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Farmers' Choice of the Modern Rice Varieties in the Rainfed Ecosystem of Nepal

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Abstract
In an effort to increase the productivity of rice in Nepal, several modern varieties have been released. Farmers have adopted these varieties to varying degrees depending upon the types of production environment and the considerations for attributes. This paper attempts to identify factors that condition the adoption of selected modern varieties of rice using a multinomial logit model including both production and consumption attributes valued by the farmers and farm and farmer related variables. The results show that both categories of variables are significant in determining the demand for a specific variety. The results of this paper have implications for crop improvement and the modern variety adoption. Research approaches that incorporate farmers' preferences for various attributes of rice in breeding programs and extension strategies have to be adopted. Various types of methods such as demonstration and farmer- participatory trials could be effective vehicles in this regard. Also the research system should develop a range of varieties in order to meet the multiple concerns of the farmers as a single variety may not be able to fulfill all of their concerns.

Keywords: attributes, demand, farmer, Nepal, rainfed, rice, variety

1 Introduction

Rice is the staple food crop of Nepal. It occupies about 50 percent of the total area under food crops of 3.2 million hectares and its contribution to the total food supply is more than 50 percent. This crop alone contributes to about 40 percent of the total calorie intake. In Nepal, the area under modern varieties (MVs) has increased from about 40 percent in 1993/94 to about 83 percent in 2003/04 (Ministry of Agriculture and Cooperatives, 2004). Compared to other ecological regions, this proportion is higher in *Terai* region where irrigation, roads and market infrastructures are well developed.

Nepal's experience with rice research and technology development illustrates the need to put this important sector on a high productivity path beyond what is currently attained. The rice sector in Nepal has experienced some developments especially in the spheres of

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varietal development. Over four dozens MVs have been released since 1960s. However, there has not been much progress in the productivity. The growth trend in yield of rice in Nepal during the last 30 years is about 1.5 percent per annum whereas this has been slightly higher (1.90%) for *Terai* region, which is considered the granary of the country.

The adoption of rice varieties may differ depending upon the concerns of the farmers, which are defined by the attributes. Farmers can view some attributes as positive and others as negative. The choice of one variety technology over others is greatly influenced by the balance between these two attributes. Depending on the preferences, resources, and constraints that individual farmers face, a beneficial attribute for one farmer may be a negative one for other, or the balance between positive and negative traits may be acceptable for one farmer but not for another (Bellon, 2001).

Farmers may assess a new technology such as crop variety, in terms of a range of attributes, such as grain quality, straw yield, and input requirements, in addition to grain yield (Traxler and Byerlee, 1993). Crop improvement could potentially benefit from farmers' assessments of the relative performance of different varieties under farmer management. Information on the attributes desired by farmers and their knowledge of the production system could be invaluable in setting the goals of breeding program, delineating the target environment, identifying the parents for breeding and defining the management treatment for breeding work (Sperling *et al.*, 1993; Eyzaguirre and Iwanga, 1996).

It is an established fact that farmers' are also capable of commenting on the design of particular technologies and suggesting changes that would make such technologies and innovations more appropriate for their needs. Taking farmers' input on technology design seriously would accelerate the ultimate adoption of new technologies (Pingali *et al.*, 2001).Most of the experimental work in crop improvement evaluate the rice varieties often using yield as the sole criterion. Most often these varieties have either not been adopted or adopted for a shorter period. Understanding farmers' variety preference serves as an input to future variety development and diffusion. Thus, for a successful intervention, policy has to be informed on: 'who prefers what kinds of variety most?'

The varieties released in Nepal have been recommended for different agro-ecological zones and ecosystems. Joshi (2003) reported that out of 48 varieties released, 13 for main season and 10 for spring season have been recommended for cultivation under irrigated condition of Terai region. Only about 5 varieties have been developed for rainfed lowland of Tarai. So far only 2 varieties have been released for upland ecosystem. There are 14 varieties recommended for mid-hills and 4 for high hills. Most of them do best under irrigated conditions.

