Original Research Article

Climate Adaptation Practices in Agriculture Sector of Nepal: Determinants of Intensity of Adoption

ABSTRACT

Climate change has been visualized in the agricultural sector of Nepal which calls for strategies for adaptation and resilience building. We assessed the influence of demographic and institutional factors and farm characteristics on the adoption of twenty climate adaptation practices. We used climate change impact survey data of 800 households for province 1 and analyzed by using Poisson regression and corrected the overdispersion using Negative Binomial regression. The results revealed that the operational size of landholding, years of experience in farming and formal level of education of the household head, the association of members in cooperatives and community organizations, the occurrence of disasters in the last five years, gender or sex of household head male-headed households, and receiving remittance influenced the adoption of a package of practices in agriculture for climate adaptation. The results imply that policies should be geared towards enhancing the capacity of farmers through education and skill training, strengthening social networks, increasing investment for the generation and dissemination of climate-resilient agricultural technologies and practices, implementing additional off-farm and on-farm activities to increase income, and improving access to physical resources, education, and information to for female-headed households.

Comment [SM1]: Consider a replacement. Word not appropriate in the context. Maybe noticeable or seen. Otherwise, visualize means imagined and I don't think that is what you want to say because if its imagined, it means it is not practically manifesting but an issue of imagination

Keywords: Adaptation, agriculture, climate change, farmers, influencing, intensity, negative binomial, package of practices.

1. INTRODUCTION

Agriculture in Nepal is still the main economic sector as it contributes about one-fourth to the ~~gross~~ Gross ~~domestic~~ Domestic ~~product~~ Product (GDP) and provides livelihood to over 60% of the population. The production system in Nepal is mostly subsistence [1] and cultivated under rainfed conditions. The size of the landholding is small (0.68 ha) and fragmented with an average parcels number of 4.7 per hectare. The land distribution is skewed as 53% holdings have land size of 0.5 ha or below while the rest own different land size up to….ha per household. Nepalese agriculture is characterized by low input use with low land (USD 1804/ha) and labor productivity (USD 794/person) [1]. Per capita GDP has reached to $1191 [2].

In the decade from 2011 to 2020, the real GDP growth remained at 4.37% while that of Agricultural GDP (AGDP) growth was 3.04%. The technical change contributed only one-third to the total factor productivity growth in agriculture. The agricultural sector consists of cereal crops, horticulture, livestock, fisheries, and forestry. These sub-sectors have varying level of contribution to AGDP. The cereals sub-sector's contribution to AGDP is the highest (49.4%) followed by livestock (25.8%), horticulture (16.7%) and forestry (8.1%). There are several crops and commodities under these categories [3].

Compared to other economic sectors of Nepal, agricultural production system is heavily dependent on monsoon rain, hence more sensitive to climate change. Changes in the time, duration and intensity of precipitation pattern may affect the agricultural production and productivity. Most people are dependent on agriculture for livelihood and cultivate crops like paddy, maize, wheat, millet and potato, and raise different types of livestock, changes in the pattern of precipitation most importantly the monsoon highly aggravate the poverty and inequality. Although a rise in temperature may have some location-specific short-run positive effects, these would be outweighed by the negative effects of rising temperature and drought.

This would result into vulnerability and impact mainly due to the variability of weather conditions [4].

Given Nepal's diverse topography and social vulnerability, she is mainly susceptible to geological and climate-related disasters. Inadequate and weak effective response mechanisms and strategies for addressing natural hazards has traditionally aggravated this vulnerability. Climatic hazards have led to increased soil erosion, landslides, flash floods, and droughts in recent years across the country with increased intensity and impact on the lives and livelihoods of the people in Nepal [5]. Nepal is the 10th most vulnerable country from the perspective of the occurrence of extreme weather events between 2000-2019 with 0.82 fatalities per 100,000 inhabitants and 0.39% losses per unit GDP [6] despite Nepal's very lower share to global greenhouse gas (GHG) emission.

