Price-based Valuation of Rice Genetic Diversity in Nepal

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Abstract

The study valuates different useful traits of rice landraces in Nepal to demonstration an empirical methodology for biodiversity valuation. A sample of 200 rice growers in hills and plain area was surveyed for the production of different landraces and their market price. For estimating the value put by the consumers on different rice traits a hedonic pricing model was used to disaggregate the prices paid by the consumers for different useful traits of rice. For estimating derived demand of seeds with different useful traits by the farmers, a contingent valuation method is employed. The results show that the consumers value Rs 11 billion per annum for aromatic trait and rupees two billion for tasty trait. The findings of the study will be helpful to prepare market based strategies for rice biodiversity conservation.

Key words: *agro biodiversity, rice landrace, biodiversity valuation*

Background

Rice biodiversity is a reservoir of rice genetic resources with allelic variations that have vast potential for future rice breeding. The diversity of food plants consists of crop resources that are created and maintained as active components of agroecosystems (Brookfield and Padoch 1994; Vandermeer et al. 1998). Though the need for the conservation of rice biodiversity is agreed by all, the origin conflicts for dealing with this issue stem from the rules of division and appropriation of the benefits out of the commercial utilization of the rice genetic resources.

Green revolution replacement model of agricultural development is still emphasised whereby landraces are displaced by the so called high yielding and fertilizer responsive varieties. As the market supplies high yielding varieties of rice, the rational farmers do replace narrow

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genetic base high yielding varieties for landraces they have. A few, genetically uniform, such varieties have replaced genetically variable crop landraces (Brush 1991; Harlan 1992). In Nepal, about 53 percent of the farm households continue to grow both modern varieties and landraces simultaneously (Joshi and Bauer, 2006). Their demand for these types is clearly shaped in part as a derived demand from markets, land and soil heterogeneity and in part by the consumption preferences of their families. They emphasized for a need to conserve on-farm diversity as part of a strategy to conserve crop genetic resources. Some other sceintists emphasized on the development approaches[2] that value, conserve, develop and market agro-biodiversity to alleviate the extreme poverty (Bardsley and Thomas, 2003). However, measuring the value of biodiversity is a great challenge. Reid et al. (1993) observed that even the debates on the measurement of biodiversity started in the 1950s and there is no clear consensus about how biodiversity should be measured. Pearce and Moran (1994) examined some aspects of measurement of biodiversity for genetic diversity, species diversity and ecosystem diversity. According to them the genetic differences can be measured in terms of phenotypic traits, allelic frequencies or dioxy-ribo nucleic acid (DNA) sequences. The measurements of allelic diversity and DNA sequence require high level technical information[3] which is out of the scope of this paper. We rely on the phenetic diversity that is based on measures of phenotypes, involving readily measurable practical utility to the consumers and the farmers. For the purpose of the study we take the consumers of the products as the market for different traits. This paper estimates the use values[4] put by communities for rice diversity to demonstrate their importance to policy makers.

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[2] There are other approaches to protect biodiversity, including in situ conseration through protected area conseation, *ex situ* conservation through zoos, aquaria, botanical gardens, seed banks and gene banks.

[3] The allelic measurement requires protein electrophoresis, which analyses the migration of enzymes under the influence of electric field whereas the DNA sequencing requires polymerase chain reaction technique.

[4] The use value is the value arising from the actual use of rice and further divided into direct use values like the rice consumption by the households or indirect use values, like ecosystem functions of rice field and option values, like value generated by an individual's willingness to pay to protect the rice landrace for the future use in rice breeding.

Methodology

Following the market and non-market approach of analysis empirical estimation of use value of rice genetic diversity is done. The sources of data, sampling designs and analytical procedures are discussed under this section. For the valuation of GRs two districts (Kaski from hill and Bara from terai) have been selected purposively considering the richness of the rice diversity. Four villages (Lekhnath, Lumle, Kacharba and Maheshpur) with high concentration of the landraces[5] under valuation have been identified by key informant survey. A focussed group discussion was conducted in each village to refine the survey questionnaire. The pre-tested questionnaire was administered to conduct the sample survey of the households. The farm households cultivating the rice landraces under consideration formed the sample frame. The sample households have been selected randomly using simple random sampling method without replacement. A sample of 200 households was surveyed by a team of enumerators.