The main objective of this paper is to identify the factors affecting the demand of modern varieties of rice using a discrete choice model. The paper is organized as follows. The research methodology and analytical techniques are presented in Section 2 while results and discussions are presented in section 3. The paper ends in section 4 with conclusions and recommendations.

2 Methodology and Analytical Techniques

2.1 Sampling and Data Collection

The data for this study were collected from Banke and Nawalparasi districts in the western *Terai*[1] region of Nepal. The farmers were selected from 3 Village Development Committees (VDCs) of each district using stratified random sampling. The VDCs where survey was carried out are Manikapur, Bethani and Bageswori from Banke district and Kushma, Deurali and Ramnagar villages from Nawalparasi district. A total of 222 rice growing farmers were randomly selected from these 6 VDCs of two districts.

The survey included collection of data on number and types of rice varieties grown, area under different varieties, seed sources, farmers' preference for variety characteristics, farm and farmer characteristics and associated socio-economic characteristics. The relevant data for the cropping year 2001/02 were collected by using structured questionnaires.

The farmers' preference/demand for varieties was determined following the two steps procedure. In the first step, most dominant variety (in terms of area) grown by the households in the study area were identified. Hence, five types of varieties were selected. In the second step, the selected varieties were offered to farmers and were requested to make a choice among them.

2.2 Empirical Model

Although the farmers in the study area cultivate about two dozen MVs, few varieties are prominent as exhibited by their area share. Based on the this, only 5 categories of the varieties are selected for this analysis. They are Radha 4, Janaki, Masuli, Sarju 52 and others. The multinomial logit (MNL) model was used to analyze the factors affecting the choice of these varieties. The MNL is based on the random utility model. The utility U to an adopter form choosing a particular alternative is specified as a linear function of the farm and farmer characteristics (β) and the attributes of that alternative (X) as well as a stochastic error component (e):

$$U = \beta X + e \tag{1}$$

Suppose the observed outcome (dependent variable) is choice j. This implicates for a given adopter: $U_{alternative\,j} > U_{alternative\,k}\ \forall\ k \neq j$, or

$$\beta X_j + e_j > \beta X_k + e_k\ \forall\ k \neq j \tag{2}$$

The probability of choosing an alternative is equal to the probability that the utility of that particular alternative is greater than or equal to the utilities of all other alternatives in the choice set.

Let the probability that the i^{th} farmer chooses the j^{th} variety be P_{ij} and denote the choice of the i^{th} farmer by $Y_i' = (Y_{i1}, Y_{i2}, \cdots, Y_{iJ})$ where $Y_{ij} = 1$ if the j^{th} variety is

[1] The *Terai* is a sub-tropical plain region located in the South of Nepal which borders with India.

selected and all other elements of Y_i' are zero. If each farmer is observed only a single time, the likelihood function of the sample of values $Y_{i1}, \cdots, Y_{iJ}$ is:

$$L = \prod_{i=1}^{T} P_{i1}^{Y_{i1}} P_{i2}^{Y_{i2}} \cdots P_{iJ}^{Y_{iJ}} \tag{3}$$

Assuming that the errors across the variety (e_{ij}) are independent and identically distributed leads us to the following multinomial logit (MNL) model.

$$P\{y_i = t\} = \frac{\exp\left(X_{it}'\,\beta\right)}{1 + \exp\left(X_{i2}\,\beta_2\right) + \cdots + \exp\left(X_{iJ}\,\beta_J\right)} = \frac{\exp\{X_{it}'\,\beta\}}{1 + \sum_{j=2}^{J} \exp\{X_{ij}\,\beta_j\}} \tag{4}$$

