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Factors influencing farmers decisions to technological adoption for enhancing livelihoods security in Rudraprayag district, Uttarakhand, India

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Abstract
This paper summarizes the results of an adoption study conducted in between 2014 and 2016 in district Rudraprayag, Uttarakhand, to determine the level and extent of adoption of selected technologies. This study aimed to identify reason of low adoption rates and policy lapses in adoption of technologies for future conduct of research and research-extension linkages. A sample of 604 household from 64 villages was randomly selected from three different blocks of the district to determine the distribution of adoption of the technologies. Semi-structured questionnaire and interview method were used to collect the primary data and survey questions used to identify the factors that affect farmer's decision on adoption of technology. Adoption rate was highest for the cases of inorganic fertilizer (52.21%), improved seed (19.48%), bio/vermicompost (11.03%), polyhouse (9.93%), water harvesting tank (6.99). The high rates of adoption may be due to extensive diffusion of technology. The results of the logistic regression model show that the age and education of household head (HHAge and HHEdu), land size (TLand), institutional support for adopting the new technology (InsSupp) and farmers cosmopoliteness (Cosmopo) are the main determinants of the adoption of new farm technology. The model shows that after keeping the other variables constant, the effect of variables such as age and education of the household head, area of agriculture land, institutional support and cosmopoliteness, favours adoption. This study will assist the policy makers to develop and extent area specific suitable technology with proper technical know-how for higher extension and adoption of the technology.

Keywords: Technology, adoption, extension, farmer's decision, cosmopoliteness

Introduction
India is one of the world's fastest growing economies. But the challenge is how to ensure future development in a sustainable and inclusive manner. The country has numerous challenges in different nature in terms of health, education, skills, agriculture/rural development, energy and so on. Challenges have also been imposed by exclusive and inequitable access due to multiple deprivations of class, caste and gender. Therefore, the government may consider expanding the scope of technological adoption through its extension programs. Modern machinery allows technically highly efficient farming and resource conservation. Innovative approaches and solutions, and looking beyond the conventional mode of performing various tasks are required to solve these problems. Innovative technologies could play a pivotal role not only in bringing about triggered growth and competitive environment in it, but also ensure inclusion of vulnerable groups in addition making the development environmentally sustainable.

The vast majority of farmers in developing countries like India are smallholders, with an estimated 85% of them farming less than two hectares (World Bank, 2007) [28]. These farmers mostly dependent on agro-based activities for their livelihood, but over 30 to 35% of them are threatened by the problems of unemployment and food insecurity. Hence, World Development Report (2008) [27] emphasized that the potential of agriculture to contribute to growth and poverty reduction depends on the productivity of smallholder farmers. And raising that productivity will require a much higher level of adoption of new agricultural practices and technologies than presently observed in the smallholder farming population (De Janvry & Sadoulet, 2002; World Bank, 2007) [28].

The agriculture of Uttarakhand is mostly rainfed and there is not much surplus for the market. As a result most of the able-bodied men have migrated to other places in search of employment and other diversifies their income through non-farm activities. Mostly women are left in the villages and they have started looking after the farms. The challenge is to change this structure and create employment opportunities through agriculture and allied activities.

This could be done by diversifying the agricultural pattern and technological adoption, so as to create alternative income and better living standards. The alternative areas of diversification are towards horticulture crops, spices and condiments, tea plantations, and herbal and medicinal plants cultivation with new practices/technologies. Development of protected cultivation, organic farming, small post harvest processing units, water conservation and harvesting practices for irrigation, bee-keeping, cross breed animal rearing, use of high yielding seeds, improved agricultural implements etc. are better options for sustaining agriculture-based livelihood in the hilly regions.

This study examines the informational origin of the technological intervention, factor affecting farmer's decision to adopt technology and policy lapses in the adoption of technologies.

Material and Methods

Study Area

The present study focuses on Rudraprayag district of Uttarakhand that falls in Lesser and Higher Himalayan terrain. The district is delimited by $30^0$19' to $30^0$49' N latitudes and $78^0$49' to $79^0$21' E longitudes at an altitudinal range of 650 to 4000 m asl. According to Census of India (2011) [11] the district has 688 villages and 3 developmental blocks (Agustmuni, Jakholi, Ukhimath). The total population of the district is 2,42,285 which is 2.4 percent of the state population and it is the least populous district of Uttarakhand.

Material and Methods

The present study was carried out in Rudraprayag district of Garhwal Himalayan region. This study was intended to address the household level livelihood strategies and adoption pattern of different agriculture based technologies/innovations. This study is based on primary data and analysis of these data's.

