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Socio-economic Determinants for the Adoption of Improved Rice Varieties in the Tarai Region of Nepal

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Abstract

Rice is the most important cereal crop of Nepal from food security and livelihood perspectives. In spite of this, the yield of this crop is quite low and there is wide gap between potential and national average yield. One of the reasons behind it is poor adoption of improved rice varieties in the farming communities. In this article, we analyzed the influence of socio-economic variables on the adoption of these varieties. The data for the study were collected from 180 households spreading across three tarai districts: Siraha, Chitwan and Kailali of Nepal from October to November 2011. A binary logistic regression was employed to analyze the data, and the adoption of improved varieties was defined from the perspective of whether farmers buy seed from the market or not. The result shows that in 72.7% of cases farmers adopt improved variety, and these varieties consist of both modern varieties and farmers' varieties. Farmers' behavior in adopting these varieties is mainly explained by irrigation facility, household's membership in community-based organizations (CBOs), and seed price. The findings from this research might have implications in the agriculture extension policy of Nepal and other developing countries.

1. Introduction

Increased farmers' access to seeds of improved crop varieties is considered the most efficient approach to contribute in the food security and livelihoods of rural people in the developing countries (Almekinders, Louwaars and Bruijin, 1994). After the green revolution of 1960s, a diverse range of rice varieties with respect to yield, and other traits such as resistance/tolerance to biotic and abiotic stresses have been developed and formally released in the developing countries including Nepal to address these issues. The government statistics of Nepal shows that the adoption of improved varieties is over 80% but poor seed replacement rate (SRR)[1] is a concern. The SSR of rice in Nepal is 9.2% which means that 9.2% of the total rice area is planted with early generation seed (such as foundation and improved categories of seed) of existing rice varieties annually, and this figure is quite below than the recommended SRR (25%) (Seed Quality Control Center - SQCC, 2011). The major reason behind emphasizing for changing the early generation seed is that if farmers grow late generation seed, the variety is likely to be more susceptible to diseases, and ultimately it reduces the crop yield and efficiency of other production inputs. It means farmers could not realize the potential benefits of rice varieties unless and until they grow the early generation seed regardless of the varieties in question. So, it is the interest of researchers and policy makers to analyze the seed replacement situation and find out the factors accelerating/hampering for replacing the seed at farmers' level. There are very limited studies in this issue (Joshi and Bauer, 2006; Paudel, 2011; Kafle, Paudel and Ghimire, 2012), and the available studies only focus on modern varieties (those developed by agricultural research organizations) neglecting the varieties being developed through farmers' own innovations. In those studies farmers were categorized as adopters if they had been able to spell the name of the varieties they were growing regardless of the generations of seed they used. But it is unlikely to get the precise result of adoption just asking the name of varieties to the farmers considering their poor education, handling of diversified rice varieties, and flow of seed mainly through informal channels.

In this article we analyze the farmers' behavior in adopting the improved rice varieties using market-based instrument i.e. 'whether farmers buy seed from the market or not'. This article is organized as follows. The next section deals with the context of the study. In the third section, we will discuss about the conceptual framework for the study, and it is followed by methodology. The section five presents the results and discussion, and the sixth section will conclude the whole paper.

2. The context

Rice is the most important cereal crop of Nepal in terms of both food security and livelihood perspectives. This crop shares 51% of the total cereal crop production in Nepal, and contributes 20% to agriculture gross domestic product (GDP). Moreover, rice farming serves as an important source of employment in Nepal as about 70% of the people are engaged in it at least for five month in a year. Rice is grown from tarai (from 60m ams[i]) to mountain (up to 3050m amsl- the highest rice growing altitude in the world) in Nepal (Paudel, 2011). In 2011, this crop was grown in 1.49 million ha and the tarai region shared 69.6% to the total rice area, and 72.1% to the total rice production in the country. In spite of the great significance of rice in the national economy the average yield of rice in the country is quite low (2.9t ha^{-1}) than that of the neighboring countries such as India (3.5t ha^{-1}), Bangladesh (4.2t ha^{-1}) and China (6.6t ha^{-1}) (FAOSTAT, 2012). There is huge gap (>50%) between the national average yield and potential yield of rice in the country (Ministry of Agriculture and Cooperative –MoAC, 2010). One of the reasons behind it is the poor adoption of improved seeds varieties in the farming communities. To address this yield gap government and non-government organizations (NGOs) are implementing various research and development programs. For example, Nepal Agriculture Research Council (NARC) with the mandate of developing farmers' preferred crop varieties in Nepal working in this area, and until 2011 the total of 67 modern rice varieties (including 47 for the tarai region) has been released (NARC, 2011). Similarly, community empowerment, biodiversity management and action research initiatives implemented by NGOs are the other examples (Gauchan, Smale and Chaudhary, 2005; Rana et al., 2007).

