practiced crop rotation on lowland under permanent irrigation, except during raining periods. The crops that came after the harvest of rice are mostly tomatoes, sweet-potatoes, maize and others (mostly other vegetables or peanuts). The proportion of those who practice crop rotation is sweet-potatoes (63.2 %), maize (16.2%), tomatoes (11.8%), others (8.8%), for rice V14 adopters, while optimal urea adopters, it was sweet-potatoes (70%), maize (18%), tomatoes (8%) and others (4%) .

It was said earlier that the rice crop was under irrigation system. The management and control of water irrigation may be a boost to production yield performance. The farmers surveyed (80%) informed that there is no disruption in water for irrigation (in rice nurseries and field). This may be attributed to the reparation and good management provided by SRDI institution and the rehabilitation works that have been made too recently.

Extension service: This is an incentive for agricultural technologies adoption. In the area of study, 66.7 percent reported receiving those services while in counterpart, it was just 57 percent for those who have applied recommended quantities of urea. These services are supposed to be provided by the agents of SRDI as 56% of farmers reported it. Moreover, more than 65% admitted that they did attend neither a workshop nor a field demonstration to allow them acquitted with new technologies in rice production. The lack of extension service has been linked to production inefficiency in agriculture. Since the aftermath of civil war in Burundi, the extension service provision has gone down due to the decrease of the number of agents of extension service and the lack of funds to support the department of extension works.

Credit access and source of revenue: National Bank for Economic Development (BNDE) assisted greatly the SRDI to provide agricultural credits to rice producers. There is a lump sum year given to allow the purchase of agricultural inputs such as fertilisers, pesticides and others. SRDI distributed to farmers in the form of credit. The latter is supposed to reimburse it after rice harvest and sale. The source of revenue other than agriculture is the undeniable determinant of agriculture development and source of great investment in this sector regarded as a backbone of Burundi economy. It (source of revenue) is also viewed as an indicator of rural income diversification and element needed to alleviate rural poverty. For adopters of rice V14, only 18 % informed us to have activities generating income other than agriculture while for those who have applied an optimal urea in their rice field, 13% of them had earned some income from off-farm activities. The percentages are too low to put forward that there is a great pressure on land in order to have end meet.

Production: The production of rice for this last season depends solely on the agricultural good practices and irrigation management followed from the beginning of rice production. From table 2, the production of rice oscillated between kg 500 and 15000 depending of the area of cultivation which was between 12 ares and 300 ares on average.

Table 2 : Rice Production in Gihanga

Items	N	Min.	Max.	Mean	Std. Deviation
Rice area (ares)	125	12,00	300,00	76,1600	47,14552
Rice seeds (kg)	125	10,00	300,00	80,2160	50,51295
Production (kg)	125	500,00	15000,00	2954,5200	2087,24529
Yield (kg/are)	125	10,00	120,00	43,7603	15,34103

Source : Authors' Survey, 2009

As it was seen earlier, the productivity of rice in Burundi has a quasi comparative advantage within East African Community (EAC).

This study evidenced that the yield was averaging 43 kg/are (or 4300kg/hectare = 4.3t/ha) with a range between 10 kg/are and 120 kg/are. This productivity is in conflict with the yield of 5t/ha indicated by the government of Burundi (GoB, 2008). Though the gap is not deep, this difference in yields pointed out that there are some areas of inefficiencies in rice production of the study area.

Marketing pattern: There are many actors in rice marketing system. On the upstream, we found producers and few middlemen while on the downstream, large middlemen, large and small scale traders, SRDI, millers, transport agents and also consumers. A strange phenomenon is that we also found the large scale traders rent piece of land from producers in order cultivate rice at the same time sell it. The SRDI clients must sell exclusively to SRDI so that they pay the credit contracted to this public institution. However, finding the price of SRDI less attractive, some SRDI clients preferred to sell to private traders and refund the credit of SRDI in cash. This is the reason that we found that only 89.6 % of variety adopters have sold rice to SRDI. On contrary, the private producers sell to anyone whose price can yield high returns. More than 84 % of adopters agreed to have an easy access to markets for their rice produce. This may be justified by the short distance, roughly 20 to 25 km, from Gihanga (research area) to the Bujumbura town where large number of rice consumers dwell. While the SRDI clients sold rice at FBu 585 per Kg of rice paddy, more than 64 % of private producers secured a price less than FBu 585 from different buyers. This year season was special for SRDI clients because it was the first time they sold at this high price. Fixing rice price is the duty of SRDI and the latter regarded to this task as the only tool to overcome pressure from their competitive trade entities. Besides, it is also a powerful instrument of giving incentives to their clients and of changing the laws that govern not only forces of the supply and demand of rice but also choices of consumers on local rice produce against to the imported one.

