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Assessment of Food Security through Diversity Assessment of Rice Varieties and It's Adaptation in Kaski District, Nepal

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Abstract Diversity in agricultural crop and their varieties is a basis for sustainable food security. Rice being the major staple food of the country, its contribution to food security is immense. Thus to assess relationship of varietal diversity of rice and food security, a study was conducted in Puranchaur and Lahachok VDC of Kaski District. A total of 120 sample households (60 Puranchaur and 60 Lahachok) were selected at a random for the study. Pre-tested interview schedule was used along with direct observation, focal group discussion, key informant survey and secondary data from different sources in the study. Richness in rice varieties on count basis was found to be significantly higher in Puranchaur than in Lahachok. Similarly, Simpson index and Shannon index of rice varieties was found higher in Puranchaur than in Lahachok. There was significant positive linear relationship between Simpson index and food security. Similarly there was significant positive linear relationship between varietal richness and food security. The result from Logit regression analysis indicates that sex of the household head ($p<0.05$), total land holding ($p<0.01$) and family type ($p<0.01$) has significant impact on decision on diversifying crop varieties. Thus, policy should focus on local adaptation strategies formulation; diversifying crop varieties to improve food security.

Keywords: *rice, diversity, food security, adaptation*

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1. Introduction

Agriculture is a dominant sector in Nepal, accounts more than 65% human resource involvement and contributes to 35% to economy. As one of the least developed country in the world, Nepal has low GDP of US$ 703 [1]. It is estimated that approximately one quarter of the population live below poverty line [2]. Thus food security is a major concerned to those of poor and ultra-poor people.

According to the World Food Summit [3], *food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active and healthy life*. For Asia, IRRI defines rice security as equivalent to food security.

In Nepal, rice is a major staple crop. On the trend analysis of rice area and production of four decades, it shows increasing trend of 0.59 and 1.75 percent respectively [4]. About 40% of calorie intake of people is from rice, production occupies around 20% in AGDP economy and almost 7% in GDP. Hence rice security reflects the food security in Nepal.

Varietal diversity is a key for resilience in agriculture as well as a key for better harvest. By creating functional diversity, crop variety and species mixture can limit pathogen and pest expansion [5]. To buffer crop production from the effects of greater climate variability and extreme events, variety diversification is the most rational and cost effective method. Many agricultural based economies have few other livelihoods strategies [6], thus the development of resilience agricultural systems through varieties diversification is essential since many communities depends on agriculture for livelihood [7].

2. Objectives

- To assess the diversity of rice varieties of the study area
- To relate the diversity of rice varieties with food security level
- To determine factor affecting rice diversity in the study area

3. Materials and Methods

Primary data was collected from field survey of a sample size of 120 famers, each 60 from Puranchaur and Lahachok as shown in Figure 1.

The households were selected randomly and triangulated the data conducting one FGD on each VDC also verified by KII with DADO, ASC and personnel. The collected data were coded, tabulated and analysed by using Statistical Package for Social Science (SPSS), STATA and MS Excel.

Simpson index and Shannon index are used to measures diversity of species. These index are used in agricultural research to measure the varietal diversity [9] as shown in Table 1.