Nepal has faced several climatic events during the last four decades affecting social, economic, and environmental sectors. Rapid population increase, dwindling farm sizes, and an unplanned agricultural system in hazard-prone marginal areas would all have a negative influence on those sectors. Additionally, it has been projected that natural disaster risk levels in Nepal could grow, posing a threat to human life over the 21st century through the occurrence of natural hazards like drought, heatwaves, river flooding, and glacial lake outburst floods [5]. The vulnerability of Nepal's communities, particularly those living in poverty, in remote areas, and operating subsistence agriculture, increase the risk posed by climate change. Because they are least able to cope with disasters, live in areas most at risk of hazards, and generally have the least information, knowledge, and resources to reduce their risk [7]. The impact of climate change will also be realized disproportionally in the future where the countries having resources and technologies will prevent or reduce the impacts to an acceptable level whereas technically and financially resource-poor countries like Nepal will be affected immensely due to low coping capacity [8].

The Government of Nepal (GON) formulated National Adaptation Program of Action and National Adaptation Plan to address the climate change impacts. In this respect, several projects and programs are being implemented on adaptation at varying scales on agriculture and related sectors with different practices, techniques, and technologies. These might have been adopted at different levels in different ecological zones and production systems. Climate change adaptation, which refers to adjustment in natural, socio-economic, or human systems in response to actual or expected climatic stimuli or their effects [9]. For mitigating the adverse impact of climate change on agricultural sector, adaptation is considered a critical component of any policy response [10-11]. In this context, it is more realistic to assume that an agricultural producer faces the decision to adopt a combination of practices to better manage available resources and mitigate climate-induced risk at the same time rather than one practice at a time. This necessitates to examine of the joint adoption of multiple climate change adaptation practices and their interdependence at the farm and household levels. A right combination of multiple climate change adaptation practices is crucial to improve farm productivity and to reduce the negative impacts of climate change [12-13]. It is important to understand relationships among multiple climate change adaptation practices and identify their determinants for formulating and implementing appropriate policies to scale up their adoption.

Most of the past studies analyzing the determinants of technology adoption have focused on a single technology, given that component technologies are adopted independently in accordance with farmer preference rather than all at once as a bundle or set of packages. This study differs from the previous ones following a single technology as we have considered technology adoption in terms of the total number of components adoption for a measure of adoption intensity. While decision to adopt using binary choice i.e., adopt or not adopt considers a specific technology or practice, the intensity of adoption considers the extent to which the various techniques are adopted. In analyzing the adoption decisions of multiple climate adaptation practices in agriculture, count data models are employed in which the number of practices adopted serves as a measure of intensity of adoption [14- 15]. Hence, this paper aims to identify the socio-economic, demographic, and institutional related determinants of adoption of multiple practices for climate adaptation by agricultural households in Province No. 1 using the climate impact survey data of Nepal.

The remainder of this paper is organized into four sections. Section 2 presents a review of the literature on the adoption of agricultural technologies and practices while the section 3 describes the methodology. Section 4 presents the results and discussion while the section 5 concludes and discusses some policy implications.

2. METHODOLOGY

2.1 Sampling Technique & Sample Size

The data from the National Climate Change Impact Survey 2016 undertaken by the Central Bureau of Statistics [16] has been used for this paper which is still relevant in analyzing climate change adaptation and its determinants. The sample selection for this survey was done in three stages: the districts were selected in the first stage, the Primary Sampling Unit (PSU) in the second stage and the households at the third or final stage. The process was applied for each of 16 domains separately which were treated as a stratum. Independent samples in each stratum were selected. The sample selection procedure adopted in all stages was Probability Proportional to Size (PPS) sampling, where the size measure adopted for each was the number of expected households in that district.

Once districts with the 16 domains were selected, a sample of PSUs was chosen to represent each district. The number of PSUs selected from each district was determined by dividing the number of households to be selected in each domain by 20, divided by the number of districts selected in that domain. The listing of the households was based on the ~~the~~ age of potential respondent (45 years or older) and residing in the community for at least 25 years. Large PSUs were sub-divided into more manageable size and one of these sub-divided PSU was selected to represent the whole PSU using PPS sampling. As a rule of thumb, PSUs with more than 500 households were sub-divided into smaller units. In total, 253 PSUs were selected as sample across Nepal from 26 districts with a sample of 5060 households.

