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Factors Affecting Adoption of Climate-resilient Indigenous Agricultural Technologies and Practices: A Case Study from Nepal

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Abstract

Climate change has been one of the detrimental factors affecting agriculture production. Climate resilient indigenous agricultural technologies and practices tend to be effective in combating the ill-effect of changing climate and associated vulnerabilities. Hence, this research endeavors to find out the adoption of such indigenous technologies and practices and its impact on farming. A survey was conducted in the 66 farmers of Jagannatha village of Dasharathchanda Municipality, Baitadi. A pre-tested semi-structured questionnaire was used to collect the data. The findings revealed that indigenous technologies and practices like nutrient management and plant protection methods were adopted by higher proportion of the farmers compared to other such technologies and practices from sowing to harvest. The logit regression analysis for the adoption of climate resilient indigenous agricultural technologies and practices revealed that commercialized farms and farmers receiving external support like subsidies had lower chances of adoption of climate resilient indigenous agricultural technologies and practices. Lack of awareness about climate change was the major problem for adoption of climate resilient practices. Farmers never felt its need to overcome the challenges posed by climate change. From the study, it could be concluded that creating the awareness about climate change, climate resilient indigenous agricultural technologies, and formal education of the household head play an important role in understanding the value of indigenous agricultural technologies and practices. Similarly, female household heads

were more likely to adopt indigenous agricultural technologies and practices suggesting for the consideration in development interventions.

Keywords: Awareness, climate change, indigenous knowledge, resilience, subsidies

Introduction

Greenhouse gas emissions from the combustion of fossil fuels, deforestation, urbanization, and industrialization are the leading causes of climate change causing fluctuation in temperature, precipitation, and solar energy which severely impact human health, food security, freshwater habitats and geographical processes such as landslides, floods and desertification (Malla, 2008). Natural disasters such as drought, flood, heat stress, and high temperatures are projected to raise the severity of climate change, threatening the survival of species of plants in specific regions and significantly reducing agricultural productivity, especially in low latitude areas (Alotaibi, 2023). Climate change may have more pronounced effect on small and marginal farmers, especially those reliant on vegetables. Shifts in climatic conditions often leads to crop failures, shortage of yields, reduction in quality and increase in pest and disease problems are common and making the vegetable cultivation unprofitable (Rashid et al., 2020).

To address the issue, an integrated and coordinated strategy is required, which include funding for climate resilient farming, sustainable land management practices and programs that enhance adaptive capacity programs, while fostering the collaboration among policymakers, farmers and stakeholders to mitigate climate impact and ensure the sustainability and resilience of agriculture (Toromade et al., 2024). Mengistu (2024), stated that the land tenure system, the availability and dependability of indigenous farming methods, the terrain and distance from farms, the availability of the farm capital and socio-demographics of smallholder household including age, gender, years of experience, educational attainment and socio-cultural beliefs of the farmers, all had varying degrees of influence on the smallholder farmers' decision to adopt indigenous farming methods.

Organic farming is a major source of income for local farmers, helps to lower greenhouse gas emissions, while trees contribute to the global carbon cycle by storing and fixing carbon (Amare, 2018). According to Melash et al. (2023), intercropping terracing, and agroforestry are the example of indigenous farming methods that reduce environmental pollution by using synthetic pesticides and fertilizers. As these technologies have reduced carbon nitrogen and water footprints, they may be a good option for reducing greenhouse gas emission. It is necessary to work with and strengthen local organizations in order to integrate these practices into modern farming. In this regards, this study was conducted to identify the factors influencing the farmers's choice for adoption/non-adoption of climate resilient agricultural technologies and practices and to understand its impact on farming.