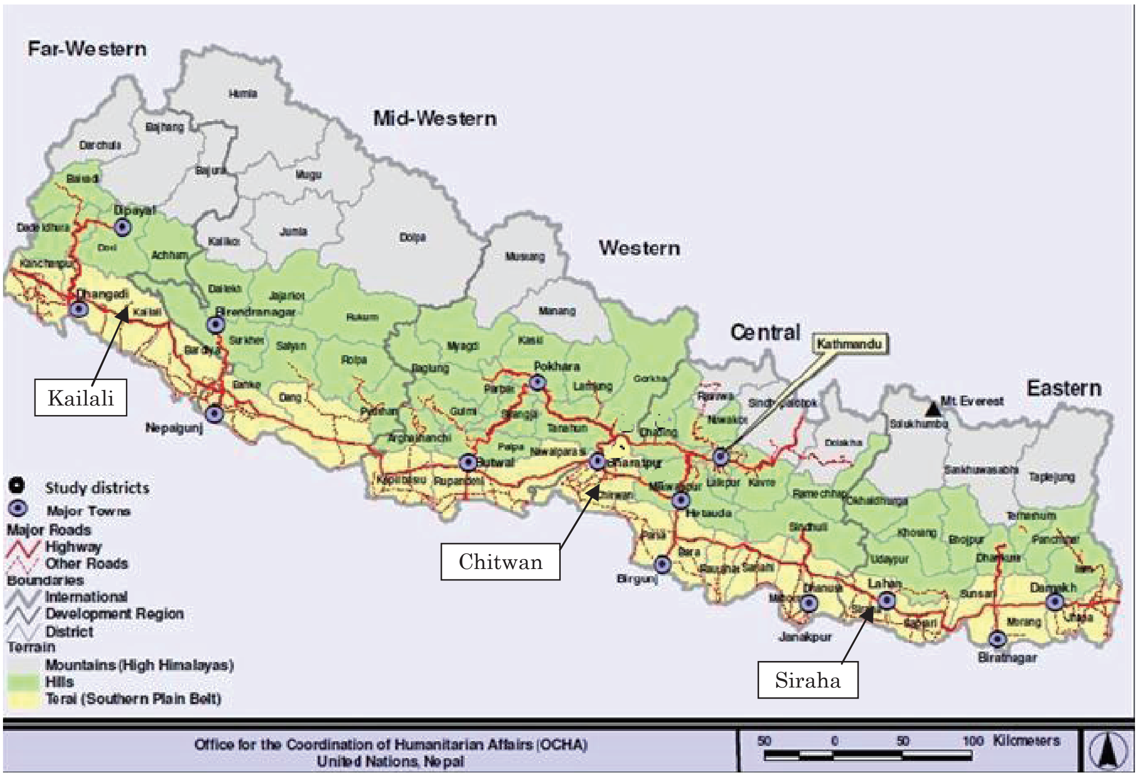
3. Conceptual framework

Agricultural scientists consider improved rice varieties for modern rice varieties, and 'improved seed' for seeds of those varieties maintaining certain standard of seed quality verified by the formal/government agencies (Almekinders, Louwaars and Bruijin, 1994). This concept of defining improved varieties might be different from that of farmers' perspective. It is because farmers intend to diversify the crop varieties combining modern varieties with others evolved from their own innovations to meet their diversified needs, and to averse the risk situation (Joshi, Sthapit and Witcombe, 2001; Gauchan, Smale and Chaudhary, 2005; Joshi and Bauer, 2006). Whatever the sources of origin, farmers tend to change the seed of the existing varieties or purchase new variety that give economic incentive to them. Again, farmers could experience economic gain from rice varieties in various ways first by increasing in yield and/or byproduct. Moreover, variation in socio-economic and geophysical situations of farmers makes it more complicated to analyze such benefit. Secondly, some rice varieties (such as early maturing varieties) might not be profitable to the farmers in terms of their yield or byproducts directly, but farmers grow them looking at the total benefits they realize while growing these varieties from the whole cropping system. For example, growing early generation rice varieties might facilitate the farmers to increase cropping intensity by allowing them to integrate short duration crops such as vegetable. Moreover, farmers as the profit maximizing entity intend to be more efficient in the production process considering externalities (such as market, price, weather and so on). It means they continuously tend to innovate appropriate crop varieties and technologies to be more efficient in the production. All these situations make it difficult to model the household's behavior to buy the seed directly. Rather it could be done from the perspective that farmers develop some perception towards the variety by analyzing the potential benefits/cost while adopting the varieties in the cropping system and decide for their adoption. It can be further discussed with the help of Rogor's (1995) diffusion theory which explains that adopters go through the five stages (awareness, persuasion, decision to adopt/test, implementation and feedback) in the adoption/diffusion process and develop perception towards the varieties. The perception is influenced by various factors such as demographic, economic, social and institutional (Gauchan, Smale and Chaudhary, 2005; Joshi and Bauer, 2006; Tiwari et al., 2008). This concept address the farmers' motivation to buy both modern and farmers' varieties as improved rice varieties are defined from the perspective of whether farmers buy these varieties from the market or not (Paudel and Matsuoka, 2008).

