# Farmers' Perceptions and Adoption of Improved Farming Techniques in Low-Land Rice Production in Northern Ghana

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**ABSTRACT**
At the Fourth Tokyo International Conference for African Development (TICAD IV) in 2008, Japan made a plan to double African rice production during the next ten years to help African countries to overcome their food insecurity problems, so-called Coalition for African Rice Development (CARD). Against this backdrop, the Japan International Research Centre for Agric science JIRCAS has started and commissioned research from Ministry of Agriculture, Forestry and Fisheries (MAFF) entitled "Improvement of soil fertility with use of indigenous resources in rice systems of Sub-Saharan Africa (SSA)". This study is part of a broader research project aimed at understanding the present situation of local practices by rice farmers in northern Ghana for soil fertility management, among others. The main objective was to find out the factors that influenced the adoption of improved farming techniques by rice farmers in the Northern and Upper East regions of Ghana in the 2009/10 farming season. Other objectives were to find out farmers perceptions about the use of local farm techniques and the qualities of a good soil. The method of analysis involved the estimation of a probit model (using proportions data) and some descriptive statistics. The sample size was 300 rice farmers who were also into the cultivation of food crops. The proportion of farm techniques adopted was greater for: experienced farmers; tenants, as opposed to those who owned the lands on which they farmed; those who received extension services and motivation; and those whose farms were closer to input stores. However household labour negatively influenced adoption. We also found that farmers had in-depth knowledge, not only about the qualities of a good soil, but also the importance of local farm techniques. With such an important pre-requisite to technology adoption, what is needed is the support to increase the quantity and quality of these techniques to make significant increases in the levels of output and income. There is the need for more extension work and motivation as well education on the misconception the farmers had about the fact that if they used organic manure in their rice fields they would turn upland.

**Keywords: Adoption, Farm Techniques, Northern Ghana, Perception, Probit Model,**

## LIST OF ABBREVIATIONS

| | |
|---|---|
| AFD | Agence Française de Dévelopement |
| CAADP | Comprehensive Africa Agriculture Development Programme |
| CARD | Coalition for African Rice Development |
| FAO | Food and Agriculture Organisation |
| FASDEP | Food and Agriculture Sector Development Policy |
| GPRS | Growth and Poverty Reduction Strategy |
| JIRCA | Japan International Research Centre for Agric science |
| LRDP | Lowland Rice Development Project |
| MAFF | Ministry of Agriculture, Forestry and Fisheries |
| MoFA | Ministry of Food and Agriculture |
| NDPC | National Development Planning Commission |
| NEPAD | New Partnership for Africa's Development |
| PSI | Poverty and Social Impact Analysis |
| SADA | Savannah Accelerated Development Authority |
| SSA | Sub-Saharan Africa |
| TICAD | Tokyo International Conference for African Development |

## INTRODUCTION

The majority of those suffering from chronic hunger live in Asia and Africa (Roetter et al, 2008). Roetter et al (2008) observe that even though in absolute terms there are more people suffering from acute hunger in Asia than in Africa, in percentage terms the figures are rising in Africa while they are falling in Asia. Roetter et al (2008) stress that in many parts of Africa yields as well as the productivity of land and labour are low. This is as a result of poor soils, low and erratic rainfall and high poverty levels. It has been argued that achieving the Millennium Development Goal (MDG) of halving the number of people living in abject poverty by 2015 will require agriculture to play a significant role because of the sector's importance in determining economic growth worldwide. It is against this background that the Government of Ghana has formulated the Growth and Poverty Reduction Strategy (GPRS) II to achieve accelerated and sustainable shared growth, among others (NDPC, 2005). In this document agriculture is expected to play a lead role in the country, especially in the north. Agricultural policy therefore includes measures such as crop area expansion and intensification through irrigation and dissemination of improved on-farm technologies (NDPC, 2005).

Subsistence mixed farming is the dominant form of Agriculture in northern Ghana. Crops grown include rice, maize, sorghum, millet, cowpea, groundnuts, soybean, yam, and cassava. Major constraints of agriculture in northern Ghana have been identified to include: poor and rapidly declining soil fertility; environmental degradation; high cost of farm inputs; and inadequate knowledge and use of improved farming techniques. Despite the constraints, northern Ghana has a high potential for rice and maize cultivation. At the moment paddy rice produced in northern Ghana accounts for a large part of national production. The Northern Region in particular possesses a great potential for rice cultivation, and lowlands represent the largest area, but are mostly unused. Official sources put the area of lowlands liable to flooding in the region at

400,000 hectares.