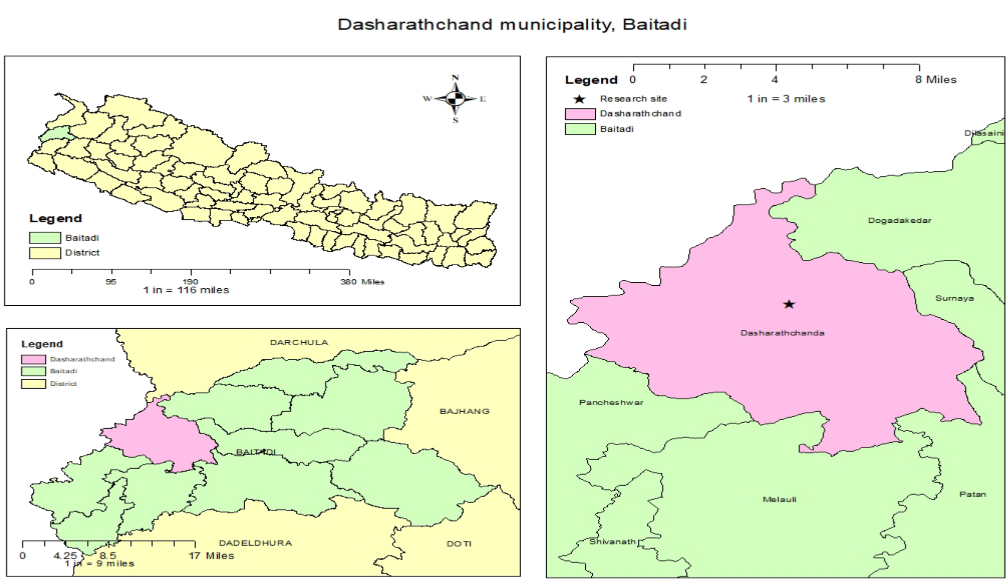
Research Methodology

Site Selection and Sampling

The survey research was conducted in Baitadi district, Dasharathchanda Municipality, ward number 4, Jagannatha village. This village was selected because it represents the hilly region with significant potential for agricultural development as well as it is one of the PMAMP focus area. Baitadi district is situated in between latitudes 28°21’N to 29°23’N and longitudes 80°40’E to 81°29’E, it covers a diverse landscape. The municipality includes areas ranging from approximately 2,439 m to 6,936 m above sea level, presenting varied agricultural conditions. Baitadi is bordered by Darchula in the west, Doti in the east and districts like Dadeldhura and Bajhang to the south. A total of 66 samples were taken from the total farming households of 208 in Jagannatha village of Baitadi district by the use of Rao-soft sample size calculator with 95% confidence level and 10% margin of error (http://www.raosoft.com/samplesize.html). The samples were randomly selected from the list of residential households of Jagannatha village of Baitadi.

Figure 1

Map of the research site (Dasharathchanda, Baitadi, Nepal)



Data Collection and Analysis

Before to the main survey, a visit to the study area provided insights into the socio-economic, demographic, and geophysical conditions, including informal meetings with farmers, which informed the selection of the survey area and the design of the questionnaires to gather necessary information. In the month of March-April 2024, a field survey was conducted in the Jagannatha village of Baitadi district. Respondents were given a pre-tested interview schedule to gather primary data through interpersonal interviews regarding factors affecting the adoption of climate-resilient indigenous agricultural technologies and practices in vegetable farming. Questionnaire has undergone pre-tested with a small sample of respondents (though non-sampled households) who provided insightful feedback on its clarity, relevance, and simplicity of completion, leading to adjustments that enhanced its overall quality and reliability prior to the main data collection.

The primary data for this research were collected from farmers through field surveys, focus group discussions, direct observation, and key informant interviews. Secondary data were gathered from relevant literature, reports, and publications from the Prime Minister's Agriculture Modernization Project and Agriculture Knowledge Centre. Data was collected through a semi-structured questionnaire via a household survey conducted using the mobile application Kobo-Collect. After completion of data collection, the collected data were downloaded on MS Excel and data management tasks such as refining, cleaning, editing, shorting, filtering, and deleting duplicates were done. In order to better understand the data and identify trends and patterns, descriptive statistics was used to examine the data.

Logistic Regression Model

Logistic regression analyzes the relationship between several independent variables and categorical dependent variable (Park, 2013). The result variable is binary or dichotomous in logistic regression model (Hosmer et al., 2013). In a basic model let Y be the binary response variable of farmers which has two possible outcomes Y=1, if farmer adopts the recommended practice and Y=0, if the farmer does not adopt it. Suppose, X is a vector of explanatory variable contributing to the adoption and β_i vector of slope parameters, which measures the change in X on the probability of farmer's decision to adopt recommended practice.

If $Y_i = 1$, then:

$$P(Y_i = 1) = P_i = 1 / (1 + e^{-z})$$

And if $Y_i = 0$, then:

$$P(Y_i = 0) = 1 - P_i$$

Where,

$$z = \beta_1 + \beta_2 X_i$$

The influence of independent variables in logistic regression is frequently represented by odds, which are the ratio of the likelihood that an event will occur to the likelihood that it won't (Park, 2013). By dividing the probability of adoption "Yi=1" by the probability of non-adoption Y≠1, one may determine the likelihood that the farmer would implement a suggested practice.