Conventionally, market price approach is used for estimating the value of the environmental goods and services. Early applications of the hedonic pricing methods start from 1920s on farm land characteristics. The first reference of hedonic modeling is found in price differences in fresh vegetables (Waugh, 1928). One expects that property prices are an increasing function of the environmental quality given the characteristics of the commodity. The theoretical foundation for integrating characteristics in modeling is further elaborated and formalized by Lancaster (1966). Environmental characteristics like air or water quality affect the price of land either as a producer good or as a consumer good. The hedonic pricing

[5] Landrace includes the farmers' traditional varieties that farmers have produced and maintained themselves, often for many generations, as well as former high yielding varieties that had been bred and were then released more than 15 years and that have since become incorporated into farmers' own seed production (Almekinders and Louwaars 1999; Cleveland and Soleri 2002).

literature on environmental valuation are built upon the input characteristic modeling of the utility maximizing hedonic pricing model, as originally presented by Griliches (1966), Lancaster (1966) and as adapted by Ladd and Savannut (1976). There are a number of empirical studies estimating the hedonic property value model for environmental values. Ridker (1967) is the first to use this method on environmental goods for estimating marginal value of air quality in residential areas. The equilibrium is achieved when the variation in price reflects the variation in the attributes under the condition of full information. Price (p) of rice with a vector of traits (z) and a vector (α) of parameters that describe the functional forms (Haab and McConnell, 2002) can be written as:

$$p = h(z, \alpha) \tag{1}$$

The equilibrium exists when the buyer maximizes the utility from consumption of a composite bundle of commodities (x) with a vector of household preference function (β), the utility function is $u(x, z, \beta)$ and budget constraint with income $y = h(z) + x$.

Other important early studies in environmental valuation employing hedonic pricing include Freeman (1974a; 1974b), Anderson and Crocker (1971; 1972), Lind (1973), Pines and Weiss (1976) and Polinsky et al. (1976). Later on some other studies like Nelson (1978), Portney (1981), Horowitz (1986), Murdoch and Thayer (1988), and Kanemoto (1988) also employed hedonic pricing method to estimate individual's marginal willingness-to-pay as a decreasing function of environmental quality. More elaborative account of environmental valuation was provided by Smith (1990) by reviewing the conceptual basis for valuing environmental amenities. Burgess and Harmon (1991) tested specification for addressing the considerable econometric problems present in hedonic models. Without mentioning biodiversity, Dalton (2003) estimated a nonseparable household hedonic pricing model of upland rice attributes

combining both production traits, similar to those found in input characteristic models, and consumption traits, consistent with classic consumer goods characteristic models.

The following model is used for estimating the use value given by the consumers attributable to major traits of rice varieties.

$$PP = \alpha + \beta 1T + \beta 2S + \beta 3BR + \beta 4LS + \beta 5Md + \beta 6Ce + \beta 7Ex + \beta 8ST + \beta 9MP + \beta 10TA + \beta 11Ms + \upsilon \quad (2)$$

Where PP is the farmgate price of paddy rice, T stands for tasty trait, S for aromatic, BR for suitability for bitten rice (flatened rice used for snacks), LS for good for *latte* and *siroula* (local dishes for special occasions), Md for medicinal uses, Ce for used in ceremony, Ex for expansion in cooking, ST for good storage, MP for milling percent, TA for terai area, Ms for main season crop and v for the error term.

Valuation of Rice Genetic Diversity

The sample farmers of 200 households are growing 78 rice verieties altogether. The relative abundance of these varieties is presented in Table 1.