In December, 2002, the United Nations General Assembly at its 57th session recognizing that rice is the staple food for more than 50% of the world's population and re affirming the need to pay much attention to the potential role of rice in alleviating food insecurity problem declared the year 2004 the International Year of Rice (FAO, 2006). Ever since, FAO (2006) reports that global paddy production has been increasing (for example, in 2005, it reached a record high of 629 million tonnes). However, this was only enough to cover consumption. In the case of SSA, production continues to be outpaced by consumption, and therefore, the continent spends about 1 billion US Dollars annually on rice imports. In Ghana rice output is low compared with China, Vietnam and Thailand. For instance, in 2005 rice output in Ghana was only 142, 000 tonnes, representing just about 0.44% of that of Vietnam (FAO, 2006).

At the Fourth Tokyo International Conference for African Development (TICAD IV) in 2008, Japan made a plan to double African rice production during the next ten years to help African countries to overcome their food insecurity problems, so-called CARD. Against this backdrop CARD, JIRCAS has started and commissioned research from Ministry of Agriculture, Forestry and Fisheries (MAFF) entitled "Improvement of soil fertility with use of indigenous resources in rice systems of Sub-Saharan Africa (SSA)". This study is part of a broader research project aimed at understanding the present situation of local practices by rice farmers in northern Ghana for soil fertility management, among others.

The main objective of this study was to find out the factors that influence the adoption of improved farm techniques in the Northern and Upper East regions of Ghana. These techniques are improved seed varieties, chemical fertilizers, dibbing and sowing in rows. In addition, the study sought to find out:

1. Farmers' perception about the indicators of a fertile rice field;
2. Other local practices that farmers adopt to improve soil fertility; and
3. The profitability of the use of the chemical fertilizers.

**The Study Area**

Northern Ghana comprises three regions; Northern, Upper East and Upper West. These regions are bordered by Togo to the East, Cote d'Ivoire to the West, Burkina Faso to the North and Brong-Ahafo and Volta regions to the south. Compared to the south, the north is relatively dry with a single rainy season that begins in May and ends in October with an annual rainfall record varying between 750mm and 1050mm. The dry season starts in November and ends in March/April with maximum temperatures ranging between 40 $^0$C - 43$^0$C, occurring between March and April and minimum temperatures in December and January. However, from December to early February the southwest monsoons, also known as harmattan winds occur and these have a considerable effect on the temperature in the region, which may vary between 14$^0$C at night and 40$^0$C during the day. Humidity however, is very low. The main vegetation of the region is the savannah grassland, interspersed with the guinea savannah woodland and characterised by drought-resistant trees such as baobab, acacia, dawadawa, shea, mango and neem. The harsh climatic conditions of the regions are a limiting factor for the north to attract both material resources and human capital.

**Sampling Procedure**

The survey covered seven districts in the Upper East and Northern regions (these are the two major rice growing regions of northern Ghana). A total of 300 lowland rice farming households were randomly selected from thirty (30) communities for the survey. The communities were also selected through simple random sampling (lottery method). The survey was carried out in the 2009/10 farming season. The number of respondents selected in each district is indicated in Table 1 below.

**Table 1 Number of Respondents Segregated by District and Region**

| | **District** | **Region** | | **Total** |
|---|---|---|---|---|
| | | **Northern** | **Upper East** | |
| 1 | Bolgatanga Municipality | **-** | **30** | 30 |
| 2 | Central Gonja | 40 | - | 40 |
| 3 | East Gonja | 20 | - | 20 |
| 4 | Kasena-Nankana East | - | 30 | 30 |
| 5 | Savelugu -Nanton | 80 | - | 80 |
| 6 | Tamale Metropolis | 30 | - | 30 |
| 7 | Tolon- Kumbungu | 70 | - | 70 |
| | **TOTAL** | **240** | **60** | **300** |

## MATERIALS AND METHODS

### Theoretical framework

Adoption may be defined in simple terms as the extent of use of a new technology or innovation. Feder et al (1985, p.256) stress that "adoption takes place only in a long run equilibrium when the farmer has full information about the technology and its potential." The terms adoption and diffusion, though interrelated are different, in the sense adoption is when an individual makes use of an innovation, while diffusion means the spread of the innovation among a community or even globally (Feder et al. 1985).