Odds $Y = P(Y_i = 1) / (1 - P(Y_i = 1))$

The logit(Y) is given by the natural log of odds as:

$\ln P(Y_i = 1) / (1 - P(Y_i = 1)) = \log \text{Odds} = \text{Logit}(Y)$

Where,

ln = natural logarithm

$P_i / 1\text{-}P_i$ = odd ratios for i = 1, 2, …, n farm households

The logistic transformation of the probability of the adoption is given as:

$$L_i = Logit\ (Y_i) = \propto + \sum_{n}^{i=1} \beta_i X_i + \varepsilon_i$$

Where,

L_i = Logit

Y_i = Binary dependent variable (1 = if farmers adopt the practice; 0 = otherwise)

X_i = Vector of explanatory variables used in the model

β_i = parameters to be estimated (coefficients of independent variables)

α = intercept

ε_i = error term of the model

$Y_i = f(\beta_i X_i)$ = f (Age, sex, education level, family type, female involvement, farming experience, khet ropani, fertilizer, subsidy in farming, internet access, mass communication tools, loan for farming)

Thus, the binary logit regression model was expressed as (details of variables are described in the Table 1):

Table 1

Variable and their descriptions

Variable	Type	Description
Dependent variable		
Adoption of climate resilient indigenous agricultural technologies and pratices	Binary	Adoption of Climate Resilient Indigenous Agricultural Technologies = 1 Otherwise = 0
Independent variable		

Age	Continuous	Age of the household head in years
Sex	Dummy	1 = Male-headed household 0 = Female-headed household
Education Level	Continuous	Years of schooling of household head
Family Type	Dummy	1 = Joint family 0 = Nuclear family
Female Involvement	Dummy	1 = Involvement of female farmers in the decision-making process 0 = Involvement of the male farmers in the decision making
Farming Experience	Continuous	Total years of experience in farming
Khet	Continuous	Total khet land owned (in ropani *)
Fertilizer	Dummy	1 = If the farmer uses chemical fertilizer 0 = Otherwise
Subsidy in Farming	Dummy	1 = If the farmer has received subsidy from government 0 = Otherwise
Internet Access	Dummy	1 = If the farmer has access of internet 0 = Otherwise
Mass Communication Tools	Dummy	1 = If the farmer has access of mass communication tools like tv, radio to watch agriculture related programs 0 = Otherwise
Loan for Farming	Dummy	1 = if the farmer has taken loan for farming 0 = Otherwise

Note. * standard land measuring unit adopted in the hilly regions of Nepal where 1 ha equals around 20 ropani

It is to be noted that, in our case, adoption of indigenous technologies and practices include adoption of: indigenous nutrient management (use of FYM, indigenous species for green-manuring, intercropping, mixed cropping); indigenous plant protection measures (erecting scare-crow in standing crop to scare birds, burning residue of crop, setting bamboo stick of the tree, selecting seeds from healthy plants for next year seedlings, use of locally available plant materials, spraying of cow urine, uses of ash); and use of locally available plant materials used for pest management (timur, neem, titepati, chilli leaves, bojho).

Results and Discussion

Socio-economic Characteristics of Sampled Households

Gender distribution of household head showed 70% of them to be males. The population distribution from among the selected 66 households showed 193 males (45%) and 235 females (55%) totaling 428 people (Table 2). The 48 families in the samples are joint families that include extended family members living together and rest (18 households) are nuclear families that comprise mostly of parents and their children only. The majority (88%) of household decisions were done by male members and only around 6% of household have females deciding about the household matters, especially economic and financial. The age of the heads was classified into three categories of which mid-aged heads are the majority (36-59 years old with 65% share). In the study area all of the respondents were found to be Hindu 100%. The educational status of the respondents was assessed in five categories and mostly they have schooling between illiterate to less than 12 years of schooling (majority, that is 32% have schooling up to 8 years). The samples are ethnically diversified yet the majority is with the Brahmin and Chhetri (70%) which goes up to 93% if Thakuris are also included. Dalit is another ethnic group comprising only 6% of the households. The average family size of the selected household is 6.48 (with minimum of 1 and maximum of 12).