Among the 7 provinces of Nepal, this analysis is focused ~~to~~ on Province No. 1 comprising 5 districts- one each from Mountains and Terai and three from the hilly ecological region of Nepal. The Primary Sampling Unit (PSU) from 101-140 having 800 households were considered as a sample size.

2.2 **Analytical Technique**

In order to investigate the factors influencing the adoption of a number of climate change adaptation practices by the households, a count data (Poisson) model was used. The number of agricultural climate adaptation practices adopted by each household defines the dependent variable. Hence, it is a discrete nonnegative integer value count variable. The number of climate change adaptation practices at any given y_i which is an integer count variable, can be said to come from a Poisson distribution and can thus be modelled using the basic Poisson model [17-19]:

Consider a sample of count data $y = (y_1, y_2 \ldots y_n)$, it is assumed that the sample is generated from a Poisson distribution,

$$p(y_i \mid \lambda_i) = \exp(-\lambda_i)\, \lambda_i^{y_i} / y_i \quad i = 1 \ldots n. \tag{1}$$

The parameter of the Poisson distribution, λ_i, follows a lognormal distribution. Given a $k \times 1$ vector of covariates x_i, and a $k \times 1$ parameter vector β.

$$\log \lambda_i = x'_i \beta + u_i \tag{2}$$

where $u_i \sim IN(0, \sigma^2)$. The Poisson regression model is a special case when $\sigma = 0$.

Negative Binomial (NB) Distribution:

Poisson and negative binomial (NB) regression models differ regarding their assumptions of the conditional mean and variance of the dependent variable. Poisson models assume that the conditional mean and variance of the distribution are equal. NB regression model does not assume an equal mean and variance and particularly correct for overdispersion in the data, which is when the variance is greater than the conditional mean

NB usually estimates the count frequency of an event when there is Poisson deviance, which is otherwise referred to as overdispersion. In essence, binomial deals with a non-negative count variable. In this model, the count variable is assumed to be generated by Poisson-like process, except for the issue of overdispersion where the variation is greater than that of a true Poisson.

The NB distribution is a two-parameter distribution. For positive integer *n*, "it is the distribution of the number of failures that occur in a sequence of trials before *n* successes have occurred, where the probability of success in each trial is *p*" [20]. The distribution is defined for any positive *n*. The NB distribution combines both Poisson distribution and the Gamma distribution or generalized factorial function. Unlike the Poisson, which is fully characterized by its mean μ, the NB distribution is a function of both μ and α. Its mean is still μ, but its conditional variance is μ (1 + αμ). Then, it is evident that as μ tends towards 0 (that is, $\mu \rightarrow 0$), the distribution becomes Poisson distribution.

The NB distribution model with the following characteristics is expressed as:

$$Pr(Y = y|\lambda, \alpha) = \frac{\Gamma(y+\alpha^{-1})}{y!\Gamma(\alpha^{-1})}\left[\frac{\alpha^{-1}}{\alpha^{-1}+\lambda}\right]^{\alpha^{-1}}\left[\frac{\lambda}{\alpha^{-1}+\lambda}\right]^{y} \quad (3)$$

The NB distribution has two parameters; that is, λ and α.

where,

λ is the mean or expected value of the distribution and α is the over dispersion parameter. When α = 0, the negative binomial distribution is the same as a Poisson distribution.

2.3 Variables Used

The variables used in this paper influencing the adoption behavior of the farmers have been categorized into four groups: demographic factors, farm characteristics, location factor, and institutional factors. One important proxy used to measure the scale economy is the farm size which has played a significant role in both the theoretical and empirical literature of technology adoption. In this respect, we have considered size of the operational land holding as one of the variables. In general, operational landholding is hypothesized to have a positive impact on adoption decisions. The education level of the farmer is also found to be a significant determinants of adoption decisions as well. More educated farmers are more likely to adopt a new technology than the uneducated ones. Similarly, the male farmers are expected to be more likely to adopt and intensify the use of new technologies because women have limited access to resources such as land, capital, and extension services. The households that have an alternative source of income may be better able to adopt new technology because of improved liquidity. The institutional variables such as members in cooperatives, community organizations and services received from the Agriculture Service Center may have positive influence on the technology adoption. Membership of the farmers in such institutions facilitate the exchange of information and the opportunity to learn from one another. It also enables farmers to access inputs on schedule and overcome credit constraints and shocks. It can reduce transaction costs and increase farmers' bargaining power, helping farmers earn higher income. This in turn can affect technology adoption. The location dummy used is the ecological zone of the district to examine the unobserved location-specific effects in the household technology adoption (Table 1).