The multinomial logit model is used to predict the probability that a farmer demands a certain variety and how that demand is conditioned by different farm and farmer characteristics and attributes of the variety valued by the farmers.
By differentiating equation (3) with respect to the covariates we can find the marginal effects of the individual characteristics on the probabilities as

$$\frac{\partial P_j}{\partial X_j} = P_j \left[\beta_j - \sum_{k=0}^{j} P_k \beta_k\right] = P\left[\beta_j - \bar{\beta}\right] \tag{5}$$

The MNL model is general enough to be useful as a tool for studying different circumstances faced by farmers and different problems encountered in the context of choice among multiple varieties. The marginal rate of substitution (MRS) between two varieties is shown to be a weighted sum of the marginal contribution of each variety to the total amount of each attributes demanded (supplied). Households might simultaneously plant multiple varieties if certain attributes are unique to a particular variety. For this reason, we consider a multitude of production and consumption attributes preference of farmers as explanatory variables. The production characteristics considered are duration of maturity (MATURE), irrigation requirement (IRRIG), and threshability (THRESH) where as the consumption characteristics considered are the preference for taste (TASTE), and suitability of the grains for preparing special products (OTHUSE) that are valued by the farmers. Similarly, other farm and farmer's characteristics considered as explanatory variables are education of the household head (EDN), experience of the farmer in rice farming (EXPERI) and the source(s) of seed (SEEDSOU). The definition of the variables and their measurement is presented in Table 1.

3 Results and Discussion

3.1 General Features of the Production System

The basic features of the production systems in the two sampled districts are presented in Table 2. The average farm size is much larger in Banke than in Nawalparasi. While rice is the dominant crop in both the locations, the share of MV was higher in Banke than in Nawalparasi. The cropping intensity and the proportion of irrigated area are higher in Nawalparasi than in Banke.

Table 1: Definition of the variables used for variety demand analysis

Variable	*Definition*	*Measurement*	*Mean*
Attribute	Dependent variable used in multinomial logit	0 = Radha-4 1 = Janaki 2 = Masuli 3 = Sarju-52	-
EDU	Educational attainment of the household head	No. of years of schooling	3.90
EXPERI	Experience of the household head in rice farming	Number	26.3
SEEDSOU	Sources of seed	Binary; 1= if received from formal sources, 0 = otherwise	0.27
THRESH	Farmers' preference for easy threshability of the grains	Binary; 1= if a farmer considers easy threshing as an important attribute, 0 = otherwise	0.73
MATURE	Farmers' preference for early maturity of the variety	Binary; 1= if a farmer considers early maturity as an important attribute, 0 = otherwise	0.62
IRRIG	Farmers' preference for less irrigation requirement	Binary; 1= if a farmer considers less irrigation requirement as an important attribute, 0 = otherwise	0.36
TASTE	Farmers' preference for taste attribute	Binary; 1= if a farmer considers taste attribute as an important attribute, 0 = otherwise	0.88
OTHUSE	Farmers' preference for preparing other speciality products such as *murahi* and *chiura*	Binary; 1= if a farmers considers preparing speciality product(s) is an important attribute, 0 = otherwise	0.63

Table 2: General feaures of the production systems in the study area.

Description	*Districts*	
	Banke	*Nawalparasi*
Average size of land holding per household (ha)	2.3	1.1
Cropping Intensity (%)	151	185
Area under rice (% of total cropped area)	53	52
Area under MV of Rice (%)	81	73
Average Yield of MV (t/ha)	3	3
Percentage Area Irrigated (including seasonal)	35	72

3.2 Description of the Modern Varieties (MVs) Grown

Farmers in the study area grew about two dozens MVs. The most popular MVs and thir area share is presented in Table 3. Among them, Radha 4 ranked number one followed by Janaki, Masuli and Sarju 52 in terms of area coverage. The Radha 4, and Masuli were popular in both the districts whereas Janaki was popular among the farmers in the Banke district. Farmers have also cultivated Indian varieties such as Sarju 52 which was popular in Nawalparasi district. Based on the quality of the grains, the varieties such as Radha 4 and Janaki are considered as coarse rice and Masuli is considered as fine rice.