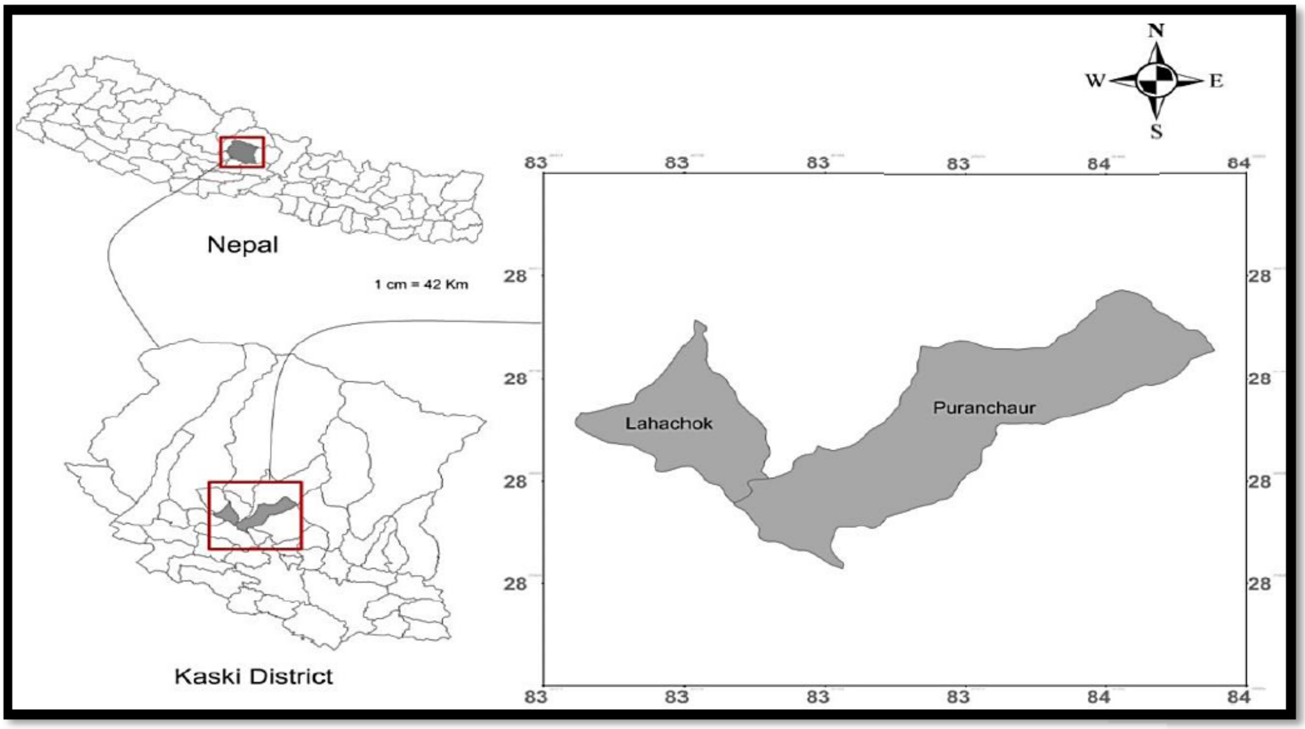

Figure 1: Map of Research Site

Table 1. Assessment Index of Agrobiodiversity

Assessment Index	Formula	References
Richness	$D = n \text{ or } m$ n=number of the varieties m=number of the crop	
Simpson Index	$VDI = 1 - \sum_j \left(\frac{\propto_{ij}}{A_i}\right)^2$ $\propto_{ij}$ is the area planted to the jth variety by the ith farmer and A_i is the total rice area planted by the ith farmer.	[8]
Shannon Index	$SI = -\sum \left(\frac{\propto_{ij}}{A_i}\right) ln \left(\frac{\propto_{ij}}{A_i}\right)$ $\propto_{ij}$ is the area planted to the jth variety by the ith farmer and A_i is the total rice area planted by the ith farmer.	[8]

3.1. Determination of Factors Influencing Decision of Household on Diversifying Rice Varieties

Factors affecting decision of household on diversifying rice varieties was assessed through the Logistic regression model using a bid value of one or zero, where one represents food insecure and zero represents food secure. The logistic regression then provided a model of observing the probability of a household becoming food secure in relation with various factors or variables as shown in Table 2. The probability of adopting adaptation strategies was expressed as,

$$\text{If } Y_i = 1; P(Y_i = 1) = P_i$$
$$Y_i = 0; P(Y_i = 0) = 1 - P_i$$

Where, $P_i = E(Y = 1/X)$ represents the conditional mean of Y given certain values of X.

The Logit transformation of the probability of the practicing stronger adaptation strategies by farmers were represented as follows [10].

$$\text{Ln}\left(\frac{\text{pi}}{1-\text{pi}}\right) = \beta 0 + \sum_{k=0}^{k=11} \beta \text{ixi} + \text{ei}$$

Where Y_i = a binary dependent variable (1, if farmers practicing adaptation practices, 0 otherwise), X_i includes the vector of explanatory variables used in the model, β_i= parameters to be estimated, β_0 = a constant term, ε_i= error term of the model, exp (e) = base of the natural logarithms, L_i = Logit and $[P_i/1\text{-}P_i]$ = odd ratios

i = 1, 2, 3, 4 …n farm households.

Thus, the binary Logit regression model was expressed as:

$$\mathrm{Prob}(\mathrm{Yes}=1)=\mathrm{f}\ (\mathrm{X_i})$$

= f (age of household head (year), sex of household head (0=female, 1=male), education of household head (year), Income (log value), economically active member in family (number), size of land (Ha.), livestock holding (LSU), primary occupation (1=agriculture and 0=other), caste (1= Brahmin/Cheetri 0= other caste) family type (1= Joint and 0= Nuclear) and training on climate change (1=yes, 0=no)).