Four varieties, namely BG-1442, Basmati, Sona Masuli and Anadhi are the most popular grown by more than 20 percent of the farmers. Farmers plant each variety separately on different plots or sometimes in the different parts of the same plot. On average, each farmer is growing 4.62 varieties of rice every year. Owing to the small size of the land holding, each variety on average commands very small area. For example, the average area under the most popular (grown by over 44 percent of the households) variety BG-1442 is 0.26 ha followed by the Basmati 0.16 ha (Table 2). Though the Basmati is grown by larger proportion of the households (nearly 38 percent) than Sona Masuli (nearly 30 percent) the area command shows the opposite. This is more distinct in case of Anadi. Though this long grain aromatic

landrace is grown by over one-fourth of the total households, the average area per household is very small. It means these precious landraces (like Basmati and Anadi) are unable to compete with other commercially grown moden varieties. These varieties are thriving in the farmers' field only due to their special phenotypic characteristics that are controlled by the respective genes. To protect such genes from extinction, there is a need to understand the value of these genes and make the landraces competitive to stay on the farmers' fields.

Table 1: Relative abunadance of rice varities

Relative abundance (%)	**Name of the Rice Variety (number of varieties)**	**Name of rice landrace (number of varieties)**
40 to 50	BG-1442 (1)	(0)
30 to 40	(0)	Basmati (1)
20 to 30	Sona Masuli (1)	Anadhi (1)
10 to 20	Mansuli, China-4 and Sabitri (3)	Kathe, Anga, Meghdoot, Jetho Budho, Pahele, Sotwa, Rekshali, Ekle, Dhudhraj and Harinkar (10)
Less than 10	Lumle-2, Chaite-1, BGAR-4, Ghaiya -2, Radha-7, Janaki, Radha-9, Barkhe-2, Machhapuchhre, Khumal -4, Chhomrong, Jaya, Biramful*Himali, Ekle hybrid, Ekle*KY, HY-6264, IR-6465, Mansara Hybrid, Sano Gurdi Hybrid, Sano Gurdi * NR, Thulo Gurdi Hybrid and Thulo gurdi*NR (22)	Rate, Kalopatle, Gurdi, Biramful, Chhatraj, Mutmur, Rato Anadi, Bayarni Jhinuwa, Chhote, Jerneli, Mansara, Seto Anadi, Darmali, Madhesi, Manamuri, Natwar, Budho Sigdeli, Nakhisaro, Kaskeli Thude, Gauria, Kathe Gurdi, Ranga, Sokan, Thulo Gurdi, Sathi, Gajale Gurdi, Madhumala, Masula, Philipes, Lamjunge, Deurali, Sano Gurdi, Seto Gurdi, Rato Darmali, Deupure Kathe, Kaskeli Kathe, Bhelasaro, Lahare Gurdi and Bhalu (39)
Total	(27)	(51)

Note: The Relative abundance is measured as the percent of the households growing that variety or landrace.

The reason for very small area under Anadhi is that its productivity is low and the price is not high enough to compensate the lower productivity. It is clear that the gross return from Anadhi is about one third of the gross return from other competing varieties. The Anadhi landrace is surviving in the field of the farmers only due to its typical characteristics that other varieties can not fulfill. It shows that the typical landraces with unique genes are finding

difficult time to survive *in situ*. We should either go for *ex situ* conservation or understand the value of these landraces to the society and find market means of conserving them *in situ*.

Table 2: The most popular four varieties

Variety	Type	Relative abundance (% of households)	Average area (ha)	Productivity (qt/ha)	Price (Rs/qt)	Gross return (Rs/ha)
BG-1442	Improved	44.5	0.26	41	1074	44,034
Basmati	Landrace	37.5	0.16	30	1622	48,660
Sona Masuli	Improved	29.5	0.23	49	1126	55,174
Anadhi	Landrace	26.5	0.02	14	1168	16,352

Source: Household survey 2006.

For the purpose of estimating the value the society puts on different traits of the rice varieties, a hedonic pricing model is fitted with the market price of paddy rice. The descriptive statistics of rice traits fitted in the model are presented in Table 3. Though some of the traits appear to be not mutually exclusive, they are used separately as long as there is no risk of multicollinearity.