4. Methodology

4.1 Study area

The study was carried out in three tarai districts: Siraha, Chitwan and Kailali of Nepal representing Eastern, Central and Far-western development regions (Figure 1). Rice is the major food crop in these districts which is mainly grown as a main season crop during rainy season (planting in June/July and harvesting in October/November). In 2009/10, this crop was grown in 63,000, 29,605 and 58,500 ha with yield level of 1.7t ha^{-1}, 2.8t ha^{-1} and 2.5t ha^{-1} in Siraha, Chitwan and Kailali, respectively. Chitwan is centrally located district with better infrastructure (such as road network and irrigation facility) and extension facility compared to other two districts. There is increasing trend of monsoon rainfall in this district. In contrast to this, Siraha is drought prone district, whereas Kailali is flood-affected district (Ministry of Environment-MoE, 2010). It is hypothesized that selecting these districts this study represent the whole tarai region of Nepal. The surveyed Village Development Committees (VDCs) in the selected districts include: Jagatpur, Mangalpur, Gitanagar and Birendranagar VDCs (Chitwan district); Hakpada, Sisbani, Mahadevparoha and Betauna (Siraha); and Gardaiya, Joshipur, Durgauli and Udasipur (Kailali). The location of these VDCs is also presented in Figure 1.



Source: http://www.un.org.np/resources/maps

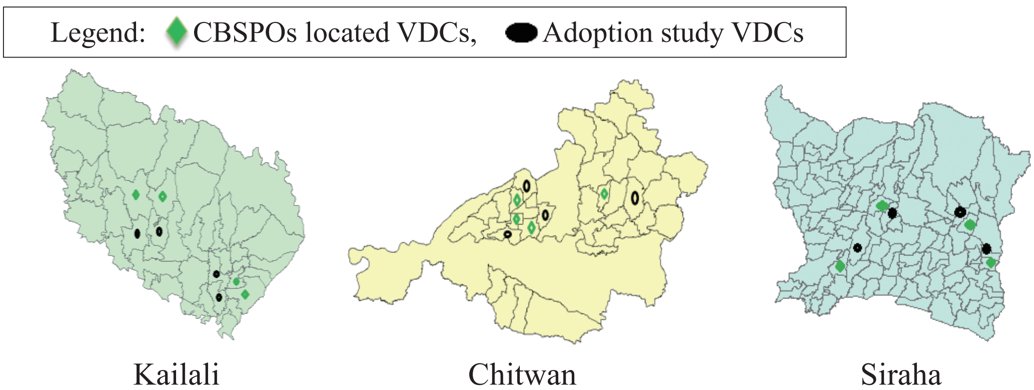


Figure 1. The map of Nepal showing the location of study districts, and survey VDCs

4.2 Sampling technique

The study uses multistage random sampling technique for selecting the study households. The districts were selected purposively to represent the geographical coverage. In each district, four VDCs were purposively selected considering the non-existence of commercial seed production program (such as existence of community-based seed producer organizations – CBSPOs). One ward (out of nine wards) from each VDC was randomly selected for the study. After selecting the ward, using the list of rice growing households inhabiting in the ward, 15 households were randomly selected for household survey. So, the total number of farmers (respondents) for household survey was 180. The survey was carried out using semi-structured questionnaire tested in the households not involved in the survey. One group discussion in each ward was organized after the completion of household survey to complement the information gathered through household survey.