The dependable variable (Adapt) is the number of practices adopted by each household ranging from zero to twenty. The explanatory variables include household characteristics, socio-economic and institutional variables. They are defined as follows:

$$Adapt = \beta_0 + \beta_1 Gendum + \beta_2 Landhold + \beta_3 Edun + \beta_4 Ecodum + \beta_5 Remit + \beta_6 Experi + \beta_7 Membcoop + \beta_8 Commorg + \beta_9 Ascservdum + \beta_{10} Disastdum + \varepsilon_i$$

β_0 …… β_{10} are the parameters to be estimated, ε_i is the error term.

The definition of variables is presented in Table 1. It shows that over two-third of the households are headed by males, the average experience of the household head is 33 years, no. of years of schooling is 3 years, and average operational landholding per household is about 17 ropani[1]. In addition, 27% of the households receive remittances, 59% of the households were affected by disasters in the last five years, only one-fourth of the households received technical service from Agriculture Service Center, 53% households are the members of the cooperatives and 41% have received membership in community organizations.

Table 1. Definition and summary statistics of variables

Definition of Variables	Mean	Standard

[1] 1 ropani equals 508.74 square meter

		deviation
Demographic	0.78	0.41
Gendum-Gender of the household head (1 for male and 0 otherwise)		
Experi- No. of years of experience in farming	33.25	18.82
Edun-No. of years of schooling of household head	3.00	3.94
Farm Characteristics		
Landhold-Operated landholding (ropani)	16.87	19.72
Remit- Households receiving remittance (1 or receiving household and 0 otherwise)	0.27	0.44
Disastdum -Household affected by disasters like drought, flood, hailstorm, soil erosion etc. in the last 5 years (1 for affected household, and 0 otherwise)	0.59	0.49
Location dummy		
Ecodum- Ecological region (1 for Terai and 0 otherwise)	0.33	0.47
Institutional		
Membcoop- Membership of the cooperative (1 for member and 0 otherwise)	0.53	0.51
Commuorg- Membership in community organization (1 for memeber, and 0 otherwise)	0.41	0.51
Ascservdum- Technical service received from Agriculture Service Center (1 for Service receiver, 0 otherwise)	0.25	0.43

3. RESULTS AND DISCUSSION

3.1 Descriptive Analysis

Twenty different practices have been adopted by the farming households at varying level (Table 2). Among them, the most frequently adopted adaptation technology component by the household was increased quantity of inorganic fertilizers (54.3%) followed by practicing mixed crops (48.1%), participation in road and infrastructure improvement (47.9%), participation in community-based based natural resource management activities (42.4%) and growing new crops (42.3%). The households using risk minimizing measures such as insurance for crop and livestock was were the lowest.

Table 2. Adoption of climate adaptation practices

S.No.	Practices	No. of Adopters	Percentage
1	Changed in cropping pattern	327	40.9
2	Reared livestock of a different breed than the earlier one	209	26.1
3	Provided supplemental irrigation	200	25.0
4	Invested in ponds for irrigation	47	5.9
5	Adopted improved seeds	298	37.3
6	Change in planting date	290	36.3
7	Used increased quantity of inorganic fertilizers	434	54.3
8	Used increased quantity of organic fertilizers	324	40.5
9	New crops grown	338	42.3
10	Raised new livestock	218	27.3
11	Insurance of livestock done	27	3.4

