Technology Adoption and Household Food Security. Analyzing factors determining technology adoption and impact of project intervention: A case of smallholder peasants in Nepal.*

KARKI, Lila Bahadur **
BAUER, Siegfried ***

Abstract

Despite substantial effort from both public and private sectors, the food insecurity is still a major challenge for millions of Nepalese. Localized diffusion, cost ineffective technology and inappropriate policies have become major hindrances to adopt improved technologies for smallholder peasants. Therefore, this study was conducted in a mid-hill district of Nepal to assess the impact of foreign-aided project in technology adoption and food security and identify factors determining adoption of improved technology in case of smallholder peasants. A household survey was conducted to collect primary data. The collected cross sectional data were analyzed using descriptive statistics, Logit binomial model and qualitative analysis. Empirical findings revealed that timely availability of credit, years of schooling, off-farm income, extension service, project intervention, farm size and experience of the farmers significantly influenced their adoption decisions. There would be a tremendous influence of project in transferring technology, alleviating food insecurity and increasing household economy if the determinants of adoption are properly addressed in future projects and programs.

1 Introduction

The agricultural sector is the backbone of Nepalese economy though it is characterized by traditional subsistence oriented farming. The paramount of this sector is reflected by its 39.2 percent share to national GDP and absorption of 81 percent labor force (ABPSD, 2002). The average agricultural growth rate has been recorded 3.3 percent per annum as compared to 2.25 percent annual population growth rate. The livestock sector is an indispensable component to sustain agricultural system, which contributes 31.5 percent to agricultural and 18 percent to national GDP. Nepalese agricultural system is sustained by livestock, which provides more than 91 percent draft power required to agricultural operation and more than 90 percent of the total fertilizer for food grain production (ADB, 1996). However, geo-physical constraints, severely resource constrained peasants and some stereotyped socio-cultural factors have hindered the pace of livestock production. Generation and diffusion of innovations are continued by an unflinching endeavor over the years, but in a dawdling motion.

Government's plan to develop the livestock sector has been followed by introduction of improved breed of exotic farm animal as a seed to multiply through upgrading indigenous species has not rigorously implemented. Moreover, upgrading alone could not meet the expected goal since the other wheels (feeds, health and management) have been not embedded into a package. As SHERCHAND, (2001) reported that farm ruminants are in shortage of feeds by 35 percent. Therefore, bringing sustainable technology package into application would help overcome this dilemmatic situation locally. The Hills Leasehold Forestry and Forage Development Project (HLFFDP) taken into study was one of those. Despite such continuous endeavour of government and donor agencies there has not been substantial improvement in peasants' living standard. Therefore, this study was designed to identify the factors determining technology adoption and influence of project on such process so that future project and programs can bring significant improvement in the household economy.

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** PhD, *** Professor, Dr.,. University of Giessen, Institute of Project and Regional Planning, Senckenbergstrasse-3, D- 35390, Giessen, Germany.

2 Technology adoption

Adoption is a mental process through which an individual passes from hearing about an innovation to its adoption that follows awareness, interest, evaluation, trial, and adoption stages (ROGERS, 1962). This five-stage model is called "the innovation-diffusion model". Diffusion is defined in relation to the spread of an innovation at the aggregate level viewed over time. Diffusion is the cumulative process of adoption measured in successive time periods in five categories: innovators, early adopters, early majority, late majority and laggards.

According to the economic constraints model (AIKENS *et al.*, 1975), resource endowments are the major determinants of observed adoption behaviour, where lack of access to capital and inadequate farm size could significantly impede adoption decisions. The more technically complex the innovation, the less attractive it may be to many farmers. The decision of whether or not to adopt a new technology will be based on careful evaluation of a large number of technical, economical and social factors associated with the technology. The economic potential of new technology in terms of yields, costs of production and profit are also very important factor for adoption decision. Typically, however, the economic impact of an innovation is not known in advance with certainty. Unfamiliarity with the new technology makes the initial impact on yields and input usage uncertain.

Concerning the situation of rural producers of a developing and under developed countries like Nepal, adoption of modern technology is urgently required to increase the productivity so as to meet the increasing demand of food (cereals and animal products) for rapidly growing population. The adoption of modern technologies, especially in subsistence farming, would be governed by a complex set of factors such as human capital, information, location, resource endowments and institutional support. Within this frame condition, farmers' decision depends on their needs, cost incurred and benefit accruing to it would be the major motivating factors for the acceptance or rejection of a particular technology (KARKI, 2004).