4.3 Empirical model

In this study, we used binary logistic model (BLM) to see the influence of socio-economic variables in the adoption of improved rice varieties. Since the dependent variable is binary (i.e. 1 if farmers buy rice seed from the market and 0 for otherwise), binary logistic model is quite suited for the analysis. Although Ordinary Least Square (OLS) can be used to analyze binary choice model, certain assumption of classical regression are violated. These include non-normality and heteroscedastic error, and questionable R^2 as a measure of goodness of fit (Gujarati, 2004). Logit and probit models have been developed to address these issues; however, logit model is preferred if the choice variables are mutually exclusive with each other (Long and Freese, 2006). Previous researchers (Joshi and Bauer, 2006; Paudel and Matsuoka, 2008) were also adopted BLM to analyze the adoption of improved varieties. Theoretically the BLM is given as follows (Agresti, 1996):

$$\text{Ln}\,(P_x/(1-P_x)) = \beta_0 + \beta_1 X_{1i} + \beta_2 X_2 i + \ldots\ldots\ \beta_k X_{ki} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1).$$

Where, Ln is log, i is the i^{th} observation in the sample, P_x is the probability of farmers buying seed from the market in consideration of the given explanatory variables ($X_{i,}$) and ($1-P_x$) is the probability of non-adoption. β_0 is the coefficient of intercept and $\beta_{1,}\ \beta_{2\ldots\ldots}\ \beta_k$ are parameters to be estimated, and k indicates the types of explanatory variables. Since the binary logistic model is estimated through maximum likelihood method, the coefficients of the model do not show the average response of independent variables on probability of adopting improved varieties. So, we estimated marginal effect[4] of independent variables on the probability of adopting improved rice varieties after estimating the binary logistic model (Sheikh, Rehman and Yates, 2003). The marginal effect values are used to discuss the influence of explanatory variables in the probability of adopting improved rice varieties.

4.4 Specification of the model and variables

With reference to the theoretical model given in equation 1, the model used in the study is specified as below.

$Y = \beta_0 + \beta_0 + \beta_1$ ln age of HHH + β_2 ln education of HHH + β_3 ln family labor + β_4 ln off-farm income + β_5 ln operational land + β_6 ln livestock + β_7 ln chemical fertilizer + β_8 irrigation dummy + β_9 CBO dummy + β_{10} ln seed price + β_{11} Chitwan dummy ....(2).

Here, Y represents the binary dependent variable (0, 1), ln is the logarithm, and β is the parameter to be estimated. We selected explanatory variables considering adoption theory, previously carried out studies and field situation. These variables are classified as demographic (age and education of household head – HHH, and family labor), economic (off-farm income, operational land, livestock, chemical fertilizer, irrigation, seed price) and institutional (household's membership in community-based organizations-CBOs). The description of the explanatory variables and their hypothesized influence the adoption of improved rice varieties is summarized in Table 1.

Since HHH is the major decision maker at household in Nepal, its characteristics might influence on household's decision making for the adoption of improved varieties. It was hypothesized that younger aged HHH might be better in adopting improved varieties as compared to their counterparts considering their better linkage with market (Paudel and Matsuoka, 2008). We hypothesized that education of HHHs might have positive influence in the adoption decision considering that the people having higher education could have better access to extension facility about the improved seed and other associated production inputs (Joshi and Bayer, 2006), and they could analyze the potential benefits and costs while adopting improved rice varieties in a better way than their counterparts do. Family labor is an important source of input in subsistence farming and it was hypothesized to have positive influence in the adoption of improved rice varieties. Households with higher family labor might be motivated towards the adoption of improved varieties because they are more likely to implement the field activities on time (planting, such as weeding, fertilizer application), and it results to increase in yield (Paudel and Matsuoka, 2008; Paudel, 2011).

Among the economic variables, we hypothesized positive influence of household's off-farm cash income in the adoption decision. It is because access to credit is still challenging in the study area as most of the bank and micro-finance services are located in the cities, and it is difficult to access credit for small farmers in these areas (Pradhan, 2009). It was hypothesized that those having access to off-farm income could easily get cash and it might be used in buying necessary inputs for rice production, and carrying out crop husbandry activities on time. Similarly, operational land holding was also considered to have positive influence in the adoption of improved varieties as households with larger operational holding have higher risk bearing capacity, and motivation to increase the yield by combining other agricultural inputs. It was expected that operational landholding would positively influence households for the adoption of improved rice varieties (Tiwari et al., 2008). Livestock is the integral component of Nepalese farming system and farmers use all the manure at their fields whatever produce at household, so we calculated livestock standard unit (LSU[2]) and it was used as a proxy to represent the amount of manure applied in rice fields. Livestock was assumed to have positive influence on improved rice varieties adoption. In addition to animal manure, farmers use chemical fertilizer, and it was hypothesized that chemical fertilizer could have positively influence on the adoption of improved varieties (Paudel and Matsuoka, 2008; Regmi et al., 2009). Similarly, it was hypothesized that access to irrigation source could have positive influence on improved rice varieties adoption. The price of rice seed was hypothesized to have negative influence on improved variety adoption in accordance to the micro-economic theory.