Table 2

Socio-economic characteristics of sampled household

Parameter	Category	Frequency	Percentage
Gender of the head	Male	46	69.69
	Female	20	30.30
Gender distribution in the household	Male	193	45.09
	Female	235	54.90
Family structure	Joint	48	72.72
	Nuclear	18	27.27
Household decisions	Male decides	58	87.87
	Female decides	4	6.06
	Both decide	4	6.06
Age group of the head	<36	8	12.12
	36-59	43	65.15
	>59	15	22.72
Religion	Hindu	66	100.00

Education status of the head	Illiterate	8	12.12
	Up to 5 years of schooling	14	21.21
	Up to 8 years of schooling	21	31.81
	Up to 10 years of schooling	16	24.24
	12 or more years of schooling	7	10.60
Ethnicity	Brahmin/Chhetri	66	69.69
	Thakuri	16	24.24
	Dalit	4	6.06
Family Size	Average		6.48
	Minimum		1
	Maximum		12

Farm Characteristics

The land holdings of the respondent were categorized into 3 groups based on their land namely Khet (lowland), Bari (upland) and Pakho (slopy upland). The average Khet size is 9 ropani (20 ropani = 1 ha) meaning around half the hectare whereas average Bari size is only around 2.3 ropani (Table 3). Pakho land is somewhat abundant with the average of 11 ropani. The irrigation condition is slightly better although year round irrigation is not ensured though 68% of the land seems to have irrigated and rest (32%) are rainfed. The average farming experience if around 33 years of the selected farmers.

Table 3

Farm and farming experience

Parameter		Values		
		Minimum	Maximum	Average
Land Size (ropani)	Khet	2	25	9.04
	Bari	1	8	2.31
	Pakho	0	50	11.04
Irrigation Status	Household with rainfed agriculture			21 (31.81%)
	Household having irrigated land			45 (68.18%)
Farming Experience (years)	Average			33.04
	Minimum			6
	Maximum			70

Institutional Information

Majority of the respondents (54.54%) of the study area had membership in local groups, cooperatives, associations, etc. (Table 4). Among sampled households, 56.06% had received subsidies from government organizations or projects. The access to internet in the sampled households was found to be around 74.24%, which could be considered quite high. Here it is to be noted that internet access has increased due to availability of smart phones and cheap internet from mobile network service providers. Access to mass communication (like radio, FM, TV, etc.) is much higher around 91%. However, households taking loans (especially for farming) was too low, only around 7.57%. Visit by extensions agents (especially from government organizations) seems to be higher, above 86%.

Table 4

Institutional information

Parameter	Category	Frequency	Percentage
Membership in the local groups, associations,	Yes	36	54.54
etc.	No	30	45.45
Subsidy received	Yes	37	56.06
	No	29	43.93
Internet access	Yes	49	74.24
	No	17	25.75
Mass communication	Yes	60	90.90
	No	6	9.09
Loan for Farming	Yes	5	7.57
	No	61	92.42
Extension agent visit	Yes	57	86.36
	No	9	13.63

Factors Affecting the Adoption of Climate-resilient Indigenous Agricultural Technologies

Adoptions of climate-resilient indigenous agricultural technologies and practices by the farmers were influenced by their socio-economic and demographic characteristics. We have used 12 characteristics of the farmers as explanatory variables affecting adoption of climate resilient indigenous agricultural technologies and practices. The explanatory variables have been selected for binary logistic regression model considering the expected importance to explain the dependent variables. The binary logistic regression model showed four variables viz. education level, female involvement, subsidy and internet access to be statistically significant though their direction are different with only the subsidy having negative impact on adoption of climate resilient indigenous agriculture technologies and practices. Age of the household head, male-headed households, joint family type, size of Khet land, application of chemical fertilizer, and household taking loans are found to have positive impact on the adoption and use of indigenous knowledge but all of these are not significant. Similarly, farming experience and access to mass communication tools have negative impact but again these are also insignificant.

Education levels of the farmers were found to have significant (10%) impact increasing the chances of adoption and/or continuation of use of indigenous knowledge. Farmers with higher educational levels are usually considered to be flexible, knowledgeable and more informed about the importance of indigenous knowledge and the benefits of adopting such technologies and practices. Several research has found that education is an important aspect in increasing farmer's knowledge and as a result of farmers' adoption decision (Ziro et al., 2023; Ali and Erenstein, 2017; Ahmed, 2016). Most of these studies concluded that being more educated increase farmer's awareness about the incidence and consequence of climate change, accessible alternatives (indigenous or modern), financial factors, health aspects, etc. and helps them select better options. This section evaluates the performance of existing extension services, farmer training programs, and knowledge-sharing platforms in encouraging the adoption of climate-resilient crops (Likhiter & Sustain, 2024).