Studies of adoption and diffusion behaviours were undertaken initially by rural sociologists (Feder et al., 1985). These studies provided the basis for economic studies. Such sociological studies included Ryan and Gross, (1943) and Rogers, (1962). In terms of Economics and for that matter Econometrics, the study by Mansfield (1961, 1966) on industrial innovation and that of Griliches (1957) on hybrid corn, offer a good starting point for examining the development in diffusion theory. However, what these studies had in common was that in most countries, diffusion was an S-shaped function of time. This was interpreted to mean that when a technology is first released, only a few agents adopt it. Then, for some reasons yet to be discussed, more agents adopt it increasing the rate of adoption. As time goes on, the number of potential adopters decreases, causing the rate of adoption to decrease. At this point, there is no increase in adoption. In most cases, the ceiling is reached before all the agents would have adopted. For those who choose not to adopt, there may be several reasons; they may not find the technology to be profitable, nor feasible or they might have found what they perceive to be more efficient than the technology in question. Thus the rate of technology adoption in the community or nation (rate of diffusion) initially increases and finally decreases, the curve looking like an S.

**The Probit Model**

Most of the adoption literature estimates a probit/logit model to find out the factors that affect the adoption of new technology or innovation (Feder et al, 1985). For instance, Foltz (2003) does not only give a theoretical explanation to the probit model, he summarises the factors explaining the rate of adoption/diffusion of a SWC technology under four hypotheses, namely resource scarcity, capital constraint, learning costs and risk aversion. According to Foltz, increasing scarcity of a natural-resource endowment (like fertile low land) leads to higher shadow prices for the resource, causing farmers to switch to a resource-conserving technology (like soil and water conservation technology). The capital constraint hypothesis also implies that new technologies would spread faster among farmers with better access to capital to pay for the new technology than farmers with little or no access. Furthermore, the learning-cost-hypothesis suggests that technologies will spread fastest in areas where information about the innovation is readily available and most easily evaluated by potential adopters. This means that farmers who have access to extension services, have better education (to be able to read and understand information about the technology), farmers who have the opportunity to attend useful workshops and take part in on-farm experimentation stand a better chance to adopt the technology than the less privileged ones. Lastly, risk aversion implies that farmers will not like to invest in unknown technologies because of uncertainties with respect to yield and for that matter income. Similarly, if a technology is expensive it becomes relatively more risky in the sense that farmers are not sure if they would be able to recoup the money invested into the technology. In this case the chances of adoption/diffusion would be slim. But if a new technology is risk-reducing in the sense that farmers are familiar with it or it is relatively cheap then farmers would readily adopt it other things being equal.

The dependent variable for an adoption model is dichotomous, and equals 1 if the *ith* household has adopted the technology at the specified time, and 0 otherwise. OLS estimation is inappropriate because the basic assumptions of normality and homoscedasticity of the error term are violated. Moreover, the computed probabilities may lie outside the 0-1 range (Greene, 2003). Probit and logit models are the most popular statistical methods developed to analyse dichotomous response dependent variables.

Let:

$$A_i^* = w_i^* \gamma + u_i \quad (1)$$

Where;

$A_i^*$ is the dependent variable.

$w_i$ is a $(1 \times k)$ vector of independent variables

$\gamma$ is a $(k \times 1)$ vector of parameters to be estimated and

$u_{1i}$ is the two sided error term with zero mean and constant variance.

In practice, $A_i^*$ is unobservable, what we observe is a dummy variable $A_i$ defined by $A_i = 1$ if $A_i^* > 0$ (household $i$ adopted the technology), and $A_i = 0$ if otherwise.

Thus, in this formula

$$\begin{aligned} prob(A_i = 1) &= prob(A_i > -w_i^{'}\gamma) \\ &= prob(u_i > -w_i^{'}\gamma) = 1 - F(-w_i^{'}\gamma) \end{aligned} \tag{2}$$

where $F$ is the cumulative distribution function of $u_i$

The likelihood function is

$$L = \prod_{A_i=0} F\left(-w_i^{'}\gamma\right) \prod_{A_i=1} \left[1 - F\left(-w_i^{'}\gamma\right)\right] \tag{3}$$

where $\Pi_{A=0}$ and $\Pi_{A=1}$ indicate multiplication over observations where $A = 0$ and $A = 1$ respectively.

If we assume that the cumulative distribution of $e_{1i_i}$ is normal we have the probit model:

$$F\left(-w_i^{'}\gamma' w_i\right) = \int_{-\infty}^{-w_i^{'}\gamma_i/\sigma} \frac{1}{(2\pi)^{1/2}} \exp\left(-\frac{t^{\,2}}{2}\right) dt \tag{4}$$

where $t$ is a standardized normal variable, i.e., $t \sim N(0,1)$. We estimate $\beta/\sigma$, and not $\beta$ and $\sigma$ separately. Hence we can assume $\sigma = 1$ to begin with.

Two types of data may be analyzed in binary choice models, namely, individual and group/proportional data. In the case of the former, measurement of the dependent variable is physically discrete, consisting of individual responses. In proportional data the underlying model is discrete but the observed dependent variable is a proportion. The use of proportional data in a probit framework has been explained by Green (2003).