3 Materials and methods

3.1 Methodological approaches for impact evaluation

According to BMZ "Federal Ministry for Economic Cooperation and Development" in Germany (2000), impact generally denotes aggregate changes observable after the completion of the whole project. CASLEY and LURY (1985) defined, impact is to determine more broadly whether the program had desired effects on individual, households and institution. FAO "Food and Agriculture Organization" (2000), impact refers to the broad, long-term economic, social and environmental effects resulting from intervention. Such effects generally involve changes in both cognition and behavior. There are two major approaches according to PITT and KHANDKER (1996), KERR and KOLAVALLI (1999), GTZ "Deutsche Gesellschaft für Technische Zusammenarbeit" (2000), and BAUER (2000, 2001) to evaluate the impact of a project intervention:

(1) Before and After approach: This approach compares the conditions of the same households before the project was introduced and after the termination of the project, and **(2) With and Without approach** compares the conditions of the farmers involved in the project with the conditions of the farmers without the project activities. This approach is considered more appropriate in a situation where obtaining baseline data is problematic. Moreover, isolation of influence of exogenous factors with this approach is relatively easier than with the former one. Therefore, this approach was applied as a research methodology in this study.

3.2 Data collection

Samples were chosen by randomization in order to capture the difference between ***with*** and ***without*** groups only due to project intervention. For the purpose, a household survey was conducted to collect primary data applying multi-stage random sampling procedure that consisted of 120 households with 60 beneficiaries from the project area and 60 households from non-project villages. The beneficiaries were the primary stakeholders of the project in Kavrepalanchowk district, Nepal. The project objectively planned to work with small farmers under poverty line to raise the income of the livestock farmers and improve the ecological conditions of the degraded land.

3.3 Model selection

The model used to examine relationship between adoption and determinants of adoption involved a mixed set of qualitative and quantitative analyses. Qualitative models have been used extensively in adoption studies although they have been criticized for their inability to account for partial adoption (FEDER *et al*., 1985). Alternative specifications of qualitative choice models include the linear probability models: the Probit model and the Logit model. These are the two most frequently used applications in explaining the socio-economic phenomena, especially for analyzing the relationship between dependent discrete variables (adoption) and explanatory variables (POLSON *et al*., 1992). Both the Probit and Logit models yield similar parameter estimates and it is difficult to distinguish them statistically. Of these two models, the binomial Logit model is easier to estimate and simpler to interpret (ABEBAW and BELAY, 2001).

To measure an outcome of such discrete output, a variety of multivariate statistical techniques can be used to predict a binary dependent variable from a set of independent variables. Multiple regression and Discriminant analysis are two techniques for this purpose. However, these techniques pose difficulties when the dependent variables have only two values, 1 if the event occurs and 0 if it does not. The Binary Logit Regression Model (BLRM) is considered appropriate in such a situation (POLSON *et al*., 1992). It requires far fewer assumptions than the other two mentioned above, and even when the assumptions required for Discriminant analysis are satisfied, it still performs well (HOSMER and LEMESHOW, 1989; KLEINBAUM 1994). It is also called “Logit”, which is applicable to a broader range of research situations and is able to predict the presence or absence of a characteristic or outcome based on values of a set of predictor variables. It is similar to a non-linear regression model but is suited to models where the dependent variable is dichotomous. There is flexibility in the model where independent variables can be interval level or categorical; if categorical, they should be dummy or indicator. Therefore, the binomial Logit model was used in this study.

The relationship between the independent variable and probability is non-linear. The probability estimate will always be between 0 and 1, regardless of the value of Z in the Equation 2. The parameters of the model were estimated using the maximum-likelihood method. That is, the coefficients that make the observed results most likely are selected. Since the Logit regression model is nonlinear, an iterative algorithm is necessary for parameter estimation. The coefficients in this model are tested by the Wald statistics, which has a Chi-square distribution and t statistics.

3.4 Description of the variables included in the model

In the study, improved technology refers to improved breed of farm animals (cattle, buffalo, goat) and hybrid poultry, plantation of fodder trees, cultivation of improved cultivars of forage crops, land utilization techniques (terracing, use of ridges), management of pasture land (controlled grazing), and feeding techniques (stall feeding).

While selecting the variables to be included in the model, attempt has been made to include the most important factors influencing adoption decision in subsistence farming. Of the variables included in the model, positive relationships was expected in case of farm size, timely availability of credit, extension service, technical training, family size, off-farm income, education level, affiliation to farmers’ groups, and participation in the project activities; whereas food security, experience of the farmers (age), and easy access to community pasture land were presumed to have negative influence on adoption decision.