3.2 Farmers' responses on the most leading production constraints

Among the seven leading constraints identified in rice production, the high incidence of rice diseases and pests emerged to be the first production constraints in the study area (see table 2). The score being 0.58 indicates that the high proportion of the sampled rice farmers that identified diseases as the high production constraints among the other constraints. However, the value correlation between the frequency and the score by Kendall's tau-b showed a low relationship. Though it has being curbed by good cultural practices and pesticides (Kitaze), pycularia *oryzae* causing blast was identified the most important and affecting severe damage to the crop every year.

Table 2: Production constraints in rice crop

Production Constraints	Highest Freq.	Total Freq.	Score	Kendall's Tau-b	Rank
Diseases and pests of rice	75	129	0,58	0.098	1st
High price of agricultural inputs	60	123	0,49	-0.683	2nd
Poor management of irrigation water and sometimes seasonal shortage of water for irrigation	59	122	0,48	-0.293	3rd
Lack of extension services	46	127	0,36	-0.619	4th
Low or/and volatile paddy selling price	36	124	0,28	-0.908	5th
Insufficient human labour	32	126	0,25	-0.810	6th
Poor access on the agricultural Credits	31	124	0,25	0.195	7th

Source : Authors' Survey, 2009

The second problem that hinders farmers to improve their productivity is the price of inputs (fertilizers, pesticides, seeds, etc.). The value of correlation is relative big in absolute value which denotes a close relation between the frequency and the score. The negative sign indicates a negative trend between frequency and score. The clients of SRDI received the needed inputs in the form of credits. Although this assistance is very well welcomed by farmers, the deductions made by SRDI on the farmers' rice revenues to pay up the credit on inputs are enormous. This is the reason why rice farmers strategically choose to sell to private dealers and pay cash the debt contracted from SRDI as if this institution was there to provide agricultural assistance.

Considering that Burundi is a land-locked country, the exorbitant prices of agricultural inputs may be understandable. Poor irrigation water supply was viewed as the third mostly serious issue in rice production. The infrastructures used in building the irrigation system are very old and need seriously to be repaired. The farmers on up-stream deviate the flow of the river and this cut short the water supply to the farmers on the down stream part of the river. This occurs during the dry season. The score and the frequency are in the opposition direction. However, there is a close relationship between the score and frequency of the 5th and the 6th production constraints which are low and volatile paddy selling price and insufficient human labour. The former is set by the law of the demand and supply but SRDI sometimes fixes its selling price according to the private selling price. For instance, this last season, the price of SRDI was exceptionally good (585FBu per paddy kg against 500 FBu for the private sector).

3.3 Factors Affecting the Adoption of Agricultural Technologies

One of the basic avenues for labor productivity in agriculture to rise is the intensification of agriculture. This strategy requires increased use of fertilizers and other productivity-enhancing inputs. Urea, being the most fertilizer used in rice production in Gihanga, enters into this category of inputs used to increase labor and capital productivity.

In seeking the determinants of optimal use of urea, we found that the logistic model explained 72% of the total variation in the adoption of the highly yielding variety of rice, variety V14 (table 3). The chi-square statistic indicated that the parameters included in the model were significantly different from zero at the 1% level for adoption this rice variety. This Omnibus test is the alternative to the very known Hosmer-Lemeshow test. It shows the capability that all the predictors in the model jointly predict the response of the variables (an equivalent to F-test of normal multivariable regression). The significance found in the results (table 3) reveals that there is adequate fit of the data to the model, meaning that at least one of the predictors is significantly related to the response variable.