12	Insurance of crops done	20	2.5
13	Started farming both crops and livestock	246	30.8
14	Started agro-forestry	161	20.1
15	Practiced mixed (compatible) cropping	385	48.1
16	Started preserving local seeds (seed bank)	147	18.4
17	Contributed to soil and water conservation	223	27.9
18	Participated in flood/landslide risk reduction and water management practices	255	31.9
19	Participated in road and infrastructure improvement to protect from flood and landslide	383	47.9
20	Participated in community based natural resource management activities	339	42.4

Table 3 presents the frequency distribution of the number of practices adopted by the sampled farming households. The survey offers evidence that 717 households out of 800 in the sample had adopted at least one practice with 89.6% overall adoption rate. Over 10% of households did not adopt any practices while those adopting over 15 practices was only 2.5%. Most of the households adopted 1-4 practices (33.4%). The sampled households on an average, adopted 6 practices.

Table 3. No. of households adopting practices

No. of practices	No. of households	Percentage
15-20	20	2.5

10-14	189	23.6
5-9	241	30.1
1-4	267	33.4
0	83	10.4
Total	800	100
Average practices adopted	6	

3.2 Factors Affecting Adoption Behavior

Both Poisson regression and Negative Binomial Regression (NBR) were run. A diagnostic test was performed which shows the presence of overdispersion of count data. A goodness of fit test using the log-likelihood value was used to compare the Poisson and NBR. The log-likelihood values indicate that NBR has larger value than Poisson regression (Table 4 and 5), implying that the NBR model fits the data significantly well.

Out of ten variables estimated, 9 variables were statistically significant in explaining the intensity of adoption of climate adaptation practices in agriculture in case of Poisson regression (Table 4) while only 8 variables were significant in NBR as ecological dummy (Ecodum) variable appeared non-significant (Table 5). Among the included variables, the variables such as operational size of landholding (Landhold), no. of years of experience in farming (Experi), member of the cooperatives (Membcoop) and households affected by disasters in the last five years (Disastdum) were significant variables at 1% level; number of years of schooling of household head (Edun) and affiliation with community level organisations were significant at 5% level; and the gender of the household head (Gendum) and household receiving remittance

(Remit) were significant at 10% level. All the coefficients of significant variables were positive to the adoption of number of climate adaptation practices. The location dummy for district in specific ecological region (Ecodum) and service received from the Agriculture Service Center (Ascservdum) were positive but not significant.

Education explained as the number of years spent in formal schooling is also significant and positively impacts on adoption intensity. This suggest that as farmers spend more years in school, their understanding of the benefits of adopting climate adaptation practices in production improves.

Farmers experience in agriculture/farming has a positive effect on intensity of adoption of climate adaptation practices as per the a priori expectation. Experienced farmers are thought to have accumulated technical know-how and skills over time and therefore have better position to adopt technologies. A good count of empirical studies has found a positive effect of farming experience on adoption of agricultural technologies [21-22]. There is positive and significant coefficient of operational landholding implies that larger holders are likely to adopt the package of production practices to realize scale economies.

An increase in the household's income from remittances increased the number of agricultural practices adoption compared to non-remittance receiving households. This also addresses the credit constraint to adopt supporting technologies and practices that need to be procured from the market. These findings are consistent with other previous studies [23-24].

Male headed households are more likely to adopt improved production technologies than the female headed households as they have better access to information and other resources [25]. Similarly, the incidence of adoption among the female-led households is low possibly because they are constrained by lack of access to input, credit, and extension services [26].

The membership of the household in cooperatives is likely to increase the adoption of adaptation practices than the non-members as cooperatives provides different services on input supply, marketing, and other technical services to its members. This finding is consistent with previous studies [27-28]. Similarly, farmers who participate in community-based organizations are likely to adopt more adaptation practices than non-participants as they are engaged in social learning which is consistent with the findings of previous researchers [29]. Similarly, the households facing one or more disaster events in the last five years are aware of ~~about~~ the disaster and its impact and more likely to adopt adaptation practices when compared with households not facing disaster event which is in line of other researchers [30].