For the collection of primary data a Multistage random sampling method was used and a complete inventory made at household level for each selected villages with the help of semi-structured questionnaires and personal interviews with local mature and knowledgeable persons. 64 villages were randomly selected from all the three blocks of district Rudraprayag for collection of primary data. Primary data were collected from 604 randomly selected households in between August 2014 and June 2016. Data collection on basic household's attributes such as gender of household head and income, various technologies and government services used by farmers were gathered. All the respondent participated for this study were read about the purpose of the interview verbally and prior oral consent was obtained. The data were analysed by using SPSS 16 software.

Conceptual Framework and Model Specification

Adoption of new technology/innovations by farmers is a gradual process that involves processing of information and decision-making to optimize the use of household productive assets (Faham *et al.*, 2008) [14]. Farmers will go through stages of trial and reflection to increase their understanding of the positive and negative aspects of the technology adoption, and ultimately arrive at a final decision on whether to adopt (Jawaid *et al.*, 2015) [18]. The decision can be influenced by a wide range of factors, including the age and education of the household head, land size, farmers cosmopoliteness, institutional support, extension services and remoteness e.g. lack of access to markets, transportation facilities, unavailability of planting materials and other necessary inputs and also external factors including product prices; and even government policies in relation to regular supply of input and product purchasing. Because the dependent variable is the adoption of whether or not to adopt, and many factors have including categorical variables have been found influence this decision, the decision was made to characterize the uptake of technology by farmers through the use of logistic regression (following Negi, 1993) [21]. Binary logistic regression is a statistical technique used to estimate the probability of the dependent variables which is dichotomous in nature, as a function of explanatory variables that are hypothesized to shape the outcome. The dependent variable for the present case is the adoption or non-adoption of new technologies, which takes a value of 1 if a farmer is an adopter and value 0 otherwise. The nature of the dependent variable suggests the discontinuous relationship and the non-applicability of the ordinary least square method (Jawaid *et al.*, 2015) [18]. The binary logistic regression model applied in the analysis and facilitates to identify the factors that influence the adoption of new farm technologies. The model parameters were estimated and statistical tests performed using SPSS 16.

The derivatives of the likelihood estimates of the coefficients of influencing factors yield the probability of being in one of the two groups (adopters or non- adopters). Each coefficient is a measure of the strength of response of the dependent variable for the independent variables. For the present study, a number of contextual variables were regressed with the dependent variable Y to derive estimates of the parameters (β_i values). The binary logistic model is specified as:

$$E(Y)= \beta_0 + \beta_1 * X_1 + \beta_2 * X_2 + \beta_3 * X_3 + \beta_4 * X_4 + \ldots\ldots\ldots\ldots..+ \mathcal{E}$$

where the β_is are population parameters of the model to be estimated, X_i are the explanatory variables, and $\mathcal{E}$ is an error term.

Result and discussion

The selection of the variables for the model as reported in table 1 is based on various agricultural decision-making premises. For instance, one is that a young head of a family has a greater chance of adopting new activities than an older head of a family. The intrinsic and extrinsic quality of decision-making of farmers increases with increase in the education level of the farmers. Thus, a farm household with a young and educated head has a higher probability of adopting new farm technology compared to the family which does not have these attributes. This similar situation occurs for farmers with a large land holding, institutional support and who are cosmopolite, because they have more liberty to allocate land and institutional support with wide exposure to explore new technologies and gain technical know-how, for instance polyhouse, which needs huge investment and technical knowledge about cultivation within polyhouse. Technical knowledge about an activity, whether acquired through self-learning or obtained from extension services is also an important contributor to its adoption. Thus, the farmers experience through other's field exposure (cosmopoliteness) is expected to have a positive effect on the adoption of technology. Extension services like awareness campaign regarding new technology options for enhancing farm productivity, institutional support such as subsidies, loans and insurance are also key factors that result in favourable attitudes among farmers towards the adoption of related technologies (Siriri *et al.*, 2000) [26].