The maximum likelihood estimates of logistic regression are also shown in the table 3. Land size, depend ratio, experience in rice production and membership in associations significantly influenced the adoption of highly rice variety V14 in the study area.

Table 3: Parameters Estimates for Factors Affecting Adoption of Rice V14

Explanatory Variables	**B**	**S.E.**	**Wald**	**Exp(B)**
Constant	-3,135*	1,445	4,709	0,044
Gender (1 male, 0 female)	-0,019	0,582	0,001	0,982
Age (years)	0,044	0,032	1,877	1,045
Education conjoint (years)	-0,066	0,088	0,565	0,936
Land size (ares)	-0,008*	0,004	3,135	0,992
Dependency ratio	0,631***	0,212	8,832	1,879
Experience (years)	-0,047*	0,035	1,745	0,954
Membership	1,781**	0,689	6,683	5,939
Extension service	0,648	0,569	1,294	1,911
Market accessibility	0,623	0,643	0,939	1,864
Off-farm income	-,040	,468	,007	,961
Model chi-square	33.077***			
Overall cases correctly predicted	72.%			
- Log Likelihood	137.31			
Sample size	125			

Note: *** = significant at $p < 0.001$, ** = significant at $p < 0.01$, * = significant at $p < 0.05$

The odds in favor of adopting rice V14 decreased by a factor of 0.992 for farmers with large land size, possibly because the size of land is usually a proxy of the level of wealth farmers. Therefore, farmers with large land size are able to purchase other rice varieties rather than rice V14. Furthermore, most them are not clients of SRDI, we hint by saying that they are not bind by SRDI rules and regulation, hence, their adoption to this rice variety distributed by SRDI cannot fully achieved.

However, the dependency ratio which is a proxy to labor availability significantly and positively influenced likelihood of adopting the rice variety V14 by a factor of 1.89 at 1% level. The production of rice under irrigation is labor-intensive. A high dependency ratio reflects a high proportion of children to adults. This leads to high labor supply and also a high pressure to care and support a large family. The high level of adoption of rice variety V14 is justified by this labor availability and likeness of belonging to SRDI program. The family labor plays a crucial role in agricultural production. This result in this study agrees with the outcomes reported by Lopez and Valdez (2000) in Bravo-Ureta (2006) regarding the importance of family labor in the success of development of projects in Central America.

Contrary to expectation, the odds to adopting rice variety V14 decreases by a factor of 0.95 for farmers who have a long experience in rice production. Membership to an organization or association is linked to the adoption of new rice variety. In this model, the coefficient for this variable is statistically significant. In order to be served by SRDI, the rice producers must group into associations. In this form, the distribution and follow up of agricultural credits become easier than if farmers are assisted individually. As shown by the results, the adoption of new technology promoted by SRDI is enhanced once farmers are organized into association. Furthermore, farmers learned from each other. The social participation as pointed out by Prasanna *et al.* (2004) and Mbonimpa and Ndikubayo (2008) determines the technology appropriateness and influences agricultural resource accessibility.

The urea being the most used fertilizer in the study area because rice is critically in need of nitrogen based fertilizer. As shown in the table 4, the model explained 77% of the total variation of the adoption of optimal urea application. Overall test of fit were significantly different from zero at 5% level. Like in the previous model (see table 2), dependency ratio was the factor affecting the adoption of optimal use of urea. Furthermore, the education of wives in the households was found to positively influence the optimal use of urea in rice production. The odds in favor of adopting optimal urea increased by a factor of 0.78 for women who were more educated. It has been documented that the women play a critical role in agricultural development.

Table 4: Parameters Estimates for Factors Affecting Adoption of Optimal urea Application

Explanatory Variables	B	S.E.	Wald	Exp(B)
Constant	0,829	1,490	0,310	2,291
Gender (1 male, 0 female)	0,976	0,632	2,389	2,654
Age (years)	0,042	0,035	1,427	1,043
Education conjoint (years)	0,238*	0,095	6,244	0,788
Land size (ares)	0,001	0,004	0,010	1,000
Dependency ratio	0,149*	0,193	0,597	1,161
Experience (years)	-0,097	0,039	6,094	0,908
Membership	-0,446	0,735	0,369	0,640
Extension service	0,546	0,599	0,833	1,727
Market accessibility	-0,396	0,697	0,323	0,673
Off-farm income	0,254***	0,517	0,242	1,290
Model chi-square	15.30*			
Overall cases correctly predicted	76.80			
- Log Likelihood	120.20			
Sample size	125			