In this study, the dependent variable is the proportion of improved farm techniques which ranges from zero to one. The adoption categories are: 0, if none of the techniques is adopted; 0.25, if only one technique is adopted; 0.50, if two of the techniques are adopted; 0.75, if three are adopted; and 1.00 (if all are adopted). The advantages of proportional data in a probit framework over a normal probit model in this way are (I) we have a continuous, as opposed to a discrete (zero, one) dependent variable. In this case we are able to cater for partial adopters and (II) since the dependent variable is observed the coefficients of the variables are useful in that they measure the direct effects of the explanatory variables on the dependent variable.

### The Chi-Square ( $\chi^2$ )

The most popular diagnostic test in such cases is the $\chi^2$ statistic (which is like the F-test) defined based on a likelihood ratio formulation as:

$$\chi^2_{(n)} = -2\ln\frac{L_R}{L_U} = -2(\ln L_R - \ln L_U) \qquad (5)$$

where $L_R$ and $L_U$ are the restricted and the unrestricted likelihood function, respectively.

The restricted log-likelihood function is obtained when equation 1 is estimated with the restrictions that the slope parameters are all equal to zero and unrestricted because *a priori* there are no restrictions put on the parameters. This implies that in the case of the former, only the intercept term is estimated while the latter involves the intercept as well as the slope parameters. Like the log likelihood ratio test in general, the basic idea behind the above test is that if the *a priori* restriction is valid, the log-likelihood function of the restricted and unrestricted equations should not be different in which case the test statistic $\chi^2$ (or $\lambda$ in the case of generalised likelihood test) will be zero. But if that is not the case the two likelihood functions will divert. Thus we can test the extent of divergence between the restricted and unrestricted likelihood functions at 1 or 5 percent significant levels.

### The Empirical Model

The dependent variable is adoption, ranging from non-adoption to full adoption. Four main soil fertility management practices were identified as: adoption of any chemical fertilizer; adoption of improved varieties of rice seeds; dibbling; and sowing in rows. Following from the theoretical model in equation 7, the empirical model is defined as:

$$y_i = \beta_0 + \beta_1 Extension + \beta_2 Landownship + \beta_3 HHlabour + \beta_4 Motivation + \beta_5 Experience + \beta_6 InputDist + u_i \qquad (6)$$

Where;

$\boldsymbol{y = 0}$ if a farmer failed to adopt any of the four categories of the farming practices during the farming season under review;

$y = 0.25$ if a farmer adopted any one of the four categories of the farm techniques;

$y = 0.50$ if a farmer adopted any two of the four categories of the farm techniques;

$y = 0.75$ if a farmer adopted any three of the four categories of the farm techniques; and

$y = 1$ if a farmer adopted all the four categories of the farm techniques.

## RESULTS AND DISCUSSION

### Demographic indicators

For the purpose of this survey, a household is defined as a group of people who constitute a production and consumption unit within a compound. They are usually bound together in production by the household farm and in consumption by usually taking at least one meal a day from a common source. It needs also to be mentioned that the farmers in the study area were into the cultivation of other crops such as maize, sorghum, millet, cowpea, groundnuts, soybean, yam, and cassava. These were cultivated on uplands. However, in this particular study we are concerned about the cultivation of rice in low-land areas. The average household size in the study area was 8.4. The figure for the Northern Region (8.7) was relatively high compared with that of the Upper East Region (7.1) The 2000 Ghana Population and Housing Census results put the average household size in Ghana in the range of 4.3 and 11.2**.**

In terms of age, 67.7% of household members were within the ages of 11-60 years; this indicates the abundance of active labor force for agricultural and other related purposes. A large majority (67.1% and 85.0% for adult males and adult females respectively) had not had any formal education. Comparatively, a greater percentage (26%) of women in the Upper East region had received formal education as compared to the northern region where only 12.6% had been to school. Also, while 3.7% of males had had some tertiary education, only about 1% of females had made it to the tertiary level, suggesting that the Senior High School may be the terminal point for the very few females that ever had opportunity to be in school. The low levels of educational achievements among household members in the area mean that a lot of education would be required in extending modern farm techniques to the farmers. All the farmers were males but as the study was at the household level it implies that the other members of the household were involved in the farming activities.

**Farmers' View of a Fertile Rice Field**

One of the objectives of this study was to find out farmers' views about indicators of a fertile rice field. The key indicators of a fertile rice field from the farmers' experience included: the presence of green weeds (42.0%); the presence of humus, that is the soil should be dark in colour (28.0%); ability of the field to retain water (16.0%); and the presence of soil organisms, for example, earthworms (5.7%). Table 2 gives the details of the farmers' views on the indicators of a fertile field. From the answers given, it is clear that the farmers in the study area are knowledgeable with respect to the qualities of a good soil.