Table 2. Description of Variables used in the Logit Model

Variables	Expected sign
Continuous	
Age of household head (Yr.)	+/-
Family size(Number)	+/-
Education of household head (Yr.)	+
Total land size (ha)	+
Livestock holding (LSU)	+
Income (log)	+/-
Dummies	
Sex of household head	+/-
Caste	+/-
Family type	+
Primary occupation	+
Training	+

4. Results and Discussion

4.1. Diversity Assessment of Rice Varieties

4.1.1. Contribution of Rice Varieties to Total Number of Varieties in Use and Total Cultivated Area

In the context of rice, total numbers of varieties found in Puranchaur were 28 and in Lahachok were 21. Sorenson similarity index was used to find similarity in varieties grown in two VDCs. Sorenson similarity index among the varieties grown in two VDCs was found to be 0.71. This indicates that 71 percent of rice varieties grown in two VDCs were similar as shown in Table 3. It may be due to similar topographical situation of VDCs.

Table 3. Contribution of main varieties of rice to total number of varieties in use and total cultivated area

Crop (Rice)	Puranchaur	Lahachok	Sorenson similarity index
No of varieties	28	21	0.71
No of main varieties	5	5	
% of total varieties	17.85	23.8	
% of total cultivated area	61.0	67.0	

On the context of top five varieties grown in two VDCs, in Puranchaur out of total varieties five varieties accounted 17.85 percent occupying 61 percent of the cultivated area while in Lahachok it accounted 23.8 percent occupying 67 percent of the cultivated area.

4.1.2. Varietal Diversity

Table 4 shows the diversity indices across the VDCs. The richness in rich varieties on the count basis, in Puranchaur (2.58) was found higher than in Lahachok (2.03) that was statistically significant with mean difference of 0.3. Similarly, the result of richness in cereals on the count basis, in Puranchaur (2.37) was found higher than in Lahachok (2.33) that was statistically insignificant with the mean difference of 0.02.

The Simpson index measures the richness and dominance. The Simpson index in rice varieties, in Puranchaur (0.57) was found higher than in Lahachok (0.50) that was statistically significant with mean difference of 0.02. The Shannon index measures the richness and evenness. Similarly, Shannon index in rice varieties, in Puranchaur (0.81) was found higher than in Lahachok (0.58) that was statistically significant with mean difference of 0.20.

Table 4. Varietal diversity in rice in Puranchaur and Lahachok

Diversity	Puranchaur	Lahachok	t-test
Richness Rice varieties (Count Index)	2.58 (1.24)	2.03 (0.94)	2.741**
Richness Cereals (Count Index)	2.37 (0.98)	2.33 (0.96)	0.25
Simpson index (Rice varieties)	0.50 (0.22)	0.38 (0.24)	2.83**
Shannon index (Rice varieties)	0.81 (0.40)	0.58 (0.38)	3.17**

Figures in the parentheses indicate SD
** indicates significance levels at 1%.

4.2. Food Sufficiency

From the Figure 2, it can be inferred that 40 percent of the respondent in Puranchaur were food self-sufficient compared to 41.7 percent in Lahachok. The respondents having food self-sufficiency of 9-12 months were found lower in Puranchaur (28.33 percent) as compared to that of Lahachok (31.7 percent). Likewise, 20.0 percent of the respondents in Puranchaur were self-sufficient for 5-8 months where this figure was only 18.3 percent in case of Lahachok. Similarly, 11.7 percent of the respondents in Puranchaur were self-sufficient for 0-4 months where this figure was only 8.3 percent in Lahachok as shown in Figure 2.

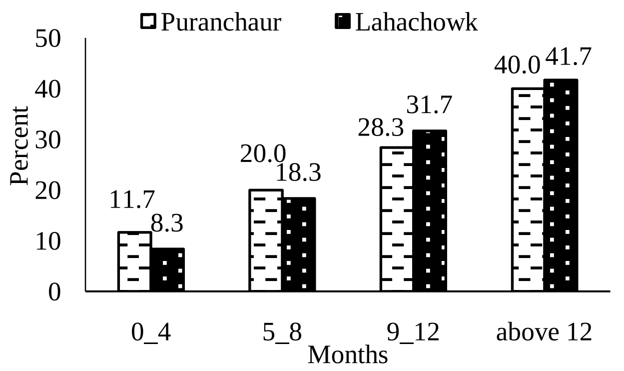

Figure 2. Food sufficiency in Puranchaur and Lahachok VDCs, Kaski

4.3. Food Security and agrobiodiversity

Agrobiodiversity is a strong predictor of food security. Simpson index and rice varietal richness was used to see the relation with categorical food security. Instead of dietary food security value, categorical food security value was used to see the relation with agrobiodiversity in a research conducted in [10]. From his research, the correlation of categorical food security value with Simpson index and varietal richness of rice