Table 1: Description of explanatory variables used in binary logistic analysis for the adoption of new farm technologies

Parameter	Description
HHGend	Gender of the household head
HHAge	Age of the head of household
HHEdu	Education level of head of family
HHSize	Household size
IncomeL	Monthly income level
TLand	Total agricultural land
InsSupp	Institutional support for the adoption of relevant technology
ExtSer	Extension services
Cosmopo	Farmers cosmopoliteness
Remotnes	Remoteness (lack of transportation and other necessary services)

The model adequacy is judged by the Nagelkerke R^2 statistic. The strength of the relation is measured by the Percent Concordant. The logistic regression model was assessed using the Hosmer and Lemeshow Goodness of Fit (GOF) test. This test compares the expected and observed frequencies of events in bins defined by the predicted probability of the outcomes (SAS Institute Inc., 2008) [24]. Table 1 provides the details of the explanatory variables included in the model, i.e. the regression model hypothesizes that the considered explanatory variables explain the technology adoption decision.

Adoption of Improved Technologies/Innovations

The distribution of the farm households based on their adoption of improved innovations is presented in Table 2. The table revealed that the most adopted technology was the use of inorganic fertilizer, improved seed, bio/vermicompost, polyhouse, water harvesting tank, etc. The high rates recorded may be due to their wide diffusion which in itself results from a series of individual decisions to begin using the new technology, decisions which are often the result of a comparison of the uncertain benefits of the new invention with the uncertain costs of adopting it. The low technology usage as in the case of power tiller and thresher services is circumscribed by land fragmentation which hinders farm mechanization and also the high cost of these technologies. Azola culture is recently introduced in the village Butolgaon by Manav Bharti organization for demonstration purposes. Only four families of the village adopted this technology, they use azolla as an animal feed and recognize a good animal feed. The result in table 2 suggests that ample opportunities exist for the farmers to increase their use of new technologies and thus improve the productivity and in terms increase their income.

Table 2: Adoption of improved technologies/innovations

Adopted Technologies	Agustmuni (Total Household 272)		Jakholi (Total Household 155)		Ukhimath (Total Household 177)	
	Frequency*	Percentage (%)	Frequency*	Percentage (%)	Frequency*	Percentage (%)
Polyhouse	27	9.93	6	3.87	15	8.47
Bio/ Vermicompost	30	11.03	10	6.45	15	8.47
Improved seeds	53	19.48	27	17.42	34	19.21
Inorganic Fertiliser Use	142	52.21	31	20.0	28	15.82
Water Harvesting Tank	19	6.99	4	2.58	2	1.23
Biogas	10	3.68	1	0.65	0	0.00
Azola culture	4	1.47	0	0.00	0	0.00
Bee-keeping	7	2.57	23	14.84	21	11.86
Power tiller	2	0.74	0	0.00	0	0.00
Thresher	9	3.31	0	0.00	0	0.00

* Multiple responses recorded

Factors Influencing Adoption of Innovations/Technologies

The factors influencing farm households' decision about adoption of new technologies were analysed by using the logistic regression model. The factors include gender and age of the household head, the level of education of household head, income level, farm size, institutional support, extension services, cosmopoliteness and remoteness of the area.

Table 3: Estimated coefficients and other statistics of the logistic regression equation (adopter- 58 (except the inorganic fertilizer user due to small quantity and negligible effect on crop productivity) and non-adopter- 546)

Variable	Regression coefficient (B)	Standard Error (S.E.)	Wald	Significance	Exp(B)	Lower CI	Upper CI
HHGend	0.204	0.654	0.097	0.755	1.227	0.340	4.422
HHAge	-0.167	0.038	19.187	0.000*	0.847	0.786	0.912
HHEdu	0.238	0.115	4.306	0.038*	1.269	1.013	1.590
HHSize	-0.090	0.223	0.161	0.688	0.914	0.590	1.416
IncomeL	0.345	0.238	2.100	0.147	1.412	0.885	2.252
TLand	0.053	0.019	7.991	0.005*	1.055	1.016	1.094
InsSupp	-2.306	0.691	11.143	0.001*	0.100	0.026	0.386
ExtSer	1.013	0.561	3.260	0.071	2.753	0.917	8.267
Cosmop	5.875	0.738	63.310	0.000*	356.149	83.772	1.514
Remotnes	-0.094	0.535	0.031	0.860	0.910	0.319	2.598
Constant	-0.182	1.935	0.009	0.925	0.834		

Percent concordant =92.1, Cox & Snell=0.31, Nagelkerke R^2= 0.72, -2 log likelihood=113.67, Hosmer & Lemeshow goodness of fit test= 2.26 (p=0.97)

Logistic regression was used to estimate the relationship between the dependent variable and the explanatory variables through maximum likelihood estimates of parameters. The estimated parameters characterize the adoption behavior of the farmers. The significant likelihood ratio test showed that for the farmers, the estimated models with a constant and the set of explanatory variables fit the data better compared with those containing the constant only. The value of close to one of the Nagalkere R^2 and the high p value of the Hosmer and Lemeshow Goodness of Fit test showed the GOF of the model. In addition, the high association of predicted probabilities and observed responses, i.e. percent of concordances, suggest that the estimated adoption model had a good explanatory power.