**Table 2 Farmers' views on the indicators of a Fertile Rice Field**

| **Soil Fertility Indicator** | **Northern Region** | | **Upper East Region** | | **Pooled** | |
|---|---|---|---|---|---|---|
| | **Freq.** | **%** | **Freq.** | **%** | **Freq.** | **%** |
| Water logged and soft | 43 | 17.9 | 5 | 8.3 | 48 | 16.0 |
| Dark soil colour/Humus present | 40 | 16.7 | 46 | 76.7 | 86 | 28.7 |
| Presence of green weeds/Tree/Shrubs | 125 | 52.1 | 1 | 1.7 | 126 | 42.0 |
| Presence of soil organisms ( e.g. : earthworms, mud fish ) | 17 | 7.1 | 0 | 0.0 | 17 | 5.7 |
| Good yield | 0 | 0.0 | 3 | 5.0 | 3 | 1.0 |
| Fast crop growth | 1 | 0.4 | 5 | 8.3 | 6 | 2.0 |
| Good water retainability | 1 | 0.4 | 0 | 0.0 | 1 | 0.3 |
| Green substances on soil surface | 5 | 2.1 | 0 | 0.0 | 5 | 1.7 |
| Others | 8 | 3.3 | 0 | 0.0 | 8 | 2.7 |
| Total | 240 | 100.0 | | 100.0 | 300 | 100.0 |

**Local Practices Adopted by Farmers to Improve Soil Fertility**

The study also sought to find out the local practices that farmers adopted to improve upon the fertility of their farm plots, considering the fact that the soils in the study area are generally poor. The results show that 130 out of the 300 rice farmers interviewed did not rely on any local practice to improve fertility. The remaining 170 mentioned various local practices adopted to improve fertility. The commonest practice was the use of crop residue (17.7%), combination of animal droppings and crop residue (16.3%), and only animal droppings (15.0%). The other measures were land fallowing, mixed cropping, and crop rotation adapted.

One of the most important discoveries in this study however was the fact that the farmers applied most of these local practices on their upland fields where the other crops were grown, and not on their rice fields, for fear that if organic fertilizer, for instance was applied to the lowland valleys, they would gradually become upland. There is the need for immediate education on this to allay the fears of the farmers.

**Table 3 Local Practices Adopted to Improve Soil Fertility**

| **Local Practices** | **Northern Region** | | **Upper East Region** | | **Both Regions** | |
|---|---|---|---|---|---|---|
| | **Freq.** | **%** | **Freq.** | **%** | **Freq.** | **%** |
| None | 130 | 54.2 | 0 | 0.0 | 130 | 43.3 |
| Animal droppings | 5 | 2.1 | 40 | 66.7 | 45 | 15.0 |
| Crop residue | 37 | 15.4 | 16 | 26.7 | 53 | 17.7 |
| Animal droppings/ Crop residue | 48 | 20.0 | 1 | 1.7 | 49 | 16.3 |
| Crop rotation | 1 | 0.4 | 0 | 0.0 | 1 | 0.3 |
| Mixed cropping | 1 | 0.4 | 0 | 0.0 | 1 | 0.3 |
| Fallow | 1 | 0.4 | 0 | 0.0 | 1 | 0.3 |
| Shifting cultivation | 1 | 0.4 | 0 | 0.0 | 1 | 0.3 |
| Other | 16 | 6.7 | 3 | 5.0 | 19 | 6.3 |
| Total | 240 | 0.0 | 60 | 100 | 300 | 100.0 |

**Reasons for the adoption of the local practices**

When the farmers using organic materials to improve soil fertility were asked to explain why they use such materials, various reasons were given. About 58 % mentioned that organic matter increases the fertility of the soil and for that matter crop yields. Also, 11.2% said they chose local organic materials because they were cheaper and available in their communities. The reasons for adopting the local practices are given in Table 4 below.

Again, from the reasons given, it is clear that the farmers appreciated the importance of organic matter in improving soil fertility. However, the view held by most farmers that organic matter causes lowlands to become upland could be a threat to a project that aims to encourage famers to use local organic materials to improve their rice fields.