Institutional variable included in this study is the household's membership in agricultural group or cooperatives and these institutions are termed as CBOs in this study. These CBOs are the self-help organizations owned and managed by farmers for their member's benefit. Being membership in CBOs, farmers intend to access agricultural training and improved varieties as extension policy of government and NGOs is group-oriented in Nepal, and those having membership in CBOs are more likely to access extension facility from these agencies, and subsequently it might have positive influence on improved variety adoption (Tiwari et al., 2008). As discussed in the methodology section Chitwan district has better infrastructure and extension facility as compared to the other two districts. These factors would be additional sources of variation in the model and could distort the result. To address this issue, we used Chitwan (location) as a dummy variable while running the model.

As per the regression rule, diagnostic tests were carried out to check the heteroscedasticity and multicollinearity problem in the data. For this, selected explanatory variables were regressed against the dependent binary variable using ordinary least square (OLS) technique. Variation inflation factor (VIF) test was carried out to check multicollinearity among the variables. Since the VIF value for the dependent variables remained below 10 suggesting no problem of multicollinearity. Breusch-Pagan/Cook-Weisberg test was carried out to test for the heteroscedasticity and the null hypothesis of heteroscedasticity was strongly rejected (p value below 0.004).

Table 1. Description of socio-economic variables included in binary logistic regression

Variables	Definition	Expected sign
Age of HHH	Age of household head (years)	–
Education of HHH	Formal education of HHH (years of schooling)	+
Family labor	Labor force unit (LFU)[3] at household	+
Off-farm income	Household annual cash income from off-farm sources (NRs)	+
Operational land	Operational land under rice production (ha)	+
Livestock	Livestock standard unit (LSU)[2] at household	+
Chemical fertilizer	Total cost of chemical fertilizer (NRs ha^{-1})	+
Irrigation	1= if farmers' have access to public irrigation facility, 0 for otherwise	+
CBO	1= if any member of household has membership in farmer group/ cooperative, and 0 for otherwise	+
Price	Price of rice seed (NRs kg^{-1})	–
Chitwan	1 = farmers from Chitwan district, and 0 for otherwise	+

5. Results and discussion

This section is divided into three parts. In the first part, we discuss about the different improved rice varieties grown by farmers, the second part summarizes the variables considered in the model, and the third part discusses the findings from the binary logistic model.

5.1 Rice varieties grown by farmers in the study area

The study shows that farmers adopt 17 different rice varieties in the study area in the growing season of 2011. These varieties can be divided into modern varieties (58.8%) and farmers' varieties (41.2%). Out of the total modern varieties (10), only 50% varieties (Savitri, Hardinath 1, Ramdhan, Mithila and Radha 4) are the released varieties by Nepalese government; whereas, the other four modern varieties (Kanchhi Masuli, Sarju 52, Sona Masuli and Sawa Masuli) are the ones released by Indian government in 1970s, and these Indian varieties introduced in Nepal's tarai districts through informal channel (farmer to farmer contact) due to open boarder system between Nepal and India.

Table 2. Average area (ha) and yield (kg ha^{-1}) of different rice varieties across the districts

Varieties	Area/yield	Chitwan	Siraha	Kailali	Overall
Savitri	Area	0.42 (55)	0.20 (3.3)	0.43 (10)	0.41 (22.7)
	Yield	4250	3240	4160	4156
Hardinath 1	Area	0.25 (10)	0.21 (10)	0.18 (3.3)	0.21 (7.2)
	Yield	3879	2875	3689	3298
Ramdhan	Area	0.23 (26.7)		0.18 (3.3)	0.23 (10)
	Yield	4568		4381	4462
Mithila	Area		0.10 (1.6)	0.30 (11.7)	0.28 (4.4)
	Yield		2685	2732	2694
Radha 4	Area	0.27 (20)	0.20 (5)	0.71 (10)	0.38 (11.7)
	Yield	3526	2890	4263	3492
Kanchhi Masuli	Area	0.11 (1.6)	0.52 (65)		0.52 (22.2)
	Yield	3548	3248		3284
Sarju 52	Area			0.61 (81.6)	0.61 (27.2)
	Yield			5281	5281
Sona Masuli	Area	0.66 (1.6)	0.39 (53.3)		0.39 (18.3)
	Yield	4560	4060		4160
Sawa Masuli	Area	0.34 (20)	0.83 (3.3)		0.41 (7.7)
	Yield	4235	3685		4167
Gorakhnath (hybrid)	Area	0.25 (16.7)		0.18 (3.3)	0.24 (6.7)
	Yield	5570		6250	5892
Farmers' variety	Area	0.26 (11.6)	0.23 (31.6)	0.59 (23.3)	0.40 (22.2)
	Yield	3524	2546	3875	3125
Mean rice area		0.58	0.91	0.86	0.78