Table 5. Correlation of food security and agrobiodiversity indices

Food Security	Simpson index	Varietal richness
Coefficient	2.48**	0.44**
R^2	0.32	0.24

** indicates significance levels at 1%.

There was significant positive linear relationship between Simpson index and food security as shown in Table 5. According to the coefficient of determination, about 31.5 percent of variation in food security was due to Simpson index (evenness and richness) and remaining portion due to other factors as shown in Figure 3.

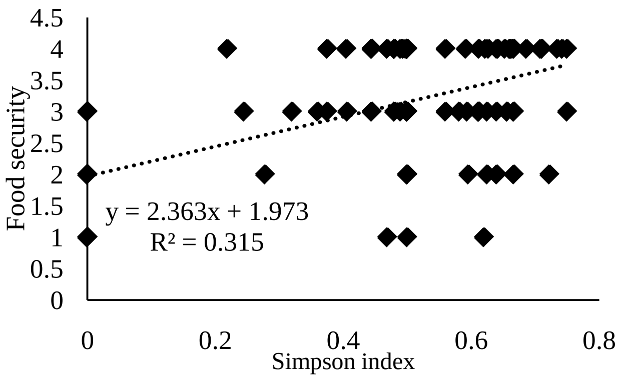

Figure 3. Relationship between simpson index and food security in Puranchaur and Lahachok VDCs, Kaski

There was significant positive linear relationship between varietal richness and food security as shown in Table 5. According to the coefficient of determination, about 24.2 percent of variation in food security was due to varietal richness and remaining portion due to other factors as shown in Figure 4.

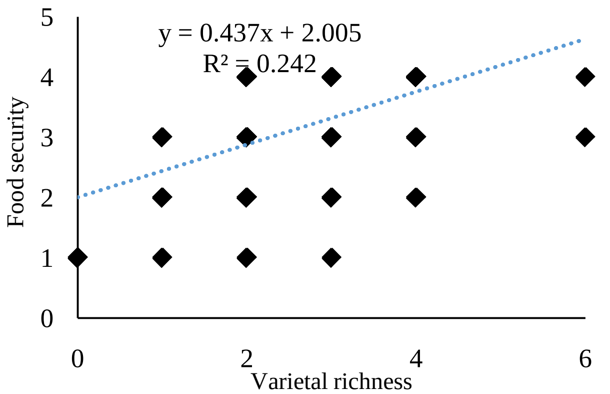

Figure 4. Relationship between varietal richness and food security in Puranchaur and Lahachok VDCs, Kaski

The OLS result indicates that Simpson index and varietal richness has significant positive relationship with food security. It is in the line of finding with [10] that agrobiodiversity indices i.e., Simpson index and varietal richness was a good predictor of food security.

4.5. Determinants on Diversifying Rice Variety on Adaptation Strategies

The binary Logit model was used to determine the determinants of rice variety diversification decision on the adaptation of different prioritized strategies for food security status of farmers. The model assumed that the rice variety diversification decision on the adoption of the adaptation strategy to food security status level at household level by diversifying rice varieties as a binary variable (Y_1) with '1 for adaptation' and '0 for no adaptation'. Based on the literature review and response from the farmers, altogether ten explanatory variables (X_{1i} to X_{10i}) were used for 120 numbers of observations. The explanatory variables in the binary model were sex of household head (X_{1i}), age of household head (X_{2i}), education of household head (X_{3i}), total land area (X_{4i}), Livestock holding (LSU) (X_{5i}), number of economically active member in family (X_{6i}), income (X_{7i}), primary occupation (X_{8i}), training (X_{9i}), and VDC (X_{10i}). Based on these variables adaptation on the climate change impact on farmers were identified and carried out.