The education of women therefore, is a key to agricultural productivity. . According to Kasnakoglu (2003), it is estimated that women accounted for 70 to 80% of household food production in Sub-Sahara region. In Burundi, women are engaged in a wide rang of agricultural activities and as men move to off-farm job opportunities or urban migration, women's importance to agriculture becomes unchallenging. Therefore, promoting education of women through adult alphabetization or free primary education has a great impact on agriculture sustainable development and as well as spillover effects to other sectors since women in Burundi play many roles at time: production, reproduction and community management.

The other determinant of optimal use of urea is the variable 'off-farm income'. Farmers with off-farm income had the cash to purchase urea and hire labor for fertilizer application. In the case of the irrigated rice in Gihanga, the income fetched in none agricultural activities served in purchasing fertilizers, particularly urea, to be applied in fields for private landlords and in extra piece of land owned by SRDI clients but not covered by the SRDI. Regarding to the impact of off-farm income on the technology adoption, Makokha *et al.* (2007) conveyed that the availability of this kind of income may either make more cash available for investing in the farm or influence the household to change their priorities and make investment in the farm not a priority. The mixed results of this variable have been reported by other authors (Rogers, 1995 and Abdulai and Hauffman, 2005). They indicated that the external sources of income provide means to invest in new technologies in order to improve resource quality and thus agricultural productivity.

8. CONCLUSIONS AN RECOMMENDATIONS

In this study, we were motivated to find out the production constraints and the socio-economic factors that dictated the degree of adoption of the highly yielding rice variety (variety V14) and the optimal use of the most used form of inorganic fertilizer (urea). The descriptive statistics indicated that the men were more than women in the survey since the many households are headed by men. The most striking results remain the poor extension service accessibility and the level of education. The analysis on determining the leading production constraints underscored that diseases and pests, and high price of productivity-enhancing inputs were the ones needed attention by the decision-makers in rice production. Besides, the logistic regression reveals that socio-economic factors like land size, dependency ratio, experience and membership in development organization or association impacted on the adoption of rice variety V14. While education of conjoint (woman), dependency ratio, experience and off-farm income were the determinants of the optimal use of urea in the study area.

We here suggested that the policy-makers, researchers and private promoters of rice production focus on the importance and impact that extension service has on the rice producers. In this realm, emphasis has to put not only on improving the quality of government extension service, but also on the cultural aspects that hinder the adoption of rice production technologies. Furthermore, the attempt to improve farmers' organization' s capacity to identify and source their own information may in time provide better support for further uptake of improved rice technology. Finally, the rice technology providers have to bank on the experience of rice producers and integrate the traditional knowhow of farmers on their program of extension service. More is needed to boost the level of education of farmers in the research area, especially that of women since we found that it promotes the adoption of rice technology.

Having gauged the performance and the determinants of technology adoption in rice production, further research is needed in the area of farmers' preference in the adoption of rice production technologies, efficiency of rice production and the impact of imported rice on the local one. The mentioned researchable areas may complete this current study.

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APPENDIX

Description and Sign Prediction of Variables in the Models

Variables	Meaning	Type of Measure	Expected Sign
Gender	Whether a farmer is male or female	B	Indeterminate: +/-
Age	Number of years	C	Indeterminate: +/-
Education conjoint	Education level of decision maker if she is a woman	C	+
Land size	Average of ares of land owned	C	Indeterminate: +/-
Dependency ratio	Ratio of number of children on that of adults in a household	C	+
Experience	Farming experience of producing rice	C	+
Membership	Whether a farmer is a member of any farm organization or not	B	+
Extension service	Whether a farmer had an access to extension service or not	B	+
Market access	Perception of market accessibility	D	+
Off-farm income	Whether a farmer had any off-farm income or not	B	Indeterminate: +/-

Note: B = Binary (two levels: 0 or 1), C = Continuous, D= Discrete (more than two levels).