Source: Survey, 2011

Recently (since 2005) farmers in Chitwan and Kailali have started growing hybrid rice variety (Gorakhnath), and agrovet introduced this variety in the study area in partnership with multinational companies. The farmers' varieties grown in the study area are *Bangali Masuli*, *Bhale Masuli* and *Mala* (in Siraha), *Local Masuli* (in Chitwan), and *Bans Dhan* and *Anadi* (in Kailali). The study also shows that the average yield of farmers' varieties is 3.12t ha^{-1} whereas the yield figure for modern varieties released by Nepalese government is 16% higher yield than farmers' varieties (3.62t ha^{-1}). But better cooking quality (e.g. *Anadi*) and adaptation in stress condition (such as drought, e.g Bans Dhan) have made these varieties popular in the study area. Similarly, the modern varieties introduced from India produce 4.22t ha^{-1} (35.2% higher yield than farmers' variety), and, the yield of hybrid variety is 5.89t ha^{-1}C. There is also variation in the distribution of improved varieties across the district. For example, Savitri is widely grown in Chitwan (adopters 55% farmers), Kanchhi Masuli in Siraha (adopters 65% farmers) and Sarju 52 in Kailali (adopters 81% farmers) are some of the examples (Table 2). The popularity of these varieties in specific location (district) may be due to their better adaptation in that location, which is often governed by variety and environmental interaction (Rana et al., 2007). For example, in case of Chitwan, farmers argued that the main reason for the popularity of Savitri in the district is due to its tolerance to leaf blast and bacterial leaf blight diseases. In case of Siraha where drought has been a serious concern, Kanchhi Masuli has been popular. Farmers argue that this variety has better adaptation in the drought condition as compared to modern varieties released by Nepalese government. Similarly, one of the reasons for wide popularity of Sarju 52 in Kailali is due to its better tolerance to flood as per the farmers' opinion.

As shown in Table 3, 72.7% of the sampled households were found to have grown improved rice varieties, but the proportion of households adopting improved rice varieties (against sampled households in the district) is higher in Chitwan (85%) which is followed by Siraha (73.3%) and Kailali (60%).

Table 3. Distribution of households growing rice varieties across the districts

Categories	Chitwan	Siraha	Kailali	Overall
Only one variety	5 (9.8)	10 (22.7)	8 (22.2)	23 (17.6)
Two to three varieties	35 (68.6)	26 (59.1)	20 (55.6)	81 (61.8)
Four or more	11 (21.6)	8 (18.2)	8 (22.2)	27 (20.6)
Total adopters	51	44	36	131

Figures in the parenthesis indicate percentage of farmers with reference to district total adopters
Source: Survey, 2011

Similarly, it was found that majority of the farmers (>80%) grow more than one improved rice varieties in their farm. More specifically, 61.8% of the farmers grow two to three improved varieties, whereas the farmers' growing single variety and those growing four or more than four varieties are 17.6% and 20.6%, respectively. The above finding shows that most of the farmers adopt diversified rice varieties. The practice of diversifying the rice varieties by farmers (specifically on subsistence farming) is also common in the developing countries as variety diversification strategy helps the farmers meet their households needs and minimize the risk of crop failure due to natural calamities or diseases / pests severity (Almekinders, Louwaars and Bruijin. 1994; Gauchan,Smale and Chaudhary, 2005). In group discussions, farmers argue that the most important reason for diversifying varieties at household level is to enhance the productivity of overall farming system. For example, early duration varieties such as Radha 4 (maturity 125 days) and Hardinath 1 (maturity 110 days) have been grown by farmers in upland (good drainage) area where they plan to grow winter vegetables (such as cauliflower, potato, radish, leafy vegetables, etc) after harvesting of rice. It makes possible for the farmers to produce vegetable 15-30 days earlier while using the early season rice varieties than they do with medium duration varieties. But in wheat growing areas (after harvesting of rice), they choose medium duration rice varieties (maturing from 130-140 days after seed sowing). In general, grain yield and straw yield of medium duration rice varieties is higher than those of early duration varieties (Yadav et al., 2005; NARC, 2011).

5.2 Summary of study variables

Table 4 shows the summary statistics of socio-economic variables of the households included in binary logistics model with reference to their mean and standard deviation. The data show that average age of HHH is 41.9 years but it varies among the households. Only 96 % of the HHHs have attended formal schooling and their average formal schooling years was 5.2. The average labor force at household is 3.2, but varieties from 2 to 15.