**Table 4 Major Reasons for Use of Local Practices**

| Reason for Choice of Local practices for Soil Improvement | Northern Region | | Upper East Region | | Both Regions | |
|---|---|---|---|---|---|---|
| | Freq. | % | Freq. | % | Freq. | % |
| Increase soil Fertility /High yield | 76 | 69.1 | 23 | 38.3 | 99 | 58.2 |
| Easy Farming/Easy to use | 1 | 0.9 | 1 | 1.7 | 2 | 1.2 |
| Low cost of production | 1 | 0.9 | 18 | 30.0 | 19 | 11.2 |
| Improves Water Holding Capacity | 4 | 3.6 | 2 | 3.3 | 6 | 3.5 |
| Good/Improve Fast crop Growth | 3 | 2.7 | 6 | 10.0 | 9 | 5.3 |
| No side effects to the field | 1 | 0.9 | **0** | 0.0 | 1 | 0.6 |
| Reduce presence of weeds | 4 | 3.6 | **0** | 0.0 | 4 | 2.4 |
| Prevents erosion | 0 | 0.0 | 1 | 1.7 | 1 | 0.6 |
| Others | 20 | 18.2 | 9 | 15.0 | 29 | 17.1 |
| Total | 110 | 100.0 | 60 | 100.0 | 170 | 100.0 |

Exchange rate in 2009/10 was approximately $1=Gh Cedis 1.50.

**Chemical fertilizer use**

Despite the poor soil fertility conditions in the study area, application of chemical fertilizers by the rice farmers to improve and/or maintain soil fertility is low. As shown in Table 5, only 32.3%, 44.30%, 44.6 and 3.0 % of the respondents applied Urea, Sulphate of Ammonia, NPK (15-15-15) and NPK (20-20-20) respectively to their fields in the 2009 cropping season. Also, even among the farmers that used chemical fertilizers, very small quantities (15.85kg, 23.45kg, 25.95 kg, and 1.2kgs of Urea, Sulphate of ammonia, NPK (15-15-15), and NPK (20-20-20), respectively) were applied. During a Lowland Rice Development Project (implemented in the northern region between 1999-2003 and funded by the Agence Française de Développement (AFD) with the objective of improving the production, processing and marketing of rice, originating with small-scale farmers), the recommended fertilizer use for an acre (0.4ha) was 80kg of NPK 15-15-15 to be mixed with 40 kg of NPK 20-20-0 to give a combination of 50N-50P-30K per acre for farmers that dibbled. For farmers that adopted the broadcast method of planting and therefore had to broadcast the fertilizer, 60kg NPK15-15-15 mixed with 20 kg NPK 20-20-0 was recommended, and for top dressing, 40kg urea was recommended for an acre. Clearly, the levels of usage are far below the recommended levels. The implication is that there is considerable nutrient mining, which can lead to serious soil nutrient depletion and hence land degradation.

**Table 5 Chemical Fertilizer Use on Rice**

| Description | Northern Region | | Upper East Region | | Both Regions | |
|---|---|---|---|---|---|---|
| | % of farmers | qty./Acre in KG | % of farmers | qty./Acre in KG | % of farmers | qty./Acre in KG |
| None (use no fertilizer) | 30.0 | - | 11.7 | - | 26.3 | - |
| Use Urea | 33.3 | 11.0 | 28.3 | 35.0 | 32.3 | 15.85 |

| | | | | | | |
|---|---|---|---|---|---|---|
| Use Sulphate of Ammonia | 37.1 | 15.75 | 76.0 | 54.4 | 44.3 | 23.45 |
| Use NPK 15-15-15 | 42.1 | 20.3 | 63.3 | 48.45 | 45.6 | 25.95 |
| Use NPK 20-20-20 | 3.8 | 1.5 | 0.00 | 0.0 | 3.0 | 1.2 |

**Profitability Estimates of rice production**

This section seeks to find out the profitability with respect to the adoption or non-adoption of chemical fertilizers. Chemical fertilizers have been considered because of their relatively high price as compared to the organic fertilizers. The analysis is spelt out in Table 6 below.

The average cost (excluding cost of family labor) of production per acre for the 2009/10 cropping season was GH¢ 52.83, and GH¢ 103.57 for farmers who did not use any chemical fertilizer and those that used some chemical fertilizer respectively. Average yields reported were relatively high for those that used some fertilizer compared with those that did not.

Gross returns per acre were GH¢ 241.17, and GH¢ 301.43 for those that used some fertilizer compared with those that did not use any respectively. The net returns, after adjusting for the value of family labor gave an average of GH¢ 189.57and GH¢ 248.50 for adopters and non-adopters respectively. Thus, the difference in net returns is GH¢ 58.93, which is about 31% of the net returns for non-adopters. Clearly, the difference is quite significant, but the fact remains that generally profits are very marginal and are not encouraging enough for farmers to stay in production. The situation is worse in the likely event of a drastic fall, given the high levels of rice importation and the level of dumping of rice into the country in recent times.