The results of the logistic regression show that the age and education of the household head (HHAge and HHEdu), area of agriculture land of the households (TLand), institutional support for adopting the new technology (InsSupp) and farmers cosmopoliteness (Cosmopo) are the main determinants of the adoption of new farm technology at 5% level of significance. The model shows that after keeping the other variables constant, the effect of variables such as age and education of the household head, area of agriculture land, institutional support and cosmopoliteness, favours adoption. In probability terms, the effect of each of these variables is more than 50%. An institutional support for adopting new farm technology is closely linked to farmers decision to adopt the new farm technology without sufficient knowledge of technical know-how and similarly, farmers cosmopoliteness may be associated with the information, awareness and knowledge about the new technology, the income from adoption of technology and technical knowhow, which determines opportunities and risks associated with the adoption. These in combination facilitate the decisions of technology adoption.

The age of the household head was positive and significant at 5% probability level indicating adoption of new technology decreases with increase the age. It has been noted that the older one becomes the more risk averse he/she is. A young head of a family has a greater chance of adopting new activities than an older head of a family, because he or she is more willing to or capable of taking risks (as suggested by Sidibe, 2005) [26].

Education increases the ability of the farmers to adopt agricultural innovation and hence improve their productivity and efficiency (Iheke, 2010) [17]. This implies that the quality of decision-making increases in tandem with a person's education level and, as a result, farmers with higher education levels is more likely to adopt new technologies or practices than those with less education (Neupane *et al.,* 2002) [22]. Obasi (1991) [23] stated that the level of education of a farmer not only increases his farm productivity but also enhances his ability to understand and evaluate new production techniques and in terms increases the household well being by increasing income.

The agriculture land size was positively related to innovation adoption. This implies that farmers with large size of land holding has more likely to adopt new agricultural production technologies for diversifying agriculture through high value crops which increase their income significantly. This finding is consistent with the literature that large scale farmers are more inclined to adopting new technologies than small scale farmers (McNamara *et al.*, 1991; Abara and Singh, 1993; Feder *et al.*, 1985; Fernandez-Cornejo, 1996; and Kasenge, 1998) [20, 1, 15, 16, 19]. This presents a serious challenge to policy makers and implementers in promoting the adoption of new agricultural production technologies in the study area. This is because majority of farm households in the study area operate on small and marginal holding with less than one hectare.

Institutional support was also positively related with the innovation adoption. The almost all the farmers in the study area adopt new technology because of the institutional support either fully sponsored or a high subsidy by government on adoption. This implies that farmers who have lack of access to government schemes for technology adoption, left behind or not adopt the new technology.

While extension services provide informal training that helps to unlock the natural talents and inherent enterprising qualities of the farmer, enhancing his ability to understand and evaluate and adopt new production techniques leading to increased farm productivity. Farmer's cosmopoliteness through farmers' organisations are sources of good knowledge, exposure, quality inputs, credit/institutional support, information and organized marketing of products. These explain their significant and positive relationship with adoption of improved technologies. They are expected to help them to receive and synthesize new information and innovations his locality and beyond.

Conclusions and Policy Implications

Due to changing environmental condition the need for technology increasing for local communities and thus require local capacity building. Specially, institutional and technical capacities. The extensions of area specific technologies are necessarily require for effective and efficient use of local resources. The adoption and knowledge of new technologies will be increased amongst farmers through demonstration and exposure visits. Extension and training programmes for related technology is the better medium for development of farmers skill. It helps farmers to change their attitudes towards the usefulness of the technology. The result suggests that the main factors preventing farmers from technology adoption are limited education and limited access to necessary information. Some of these can be influenced through government policy and programs which is only effective in the long term, as observed by Dhiman (2012) [2-10, 13]. However, education in the form of short term training can specifically be improving farmers understanding on the possibilities, limitation and requirements of any new technology. This could also reduce the negative correspondence between the age of household head, and the likelihood to adopt technology. Other measures that can possibly have a positive impact are improving the service provision of credit and insurance agencies, although a larger data set would be required to confirm this (Dhiman, 2012) [2-10, 13]. But the extension and adoption of these technologies need proper policy support for their effective implementation. There is also a need to focus research and development programmes on rainfed hill agriculture as this area is unexplored sufficiently.

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