The discussions with District Agricultural Development Office, Banke revealed that the area under Janaki is decreasing in this district. This is mainly because of the difficulty in pulling of seedlings for transplantation and threshing of the grains manually. This variety is being replaced by Radha 4 in the recent years.

Table 3: Area share (%) of popular modern varieties in the study area

S.No.	*Variety*	*No. of households*	*Percentage share*
1	Radha 4	122	45.0
2	Janaki	59	19.3
3	Masuli	36	8.8
4	Sarju-52	34	6.1
5	Other Radha types[1]	46	6.5
6	Others[2]	-	14.3

[1] includes Radha 17, Radha 9, Radha 32, and Radha 9.

[2] includes Indian varieties such as Indrashan, Sona Masuli, Orissa (OR) and Nepalese varieties such as IR- 22, Sabitri, hybrids etc.

The maturity days and years of cultivation of some of the popular MVs is presented in Table 4. The varieties such as Radha 4, and Radha 17 are early maturing , Sabitri, Sarju 52 and Janaki are medium maturing and Masuli is a late maturing . The Masuli is grown as high as for 30 years since its release in 1973. Sabitri is being cultivated for 23 years since it was released in 1979. Janaki and Sarju-52 were released respectively by NARS of Nepal and India during 1979. These varieties are being cultivated for about 20 years. Radha-4 released during 1995 and recommended for western/mid-western Terai is also being cultivated for about 7 years.

3.3 Analysis of the Variety Demand

The descriptive statistics show that the response for five varieties was 35.7%, and 16.3% respectively for Radha 4 and Janaki, 10.9% each for Masuli and Sarju 52 and 26.2% for other category.

Table 4: Maturity days and years of cultivation of some of the important MVs.

Variety Name	*Characteristics*		
	Maturity days based on		*Years cultivated* †
	*Research system**	*Farmers' response* †	
Radha 4	125-130	110-134	1-7
Janaki	135	125-150	1-18
Masuli	145-165	140-155	1-30
Sarju 52	NA	125-145	1-17
Radha 17	NA	115-140	1-4
Radha 9	135-140	125-145	2-5
Sabitri	140	115-140	2-23

Source: * NARC(1997); † Field survey.

The factors that could affect farmers' demand for specific variety using the multinomial logit model (MNL) is presented in Table 5. Taking the most preferred variety in MNL model should not imply that farmers are exclusively looking for a single variety. Of course, farmers are looking for multiple varieties with different intensity of preferences. The results show that estimated MNL model is significant in explaining farmers' preferences for variety. The Pseudo R^2 was 0.37 and the log-likelihood ratio was also highly significant.

The key and significant variables affecting demand for rice variety are attributes such as easy threshability, usage of grains for preparing special products (such as *murahi*-fried rice and *chiura*-beaten rice), early maturity, and less irrigation requirement. The variables related to farm and farmer characteristics affecting demand for variety are the sources of seed, education level and the experience of the farmers.

The contrasting results appear for Radha 4 and Janaki varieties. Farmers who are educated, having more experience in farming, preference for early maturity of the variety and easy threshability significantly increase the probability of demanding Radha 4 over Janaki. This is because Janaki is a variety with longer duration for maturity and difficult to thresh manually. The farmers who have to cultivate succeeding winter crops prefer early maturing variety. In Nepalese *Terai*, winter crops such as wheat and lentil are cultivated after rice. Due to the rainfed condition of the study area, farmers prefer early maturing varieties so as to cultivate winter crops when there is enough moisture in the soil. As a result the farmers are less interested to cultivate Janaki and Masuli varieties because of their long duration for maturity. Instead farmers prefer to cultivate Sarju 52 and Radha 4 because of their short duration. The negative and significant coefficient of IRRIG indicates that the probability of farmers' demand for Masuli and

Janaki decreases with their preference for less irrigation requirement increases, as these two varieties require high amount of water to grow and are mostly suitable to lowland areas.