3.5 The Empirical Model

The Logit multiple regression model containing 12 predictors specified in Equation 2 was regressed against dependent binary variable of technology adoption (TECHADOPT) in order to identify the factors influencing adoption of improved technology, to assess the impact of project intervention on adoption process and to estimate the probability of adoption between the two groups.

$$\Pr ob(TECHADOPT = 1) = 1/(1+e^{-z}) \quad (1)$$

$$Z = \beta_0 + \sum_{i=1}^{n} \beta_i X_i + \varepsilon_j \quad (2)$$

Where, TECHADOPT = a dichotomous dependent variable (1 if technology adoption takes place, 0 otherwise), X_i includes vector of variables included in the model, β_i = parameters to be estimated, ε_j = error term of the model, e = base of natural logarithms

In order to know the probability of technology adoption for each farm household, the predicted probability was calculated as suggested by ROSENBAUM and RUBIN (1985); BAKER (2000); WALLE (2001). According to them, the treatment groups can be compared with control groups using predicted probability created through Logit regression. The difference is the estimate of the gain due to the program for that particular observation.

Table 1: Estimated parameters of factors affecting technology adoption

Variables	Notation	Coefficient	Standard.error	Wald Statistics	Significance
Constant	β_0	5.422	1.781	9.269	0.002
Farm size	X_{1i}	0.049	0.025	3.833**	0.047
Training	X_{2i}	0.021	0.712	0.001	0.978
Credit availability	X_{3i}	3.385	1.409	5.770**	0.016
Experience	X_{4i}	-0.193	0.071	7.517***	0.006
Family size	X_{5i}	-0.226	0.359	0.397	0.529
Education	X_{6i}	3.273	1.427	5.259**	0.022
Off-farm income	X_{7i}	2.171	1.097	3.913**	0.048
Food security	X_{8i}	0.408	0.292	1.955	0.162
Project participation	X_{9i}	5.345	0.912	34.340***	0.000
Pasture land	X_{10i}	-0.187	0.837	0.057	0.823
Extension service	X_{11i}	3.220	1.389	5.375**	0.020
Group member	X_{12i}	-0.049	0.238	0.042	0.838

Chi -square (df = 12) = 142.61
(-2) Log likelihood = 147.85
Accuracy of prediction overall (%) = 89.20
Nagelkerke R^2 = 0.79
Note:*** and ** indicate significance at 0.01, and 0.05 probability level respectively

4 Model results and discussion

The positively significant coefficient of farm size indicates its positive influence on technology adoption which was as presumed. The adoption rate was found to be increase by 0.49 percent in every one unit increase in holding size. Subsistence oriented small farmers are highly risk averse to apply innovation due to limited holding and uncertain outcome of technology. The positively significant coefficient of credit was as expected. It implies that the availability of credit encourages farmers to adopt improved technology. The farmers who received credit were found to adopt improved technology 3.38 times higher than those by the non-receivers. Resource constrained farmers, primarily the subsistence ones, seemed reluctant to apply innovation when timely availability of credit was problematic. The coefficient of experience was negatively significant, which implies that the older the farmers, the less the probability of adopting an innovation. It means the risk aversion factors increases with increase in experience and age. This characteristic incites them to be more skeptical to innovation and resistant to change, as a result they belong to late adopters or laggards category. ABEBAW and ABELAY (2001); THIRTLE *et al.* (2003) reported similar findings. A converse result would presumably be found with younger farmers.

The coefficient of years of schooling was positively significant, which implies that the adoption increases with the increase in years of schooling. The coefficient of education was expected positive to decrease risk aversion behaviour and increase the rate of adoption. This result is consistent with the findings of ADHIKARY (1994). The coefficient of off-farm income was found positively significant, which implies that it widens the possibility of adopting an innovation by mitigating the shortage of capital input. Households without off-farm income are likely to be highly risks averse. Similar results have been reported by THIRTLE *et al.* (2003). The coefficient of extension service was found positively significant, which implies that regular visit of an extension worker is necessary to enhance the rate of adoption. As extension service popularizes the innovation by providing necessary information, knowledge and skills in order to enable farmers to apply innovation. Majority of the farmers in rural areas of Nepal have not been able to obtain technological information due to lack of know-how, transportation facilities, access to communication medias and technical training. This finding is in conformity with other studies (ABEBAW and ABELAY (2001). Farmers who were involved in the project had a higher probability of applying innovation. It was presumed that they were privileged with material and managerial support, followed by timely availability of knowledge and skills, which apparently helped them apply new technology as innovators and early adopters. Its largest positively significant coefficient indicates positive impact of project interventions on technology adoption. Thus, the Logit model confirms that the variables with positively significant coefficients enhance the adoption of technology. Lack or inadequacy of any of these variables could hamper the adoption decision.

According to theory of score matching and predicted probability, the mean predicted probability of technology adoption with project farmers was found higher (0.87) than non-project farmers (0.32). The difference or gain in the probability (0.55) between the two groups of farmers (project and non-project) could be due to project intervention ensuring higher technology adoption. The model was able to explain 79 percent relationship between the variables and the adoption probability and 89 percent of the sample cases correctly.