Similarly, involvement of female members in the household decision making was also found to have significant positive (10%) impact on the choices of adoption of indigenous technologies and practices. In the study are women were mostly involved in agriculture and added to it the role of making decision enhance the adoption and use of indigenous knowledge. Generally, man has a privilege in decision making process with young males prioritized for education to mentor them as future decision maker and hence they are more risk-takers and may opt for modern technologies and practices (Awiti, 2022; Asfaw and Admassie, 2004; Kumasi et al., 2019). Focusing on women may, therefore enhance the chances of adoption and use of local and traditional knowledge (Montanari & Bergh, 2019) but this may be constrained by several socio-economic issues like land tenure, etc. (Kumasi et al., 2019). Nonetheless, this highlights the importance of integration of gender perspectives in agricultural development plans, programs and policies. By addressing gender-specific barriers and fostering women's participation, agricultural interventions can become more effective and sustainable, ultimately enhancing resilience and productivity in the face of climate change. Further research should explore the specific mechanisms through which female involvement drives technology adoption and identify best practices for promoting gender equity in agricultural development. Having access to internet was also found to have significant (5%) positive impact on adoption although its role is not so clear and need further exploration.

On the contrary, the results showed that if the farmers had received any sort of subsidies, it drastically reduces the chances of adoption of indigenous technologies and practices and there is a negative association between farm subsidies and adoption. This is plausible since most of the subsidies provided by developmental organizations, including government organizations, is for the modernization and commercialization of agriculture and this will obviously reduce the use of local and traditional technologies and practices since they are usually assumed to have less productive although they may be more climate resilient. This shows that current subsidy schemes may not fully support propagation of traditional indigenous knowledge or the farmers receiving such subsidies for modern tools and technologies may not see the immediate benefit or even the necessity for adoption of traditional technologies and practices. So, we suggest designing of subsidy programs to include incentives for promoting local resources and traditional/ indigenous knowledge or there should be at least some sort of balance with modern knowledge. Subsidies have large impact on adoption and policy makers can design it in the direction of their choice and it may be necessary to induce firms to adopt the socially optimal technologies (Aalbers et al., 2008). Jena et al. (2023) found that farmers who received subsidized seeds adopted diverse crops over time.

Binary logistic regression analysis shows that connectivity to the web has a significant impact on the adoption of climate resilient indigenous agricultural technologies. This shows the importance of internet connectivity in improving agricultural practices and encouraging the dissemination of climate smart remedies. Access to internet resources and platforms can bridge information gaps and support informed decision-making regarding technology adoption (Tong et al., 2024).

Table 6

Binary logit regression for determining factors affecting adoption of climate-resilient indigenous agricultural technologies and practices

Variables	Coefficient	St. Error.	t-value	p-value
Age	0.058	0.115	0.51	0.613
Sex	1.114	0.827	1.35	0.178
Education level	*1.438	0.754	1.91	0.056
Family type	1.155	1.317	0.88	0.380
Female involvement	*5.696	3.331	1.71	0.087
Farming experience	-0.024	0.096	-0.25	0.799
Khet	0.056	0.108	0.52	0.604
Fertilizer	1.365	1.397	0.98	0.328
Subsidy in farming	*-2.044	1.229	-1.66	0.096
Internet access	**3.786	1.741	2.17	0.030
Mass communication tools	-1.398	2.317	-0.60	0.546
Loan for farming	3.110	2.266	1.37	0.170
Constant	-9.714	6.524	-1.49	0.137

No. of observation	66
Pseudo r-squared	0.32
Log likelihood	-15.12

Note. ** and * show significance at 5% and 10% level, respectively

Conclusion

Adoption of climate-resilient indigenous agricultural technologies and practices in Baitadi district is influenced by a combination of socio-economic, cultural, and external factors. To promote climate resilient farming, it is necessary to build the farmers' capacity through joint effort of institutions and farmers themselves. The findings highlight the importance of education and gender considerations in development interventions, which can positively influence adoption decisions regarding climate resilient technologies and practices. However, subsidy for modern technological innovations are found not to be in line with the need of local environment and climatic conditions. Therefore, there is a critical need of targeted subsidy programs. This approach will contribute to the resilience and sustainability of agriculture in Baitadi district assuring food security and improving the livelihoods for its farming communities.

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