These variables are fitted to a regression model to estimate the contribution of different traits on the market price. Many phonetic properties like tasty to eat, aromatic, good for preparation of bitten rice (a type of local dry food generally used for snacks), good for latte and siroula (local snacks popular in particular occasions), medicinal uses, used in ceremony, expansion in cooking and good storage quality are preferred by the consumers. It is hypothesized that for each of these preferred traits the consumers pay certain amount.

Some undesirable traits are also identified. The undesirable traits like coarse grain and not tasty do not fetch a price[6]. They are hypothesized to bear negative price in the bundle of properties. As the price is taken for fresh harvest of paddy rice, the milling percent (recovery

[6] The third category is the base category, medium coarse and medium tasty.

of milled rice) is also a concern for the buyer. It is hypothesized that the higher the milling percent the higher the buyer will pay keeping all other traits constant. Geographical area plain (Terai) is fitted to catch the fixed effects of hills and plains.

Table 3: Descriptive statistics of rice traits and price (n=932)

	Variable name	**Variable description constructed)**	**Mean**	**Standard Deviation**	**Expected (predicted) sign**
1	Tasty	Dummy variable showing presence of tasty trait	0.612	0.488	+
2	Aromatic	Dummy variable showing presence of aromatic trait	0.186	0.389	+
3	Good for bitten rice	Dummy variable for presence of traits that makes good for bittern rice	0.190	0.392	+
4	Good for latte & siroula	Dummy variable for suitability for local dishes	0.080	0.272	+
5	Medicinal uses	Dummy variable for presence of medicinal properties	0.101	0.301	+
6	Used in ceremony	Dummy variable for use in special ceremonies	0.183	0.387	+
7	Expansion in cooking	Dummy variable showing presence of expansion trait	0.201	0.401	+
8	Good storage	Dummy variable showing good storability trait	0.277	0.448	+
9	Milling percent	% recovering in milling	62.433	5.817	+
10	Terai area	Dummy variable for geographic area (plain area=1, hill=0)	0.477	0.500	-
11	Main season crop	Dummy variable main season crop=1, summer season=0	0.921	0.271	+
12	Price of paddy at harvest	Rs per 100 kg of rice	1033.870	278.537	

Source: Source: Household survey 2006.

The philosophy behind hedonic pricing model is that nobody pays for a commodity but the people pay for the embedded bundles of utilities of a product. The utilities may or may not be separable. The average price paid by the market to the fresh harvest of paddy is Rs 1,034 ranging from Rs 5,00 to 2,400. If we assume that all the farmers are getting equal market

opportunity, the variation in the price is due to the difference in the quality, that is, the bundle of traits.

The results of linear hedonic model fitted over the above data are presented in Table 4 along with the 95 percent confidence interval of the coefficients estimated. The estimates show that the consumers pay Rs 36 per quintal for a tasty trait. This estimated coefficient is on an average about 3.5 percent of total price of paddy. The estimate is highly significant. It can be inferred that by conserving the landrace with this trait and keeping alive the potential of incorporating this trait to other rice varieties in the world, we maintain the potential benefits of increasing the value of global rice production by over three percent.

Table 4: Factors affecting the price of paddy rice in Nepal

	Variable	**Coefficients**	**Standard Error**	**95% Confidence Interval**	
1	Tasty	36.545**	17.745	1.720	71.371
2	Aromatic	293.438***	21.195	251.843	335.034
3	Good for bitten rice	-50.650***	18.717	-87.384	-13.917
4	Good for latte & siroula	122.198***	28.998	65.288	179.108
5	Medicinal uses	48.242*	28.939	-8.553	105.037
6	Used in ceremony	124.797***	21.517	82.568	167.025
7	Expansion in cooking	-2.839	19.632	-41.367	35.690
8	Good storage	15.132	17.619	-19.446	49.709
9	Milling percent	-5.683***	1.362	-8.355	-3.011
10	Terai area	152.097***	18.763	115.274	188.919
11	Main season paddy	85.310***	26.806	32.702	137.918
12	Constant	1129.073***	92.007	948.505	1309.642
	N	932			
	F(11, 920)	57.99			
	Prob > F	0.000			
	Adjusted R^2	0.402			

Source: Household survey 2006.
*** Significant at 1 % level of significance, ** at 5 % level and * at 10 % level of significance.