Table 6. Statistical description of the different variables used in Logit model

Variables	Mean	Standard Deviation
Dependent variables		
Decision on diversify crop	0.466	0.500
Independent variables		
Continuous		
Age of household head (Yr.)	53.800	11.884
Family Size (No.)	5.850	2.718
Total land size (ha)	0.492	0.341
Livestock holding (LSU)	9.517	34.653
Income (log)	4.394	0.230
Dummies		
Sex of household head	0.842	0.367
Education of household head (Yr.)	5.533	4.701
Primary Occupation	0.725	0.448
Caste	0.700	0.460
Family type	0.525	0.501
Training	0.092	0.290

Summary Table of Table 6

Number of observation (N)	120
Log likelihood	-39.673
LR Chi ^{2}	37.93*** (Prob>chi^2=0.0001)
Pseudo R^2	0.323
Goodness of fit	Pearson Chi2 (106)= 103.91 Prob>chi2 = 0.539
Area under the ROC curve	0.858
Overall correct prediction	85.83%

Logit regression analysis focused on the 120 respondent household from Lahachok and Puranchaur. The LR Chi^2 for this model indicates that, the model has good explanatory power at the 1 percent level of significance. The Pseudo R^2 was 32.3 percent. The predictive power of the model was 85.83 percent, which was quit high. For the interpretation of the model, marginal effects were driven from the regression coefficients, calculated from partial derivatives as a marginal probability. The results are shown in Table 7.

The result from the Logit regression for factors affecting decision on diversifying rice varieties that are sex of the household head, total land and family type are statistically significant holding other factors constant as shown in Table 6.

Sex of household head was negatively significant (p<0.05) in affecting the decision on diversifying rice varieties of the study area. From the findings, being male household head will decrease the probability of decision on diversifying rice variety by 6.9 percent compared to those with female household head. Similar finding was found in a study in Africa by [11] that female-headed households are more likely to take up climate change adaptation methods than male.

Land size was positively significant (p<0.01) in affecting the decision on diversifying rice varieties of the study area. From the findings, it can be concluded that keeping other factor constant, increase in one unit of land size will increase the probability of decision on diversifying rice variety diversifying by 38.3 percent. It is in line with the finding of [12] that farm size has a significant and positive effect on the decision to adopt a new technology.

Family type was positively significant (p<0.05) in affecting the decision on diversifying rice varieties of the study area. From the findings, keeping other factor constant, a unit increase in the chance of family being joint, probability of adoption would increase by 13.3 percent compared to those with nuclear family. It is in line with the finding of [13] who reported that higher size of the household reduces the labour constraints and influence the adoption of new technology positively.

Table 7. Factors determining decision on diversifying rice varieties condition of the households using logit regression model in the study area

Variables	Coef.	S E	p>|z|	dy/dx
Sex (#)	-2.461	1.222	0.044	-0.069*
Age of HH (Yrs.)	-0.009	0.303	0.762	-0.0004
Education (Yrs.)	-0.003	0.070	0.962	-0.0001
Total Land (ha)	7.631	2.240	0.001	0.383**
LSU	0.006	0.006	0.318	0.0003
Family size (No.)	-0.229	0.120	0.057	-0.011
Income (log)	-1.194	1.649	0.469	-0.060
Primary Occupation (#)	0.109	0.716	0.879	0.005
Caste (#)	-0.020	0.638	0.974	-0.001
Family type	2.200	0.803	0.006	0.131**
Training (#)	0.433	1.418	0.760	0.018
Constant	6.974	7.746	0.365	

Indicate the variable as dummy. (N=120)
dy/dx indicates the margin.
* And ** indicates significance levels at 5% and 1% respectively.

5. Conclusion

Richness in rice varieties and cereals on count basis was found to be higher in Puranchaur than in Lahachok. Similarly, Simpson index and Shannon index of rice varieties was found higher in Puranchaur than in Lahachok. There was significant (p<0.01) positive linear relationship between Simpson index and food security. There was significant (p<0.01) positive linear relationship between varietal richness and food security. Thus we can conclude that diversity in rice variety is a good predictor of food security.

The result from Logit regression analysis indicates that sex of the household head (p<0.05), total land holding (p<0.01) and family type (p<0.01) have significant impact on decision on diversifying rice varieties.

Further research should focus on role of agrobiodiversity conservation, its importance to disadvantage group and relationship of dietary security and agrobiodiversity. And policy should focus to promote awareness of agrobiodiversity to disadvantage groups for better nutrition security.

Conflict of Interest

The authors declared that they have no conflict of interest.

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