In this study households represent small farmers with average operational holding of 0.78 ha (range 0.06 -4.67 ha) which is similar to the national average (0.8ha). People in the study area make their livelihoods both from on-farm (agriculture) and off-farm (business, salaried job, remittance) activities. Annual average cash income of the households is NRs 59,922. Only 63.3% of the households get cash income from agriculture, whereas 66.67% of households receive cash income from off-farm sources. The average off-farm income of households is 69,531 and it varies from NRs. 4,780 to NRs. 122,600. Livestock is the integral part of farming system in the study area. All the households were found to have raised livestock, and average LSU in the study area is 3.46 but it varies from 0.5 to 201. Cow, buffalo, goat, poultry and pig are the major livestock species being raised by farmers.

In addition to animal manure, 90% of farmers apply chemical fertilizers in rice field. The sources of chemical fertilizers are urea (nitrogenous fertilizer having 60% N), Diamonium Phosphate (DAP- having 18% N and 48% P) and Muriate of Potash (having 60% K). It was found that the amount of chemical fertilizers applied by farmers in rice field is N: P: K:: 44.9: 25: 20.9 kg ha^{-1} and this doze is smaller than the recommendation made for irrigated rice in Tarai region of Nepal (N: P: K:: 100: 30: 30 kg ha^{-1}) (MoAC, 2010). We used chemical fertilizer cost (NRs) in the binary logistic regression to represent the amount of chemical fertilizer applied in rice field. On average farmers apply chemical fertilizer with the cost of NRs. 5,244 ha^{-1} and it varies from NRs. 0 to NRs. 10,500. Sampled households use irrigation in their rice field both from public irrigation source (such as canal from river /

stream) and /or from private irrigation source (tube well). But only, 34% of the households have access to public irrigation source. Similarly, 56% of the households have membership in CBOs. Average price rice seed in the study area is 20.5 rupees; however there is quite variation on it among the households.

Table 4. Summary of socio-economic variables included in binary logistic model

Variables	**Overall mea**	**Chitwan**	**Siraha**	**Kailali**
Age of HHH (years)	41.9±13.64†	49.28±13.48	42.03±12.50	34.34±10.63
Education of HHH (years)	5.20±1.58	60.6±6.61	4.81±5.42	4.08±5.12
Family labor (LFU)	3.2±8.76	3.6±2.10	3.10±2.32	2.80±0.78
Off-farm income (NRs)	69,531±67,890	104,582±42,580	63,875±32,256	37,815±20,452
Operational land (ha)	0.78±0.66	0.58±0.45	0.86±0.66	0.91±0.78
Livestock (LSU)	3.46±1.85	5.06±3.56	1.49±0.48	2.85±1.45
Chemical fertilizer (NRs ha^{-1})	5,244±1,245	3,594±1,721	5,530±1,493	6,654±3,298
Irrigation	0.34±0.47	0.39±0.49	0.36±0.48	0.26±0.44
CBO	0.56±0.23	0.68±0.24	0.48±0.21	0.51±0.34
Seed price (NRs kg^{-1})	20.5±16.7	21.3±10.8	20.8±14.21	19.4±8.79
Chitwan	0.33			

Note: † = Standard deviation, 1 US$ = NRs. 82.96 (source: Nepal Rastra Bank, 2011.11.30)

5.3 Result of binary logistic model

The significant log likelihood statistic (done through wald test) shows that the variables chosen for the study fit in the model well (Table 5). It means the model rejected the null hypothesis that coefficients of the model are significantly different from zero (p = 0.0001). Moreover, the probability of the correct prediction from the model is also high (74.5%). These results show the goodness of fit of the model. The study shows that most of the variables' response on dependent variable is as hypothesized; however, the influence of age of HHH, family labor and off-farm income is opposite from what we had expected. Among the explanatory variables, irrigation, households' membership in CBOs, seed price and location have significant influence on households' decision for the adoption of improved varieties.

Rice is a water loving crop and it requires more number of irrigations as compared to other cereal crops; however, the number of irrigation varies with type of rice varieties (short duration vs long duration) and land (upland vs low land). The higher motivation of irrigation facility accessed households' might be due to their objective of increasing yield with the adoption of these varieties (Nkonya and Norman, 1997; Paudel and Matsuoka, 2008) or cropping intensity (Nkonya and Norman, 1997). It means farmers could increase the number of crops in a year by selecting the shorter duration rice varieties (though yield of the variety might not be higher than the existing one). In addition to canal irrigation (from river) there is potential to use underground water through tube well but less than 5% farmers use tube well; however, the reasons behind it yet to be understood.