Similarly, for the aromatic trait, the consumers are ready to pay Rs 293 per quintal. This is over 28 percent of the average price of the rice. If we lose this aromatic trait, the potential financial loss to the society would be 28 percent of the total value of rice produced globally. This is a huge figure and sufficient to warrant conservation measures. Though the analysis is generalized, there are so many specific traits in the bundle of aromatic. Each of such traits is worth conserving.

But, the rice varieties good for bitten rice is sold at lower price. This finding shows that the traits of rice that makes the variety suitable for bitten rice snacks are valued less as if they have negative impact on utility. Rice varieties with higher moisture content are good for bitter rice, but such rice is less storable. However, the rice varieties having traits suitable for other snacks like *latte* and *siroula* making can fetch higher price by Rs 122 per quintal. Similarly, the traits suitable for traditional healing purposes and use in ceremonies are valued higher than other varieties.

As expected, the traits that makes the rice coarse is valued negatively by the consumers (medium course being the base category). The result also shows that the higher the milling percent lower the consumers are willing to pay. This can not be explained under the assumptions of rational consumers and full information. This is because the consumers generally buy milled rice and hence the milling percent is the concern of the millers not of the consumers. If some consumers buy rice to mill it themselves, the milling percent is experience good that is not known to the buyers at the time of bidding a price. The farmers in plain region are getting higher price of paddy for similar quality as compared to the farmers in hill region. This is due to better transportation and communication facilities in plain areas

for better market connectivity. The independent variables explain over 40 percent variations in the price of paddy.

Rice in Nepal occupies more than a half share of principal food crops. On an average 4.00 million tons of rice is produced every year (GON, 2007) with an estimated value of Rs 41.4 billion using the price estimated from the survey (Rs 10,340 per ton) as the representative at the national level. It means the aromatic traits of rice generate an extra Rs 11 billion per annum for Nepal and tasty traits over two billion rupees. However, there are different landraces with different degree of aroma and different level of taste. A separate study is required to quantify the level of such traits and find the value for each level of aroma and taste.

The analysis apportioned the price paid by the consumers to the value given to different traits. It means protecting each of the preferred trait roughly increased value to the society by certain amount. For example, about one fourth of the value of rice produced can be the value of aromatic trait. This includes use values of rice that arise from the actual use of rice. This use value consists of direct use value of the rice consumption by the households and seeds used by the farmers. The non-use value of rice landrace is not included in this analysis.

Conclusions

The hedonic property valuation analysis apportioned the price paid by the consumers to the value they give to different traits. The study concludes that protecting each of the preferred trait increases the value to the society to a large extent. For instance, the value of the aromatic trait of Basmati or other local landraces can be about one fourth of the value of rice produced globally. For Nepal alone, the aromatic traits of rice have values of about Rs 11 billion and

tasty traits over two billion rupees per annum. There are different landraces with different degrees of aroma tastes. A separate study is required to quantify such traits and find the value for each level of them. This estimation of value includes only the use values of the rice that arise from the actual use consisting the direct use value from consumption by the households and option values generated by an individual's willingness to pay to protect the rice landraces for the future use in rice breeding. The value given by the farmers to use seeds of aromatic landrace is derived from this value given by the consumers.

The conservation of landraces is an expensive venture. Market method of conservation can be effective but still expensive. Attempts are needed to establish new markets for the conservation of landraces with unique traits. For both moral and pragmatic reasons, it is essential either to compensate local poor farmers for maintaining low productive rice landraces or make these landraces better income generating than the improved varieties that are available to them. From a moral perspective, the poor cannot afford to bear the opportunity costs of biodiversity conservation by themselves. The values of different unique traits of rice landraces are estimated to be quite large than the costs of conservation we ever imagine. Therefore, every dollar spent in conservation of such landraces makes the society better off.

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