The results also indicate that the probability of demanding Masuli variety decreases while that for Sarju 52 increases when the farmers consider the attribute such as suitability for preparing speciality products from rice. This is because farmers in the study area prepare other products such as *murahi* and *chiura* in addition to boiled rice. The experienced farmers do cultivate Masuli as exhibited by its cultivation to date since its release in 1973 where as its cultivation goes on decreasing as the farmers' consider early maturity attribute important. Farmers may not be able to cultivate succeeding winter crops because of the long duration of Masuli.

Farmers' probability of cultivating all varieties except Sarju 52 increases with the availability of seed from formal sources (SEEDSOU). As the seeds of these varieties are multiplied and distributed to farmers from the existing extension and research system as well as from NGOs, farmers demand for cultivating these varieties increases.

Table 5: Factors affecting the farmers' demand for rice variety .

Variables	*Coefficients for different variety preferences*			
	Radha 4	*Janaki*	*Masuli*	*Sarju 52*
constant	-4.572***(1.12)	2.806***(1.07)	-1.640(1.26)	-4.526***(1.40)
EDN	0.167***(0.06)	-0.159*(0.08)	0.042(0.08)	0.140**(0.07)
EXPERI	0.059***(0.02)	-0.014(0.03)	0.053*(0.03)	0.022(0.03)
SEEDSOU	1.890***(0.57)	1.602*(0.90)	2.322***(0.76)	-0.575(0.91)
THRESH	1.479**(0.71)	-3.826***(0.91)	0.883(0.78)	0.576(0.88)
MATURE	1.588***(0.50)	-0.552(0.66)	-1.720***(0.70)	1.820***(0.72)
IRRIG	-0.296(0.43)	-1.988***(0.74)	-1.862***(0.71)	-0.047(0.54)
TASTE	-0.515(0.38)	-0.422(0.48)	0.042(0.51)	-0.333(0.49)
OTHUSE	0.492(0.52)	-0.704(0.73)	-1.949***(0.70)	1.487**(0.77)
Pseudo R^2		0.37		
Log likelihood function		-205.95		
Likelihood ratio		246.61***		

***, ** and * imply statistical significance at 1% , 5% and 10% levels, respectively.
Figures in the parentheses are the standard errors.
Dependent variable is Variety. Other varieties as the reference.

4 Conclusion and Recommendation

The farmers in the study area have cultivated many modern varieties (MVs) of rice and some of them are being cultivated as long as for 30 years. The farmers also have multiple concerns and these are reflected in the selection of the variety(ies). In this paper, we have investigated the factors contributing the adoption of selected MVs of rice. We have considered the multitude of production and consumption attributes that are valued by the farmers, as well as farm and farmer specific variables. The key and significant variables affecting farmers' demand for variety are both production and consumption attributes valued by the households and farm and farmer characteristics. They are easy threshability, usage of grains for preparing special products, early maturity of the variety, less irrigation requirement, sources of seed, education and the experience of the farmers.

The results of this paper have implications for crop improvement and the modern variety adoption. The preference for irrigation and early maturity is the reflection of the production environment that the farmers are facing. Also their perceptions of the labor requirement for threshing and preparation of the special products are other variables that are the reflection of management aspects and the usage. As the farmers are the eventual consumers of the product of the agricultural research such as variety, their knowledge of the production environment and preference for the variety attributes are critically important in influencing not only the decision to adopt but also the level of the adoption. Hence, farmers' involvement in participatory varietal improvement and development programs needs to be emphasized so as to address their concerns and preferences.

The results also show that although the farmers value many attributes important, but there is no single variety that can supply all the attributes valued by them. Hence, the breeding efforts should be oriented to supply a range of varieties that can address the concerns of the farmers.

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