**Table 6 Profitability Estimates of rice production**

| ITEM | Without chemical fertilizer GH Cedis/Acre | With chemical fertilizer GH Cedis/Acre |
|---|---|---|
| Land prep (tractor hire) | 21.00 | 21.00 |
| Seed | 10.38 | 10.38 |
| Cost of hired labour | 5.86 | 5.86 |
| Cost of herbicides | 4.78 | 7.22 |
| Cost of chemical fertilizer | 0 | 47.50 |
| Other costs | 10.81 | 11.61 |
| Total cost excluding cost of family labour | 52.83 | 103.57 |
| Yield (Output/acre) | 9.8 | 13.5 |
| Price per bag | 30.00 | 30.00 |
| Revenue | 294.00 | 405.00 |
| Gross returns | 241.17 | 301.43 |
| Family labour (no. of man-days) | 34.43 | 35.27 |
| Value of family labour | 51.6 | 52.9 |
| Net returns in Gh. Cedis | 198.57 | 248.5 |

**The Determinants of Adoption**

The main objective of this study was to find out the factors that influence the adoption of improved farm techniques in the Northern and Upper East regions of Ghana. These techniques are improved seed varieties, chemical fertilizers, dibbling and sowing in rows. It must be recalled that the dependent variable of the adoption model (proportion of the improved techniques that were adopted in the 2009/10 farming season) is observed and not latent, therefore the coefficients of the variables are useful, in that they measure the direct effects of the explanatory variables on the dependent variable. The marginal effects are however, also given. Table 7 below presents the results of the estimated adoption equation 6 above.

It is observed that all the variables are significant, some of them maintaining their expected signs. The chi-squared value is also significant at 1%, implying that all the variables jointly determine the dependent variable. The results compares with other similar studies (Baidoo-Forson, 1999; Doss and Morris, 2001; Ransom et al., 2003), especially Donkoh and Awuni (2011) which uses the ordered probit model on the same data. However, in Donkoh and Awuni (2011) while household labour and motivation were insignificant, and therefore were excluded in the model, the variables were significant in the present study. On the contrary, in the previous study farm size and training were significant in determining adoption but they were insignificant in the present study and therefore were excluded in the model.

The significance of extension services in determining the adoption of farming techniques has been discussed in many studies (Baidoo-Forson, 1999; Doss and Morris, 2001; Ransom et al., 2003). Frequent contacts with extension staff give the farmer the opportunity to learn about the availability and use of new farming techniques. The problems with the extension delivery system in Ghana, like in many other developing countries are that the staff are woefully inadequate and are not properly motivated. Staff from NGOs are better motivated but they are not enough to make up for the deficiency. Could national service personnel with agricultural background fill the vacuum? As we know, the services of many national service Personnel are under-utilized because of the places they are sent; in some instances they are not even needed. HND and BSc degree holders with agricultural background would not only fill the vacuum but can give better services than the present extension staff, who are certificate and diploma holders.

Similarly, it may be necessary for extension delivery in Ghana to be privatized to bring more private organizations on board. The question however, is whether the government has the political will and whether farmers would be able to pay for the services, considering the fact that over 92% of them are small-scale (MoFA, 2007). Apart from staff, one other way by which the extension delivery system can be improved is the use of more extension methods. The mass media is one of such important methods. Currently in Ghana, the proliferation of the airwaves is one phenomenon that can be taken advantage of to increase access to extension services to farmers at relatively cheap cost. The state media are doing quite well in this area, but more can be done! Besides, the government can bring the private media houses also on board as part of their social responsibilities. One other important area that can be developed is the nucleus-farmer-out grower scheme, where, services (including extension services) are channeled through a large-scale farmer who has influence over a group of small-scale farmers.

Like the extension variable, experience had a positive and significant determinant on adoption, which implies that long years of farming also played a significant role in the adoption of the improved farm techniques in the study area. Ransom et al (2003), who made similar findings, have argued that other things being equal, long years of farming are associated with being familiar with technologies; such that when new technologies are introduced, experienced farmers tend to adopt them faster than less experienced farmers. They stress that farmers who have more experience with technologies in general are more likely to test and adopt improved varieties. Experienced farmers in the study area can be identified to mentor the less experienced farmers in the nucleus-farmer-out grower scheme and influence them to adopt modern farm techniques.

The adoption of farm techniques was also greater for farmers who were motivated by the prospects of the improved farm techniques as opposed to those were not. The motivation mainly came from fellow farmers and the increased yields they realized on their previous fields, which underscores the important role that positive peer-pressure can play in the adoption of farm techniques in the study area.