In this study, households' membership represents the proxy variable to access extension facility (e.g. agricultural training) from government and non-government organizations. The significant coefficient and high marginal effect signifies the influence of CBO's membership in the adoption of improved rice varieties As shown in the Table 6, the marginal effect of households' having membership in CBOs is 0.127 which indicates that households having membership in CBOs have 12.7% higher probability of adopting improved varieties as compared to their counterpart. This finding is consistent with other previous studies (Paudel and Matsuoka, 2008; Tiwari et al., 2008). The reason behind the higher probability of the improved rice varieties adoption by CBOs members might be due to their better linkage with the extension agencies (Department for International Development-DFID, 2010). In the group discussions farmers opined that as a member of CBO they have to participate in the monthly meeting, observation of new variety demonstration plots. They also discuss about the problems, lessons and potentials about the new crop varieties/ technologies in monthly meetings. All these factors might have influence on the adoption decision.

This study also shows that the price of seed plays significant role in household's decision for the adoption of improved rice varieties. It means households experiencing higher seed price are less likely to adopt improved rice varieties and vice versa. Previous studies have shown that farmers normally compare the price of seed with grain of the same commodity in case of self pollinated crops and if the price of seed goes up they tend to use household saved seed (Almekinders, Louwaars and Bruijin, 1994). David (2004) also found same situation in bean in African countries.

Table 5. Summary of the results from binary logistic regression

Variables	β	P value	Marginal effect[4]	Odd ratio
Age of HHH	0.031	0.184	0.0041	1.31
Education of HHH	0.112	0.121	0.013	1.06
Labor force at household	-0.043	0.165	0.117	0.46
Annual off-farm income	-0.00031	0.243	0.0001	0.37
Operational land	0.811	0.124	0.140	0.68
Livestock	0.0027	0.943	0.0003	0.41
Chemical fertilizer	0.0002	0.705	0.0002	0.55
Irrigation dummy	0.812	0.03***	0.301	3.45
CBO dummy	0.641	0.079*	0.127	2.85
Price of seed	-0.240	0.0127**	0.014	2.14
Chitwan dummy	0.221	0.014**	0.125	2.35
Constant	-2.184	0.012**		
Log likelihood: 85.37**, Number of observations: 107, Percentage correctly predicted: 74.5, Pseudo R square: 0.22				

*, ** and *** indicate significance at 10%, 5% and 1% levels, respectively.

As hypothesized we found that Chitwan district has significant positive influence in the adoption of improved rice varieties. It might be due to the variation of other variables not considered in the model such as better road network and extension facility in Chitwan as compared to other two districts but we could not explicitly indicate that only these two variables create this variation.

6. Conclusion and policy implication

In this study, we analyzed the influence of socio-economic variables for the adoption of improved rive varieties using binary logistic model. The adopters in the study were defined based on whether farmers buy seed from the market or not regardless of modern or farmers' varieties. This might have its own implication in the future variety adoption studies of developing countries. The study shows that in 72.7% of the cases farmers adopt improved rice variety, and these varieties consist of both modern and farmers varieties. The result of binary logistic regression shows that the adoption of improved rice varieties is mainly influenced by irrigation, household membership in CBOs, and price. This implies that the existing extension agencies should integrate variety promotional program with irrigation facility. This does not mean that improved variety should be promoted only in irrigated areas. Drought tolerant varieties could be promoted in rainfed areas and farmers could increase rice yield. Similarly, we found significantly positive influence of households' membership in CBOs but still about half of households are not engaged in CBOs. This implies that the extension agencies of both government and NGOs should facilitate the farmers to engage in CBOs so that they could access extension facility in agriculture and this could have positive influence in improved varieties adoption in rice. Moreover, this study shows that households experiencing higher price of seed are less likely to adopt the improved varieties. It means emphasis should be given for seed production of rice at local level so that cost of production and transportation could be reduced and farmers get seed in cheaper price. The study may not fully represent the entire rice growing areas of the selected districts as we purposively selected the VDCs from accessible areas, and future study should address this issue.

Endnotes

1 SRR is the proportion of improved seed supplied in the area with reference to the total seed required

2 LSU is the aggregates of different types of livestock kept at household in standard unit calculated using the following equivalents; 1 adult buffalo = 1 LSU, I immature buffalo = 0.5 LSU, 1 cow = 0.8 LSU, 1 calf = 0.4 LSU, 1 pig = 0.3 LSU, 1sheep or goat = 0.2 LSU and 1 poultry or pigeon = 0.1 LSU (CBS, 2003; Baral, 2005)

3 LFU is the measurement of labor force, where people from 15-59 years old regardless of their sex were categorized as 1 person = 1LFU, but in case of children (10-14 years old) and elderly people (>59 years old) 1 person = 0.5 LFU

4 Marginal effect = p (1-p) β, where p – probability of occurring the event, and β is the parameter estimated from the model.

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