5 Impact of project on:

5.1 Technology adoption: In addition to the impact of project on variables influencing technology adoption as shown by Logit model, its impact on technology adoption (package of activities) was triangulated using Cross Table Analysis. The result presented in Table 2 revealed its positive impact since the coefficient of technology adoption between the groups was found positively significant.

Table 2: Impact of project on technology adoption (Cross table analysis)

Activities	Farmers type	% adopter	% non adopter	df	Pearson X^2	Likelihood ratio	Signi-ficance
Application of livestock and related technology	Project	78.3	21.7	1	36.31***	38.41	0.000
	Non-project	23.3	76.7				

*** indicate significance at 0.01 probability level

Besides the results on difference in adoption, the findings such as the degree of adoption of improved animals was higher with treatment group (62%) as compared to control (10%). The number of saplings planted, area allocated for forage cultivation and biomass production were found significantly different between the two groups at 0.001 probability level.

5.2 Technology dissemination: Extension service has been considered as a major means of technology dissemination. It refers to the type of extension service rendered amongst the farmers to disseminate livestock and related technology. The service was enhanced by the project amongst beneficiaries. The extension service received by the project farmers was compared with non-project farmers using Cross Table Analysis, and the result has been presented in Table 3.

Table 3: Impact of project intervention on technology dissemination (Cross table analysis)

Activities	Farmers type	Frequency of extension service# (%)			df	Pearson X^2	Likeli hood ratio	Signi ficance
		1	2	3				
Availability of extension service	Project	30.0	43.3	26.7	1	36.99***	39.48	0.000
	Non-project	5.0	13.3	81.7				

*** indicate significance at 0.01 probability level

#: 1 = regular, 2 = irregular, 3 = available only on request of the farmers

Provision of regular as well as irregular extension services was found higher with the project farmers than with the non-project farmers. Only about 26.7 percent of project farmers had to request extension workers in order to have their services, whereas the majority of the non-project farmers (81.7%) had to request extension workers for the necessary services. The coefficient of availability of extension services was found significantly different between the two groups showing a positive impact of project intervention on disseminating technology at households level.

5.3 Factor productivity: The commodity factor productivity (CFP) and total factor productivity (TFP) were analyzed at a point in time in order to measure the relative technical efficiency of the individual farmers and compared with average TFP. The impact of project can be traced based on the analyzed results presented in Figure 2 which revealed that the ratio were found to be higher with project farmers as compared to that of non-project farmers. The greatest difference in the CFP ratio between the groups was found in poultry and the least was in buffalo. The difference in CFP ratio for other two commodities (cow and goat) between the groups was much less as compared to that of poultry. Similarly, the average TFP was also found higher with the project farmers (1.98) as compared to that with non-project farmers (1.64).

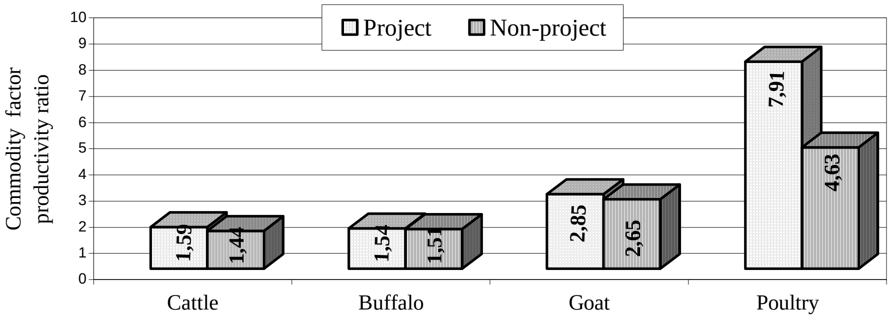

Figure 2: Commodity factor productivity (CFP) ratio of livestock enterprises

6 Concluding remarks

Application of innovation is one of the paramount means of increasing productivity primarily in subsistence farming where factors of production are highly scarce. The findings of this study substantiate that adoption decision is strongly influenced by availability of credit, level of education, extension service, level of income, participation in the project, farm size and experience of the farmers. Therefore, it is urged that future project and programs be focused on delivering services and inputs to promote the first four determinants of adoption decision since the later two can only indirectly be enhanced by the project. More importantly, the positively significant influence of off-farm income on adoption can only be substituted if future project incorporates reasonably more income generating activities along with technology package in order to make resource poor producers able to afford improved technology.

In a broad perspective, future projects should focus primarily on capacity building approach that enhances the competency and problem solving capacities of beneficiaries and other stakeholders of a community so that they would be able to apply their acquired knowledge and skills in selecting and running enterprises independently even after the termination of the project so as to solve food insecurity problem and raise their living standard.

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