The negative sign of the land ownership variables is contrary to our *a priori* expectations, considering the notion that when farmers own their plots, they would be willing to develop it by adopting new technologies. In this study, the negative sign implies that rather, tenants were the ones adopting a greater proportion of the farm techniques. There is a school of thought that it is when the techniques are long-term or permanent that owners of farm plots have greater probability of adoption. In this study, the farm techniques (improved varieties, chemical fertilizers, dibbling and sowing in rows) are short term, and tenants did not find problems adopting them on their fields. In Damisa and Yohanna (2007), contrary to our findings, landless women did not make significant participation in farm management decision-making. They stressed that since landless women undertook farming on leased land, they could not take major decisions that had to do with the lands without the owners' consent. Household labour, was another variable whose sign did not meet our *a priori* expectations. Considering the fact that most of the farm techniques in question were labour- intensive, we anticipated that adoption was going to be greater among farmers with a greater supply of household labour. In Donkoh et al (2006) household labour was a significant determinant of the adoption of Green revolution technologies in Ghana. However, the negative sign implies that such farmers adopted smaller proportion of the farm techniques. Perhaps, farmers relied more on hired labour rather than household labour. Mugwe et al (2007) found that farmers' ability to hire labour positively influenced adoption of integrated soil fertility management practices in Kenya. Similar studies that report significant positive effects of hired labour on adoption are Keil et al (2005) and Okuro et al (2002). However, in Ransom et al (2003), hired labour had a negative significant effect on the adoption of improved varieties.

Lastly, the closer an input store was to the farmer's field the greater the adoption of the input sold. This is also consistent with Hintze et al. (2003) in which road quality was significant in influencing the adoption of improved maize variety. In general Ransom (2003) also found the adoption of improved maize varieties to be higher in more accessible districts in Nepal. As strategized in FASDEP II it is important that input stores are established in at least all districts in the country to facilitate the adoption of inputs. It must be noted that already, farmers find most inputs, especially chemical fertilizers expensive and so if they have to transport the inputs from a far place and incur extra costs, given the poor road network, they may feel reluctant.

**Table 7 Maximum Likelihood Estimates for Parameters of the Probit Adoption Model**

| Variable | Parameter | Coefficient | Standard Error | T-Ratio | P-value | Marginal Effects |
|---|---|---|---|---|---|---|
| Constant | $\gamma_0$ | 0.22 | 0.30 | 0.74 | 0.46 | 0.09 |
| Extension | $\gamma_1$ | 0.06 | 0.03 | 2.04 | 0.04** | 0.02 |
| Land own'ship | $\gamma_2$ | -0.36 | 0.17 | -2.16 | 0.03** | -0.14 |
| HH labour | $\gamma_3$ | -0.26 | 0.12 | -2.15 | 0.03** | -0.14 |
| Motivation | $\gamma_4$ | 0.52 | 0.25 | 2.09 | 0.04** | -0.10 |
| Experience | $\gamma_5$ | 0.22 | 0.11 | 2.00 | 0.05** | 0.21 |
| Input Dist | $\gamma_6$ | -0.16 | 0.09 | -1.68 | 0.09* | 0.09 |
| - | $\chi^2$ | 29.89 | - | - | 0.00*** | - |

***, significant at 1% ** significant at 5% * significant at 10%

Note: Dependent variable: Proportion of farming techniques adopted. No. of observation= 300. Degrees of freedom=6. Log likelihood function and restricted log likelihood are -192.23 and -207.17 respectively. Marginal effects are computed at the means of the independent variables.

## FINAL CONCLUSIONS AND RECOMMENDATIONS

Based on the above findings the following conclusions and recommendations are made:

1. Farmers' had in-depth knowledge, not only about the qualities of a good soil, but also the importance of local farm techniques. With such an important pre-requisite to technology adoption, what is needed is the support to increase the quantity and quality of these techniques to make significant increases in the levels of output and income. They also need to be 'educated' on the misconception they have that if they use organic manure in their rice fields they would become upland;

2. With the right support and measures put in place to increase the quantity and quality of the local inputs, they would serve as a better alternative to chemical fertilizers, which are still expensive for most of the farmers, despite the re-introduction of subsidies, and often do not come at the right time. However, in the interim, any support to increase the adoption of chemical fertilizers would be in the right direction, considering the relatively high profit in using them;

3. Similar to point 2, the farmers have considerable experience in rice farming. The majority has a long history of rice cultivation of between10 and 50 years. Any intervention aimed at promoting rice cultivation in the area may not be entirely new to the farmers;

4. The area possesses a great potential for rice cultivation, lowlands represent the largest area under rice cultivation. They have the high potential for rice production due to their hydrological characteristics such as high water retention capacity.

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