Table 4. Poisson regression estimates

No. of Climate Adaptation Practices Adopted	**Coeff.**	**Std. error**	**z**	**p>|z|**
Gendum	0.1741	0.0403	4.32	0.000
Landhold	0.0042	0.0007	6.11	0.000
Edun	0.0162	0.0039	4.13	0.000
Ecodum	0.1138	0.0394	2.89	0.004
Remit	0. 0894	0. 0319	2.80	0.005
Experi	0.0150	0.0009	15.55	0.000
Membcoop	0.3601	0.0312	11.52	0.000
Commuorg	0.1527	0.0323	4.72	0.000
ASCservice	0.0483	0.0339	1.42	0.154
Disastdum	0.1400	0.0309	4.53	0.000
Constant	0.5528	0.0596	9.27	0.000

No. of observations = 800 Log likelihood = -2394.14

LR chi^2 (10) = 827.25, Prob>chi^2 = 0.0000

Pseudo R^2 = 0.1488

Table 5. Negative Binomial regression estimates

No. of Climate Adaptation Practices Adopted	**Coeff.**	**Std. error**	**z**	**p>|z|**
Gendum	0. 1407	0. 0677	2.08	0.078
Landhold	0. 0053	0.0014	3.64	0.000
Edun	0. 0157	0. 0071	2.19	0.028
Ecodum	0. 0398	0. 0670	0.59	0.552
Remit	0. 1132	0. 0579	1.96	0.051
Experi	0. 0172	0. 0018	9.71	0.000
Membcoop	0. 3904	0. 0586	6.67	0.000
Commuorg	0. 1427	0.0616	2.32	0.021
ASCservice	0.0433	0.0621	0.70	0.486
Disastdum	0.1592	0.0540	2.95	0.003
Constant	0.4737	0.0988	4.80	0.000
/lnalpha	-1.0854	0.0870		
alpha |	0.3377	0.0294		

LR test of alpha=0: $chibar^2$(01) = 497.31 Prob >= $chibar^2$ = 0.000

Number of observations: 800

Dispersion = mean Prob > chi^2 = 0.0000

Log likelihood = -2145.4861   Pseudo R^2 = 0.0568

Instead of reporting negative binomial results as a regression coefficient, measuring the effect of the independent variable on the dependent variable is carried out through the Incidence Rate Ratio (IRR) which is presented in Table 6. The IRR of the negative binomial regression model was computed and reported to show the impact of explanatory variables in terms of a percentage change in the observed response variable (in our case the no. of climate adaptation practices adopted). In principle, the IRR represents the change in the response variable in terms of a percentage change, with the precise percentage determined by the amount the IRR is either above or below 1.

In interpreting and explaining the coefficient of a given variable, all other variables are held constant. The results revealed that, if operational landholding were to increase by one point, the rate ratio for adoption of adaptation practices would be expected to increase by a factor of 1.005 or 0.50%. Similarly, the male gender compared to female counterparts are expected to have a rate of 1.15 times higher for the adoption of adaptation practices. If a household's head's education in terms of the number of years of schooling were to increase by a unit, the rate for of adoption of practices would be expected to increase by a factor of 1.06. If a farmer's experience in farming were to increase by one unit, the rate of adoption of practices would be expected to increase by a factor of 1.017.

Comment [SM2]: Should read: if a household head's education

In terms of adoption of climate adaptation practices, the households receiving remittance compared to non-receiving households are expected to have a rate of 1.12 times higher; the households having membership in cooperatives are expected to have a rate of 1.48 times higher compared to non-members; the households participating in community-based organizations are expected to have adoption rate higher by 1.15 times compared to non-members; and the households impacted by the disasters in the last five years are expected to adopt the practices by 1.17 times higher than those that are not affected.

Table 6. Incidence rate ratio of the Negative Binomial regression model

No. of Climate Adaptation Practices Adopted	IRR	Std. error	z	p>|z|
Gendum	1.1510	0. 0779	2.08	0.038
Landhold	1.0054	0.0015	3.64	0.000
Edun	1.0158	0. 0073	2.19	0.028
Ecodum	1.0406	0. 0697	0.59	0.552
Remit	1.1198	0. 0648	1.96	0.051
Experi	1.0173	0. 0018	9.71	0.000
Membcoop	1.4777	0. 0865	6.67	0.000
Commuorg	1. 1534	0.0711	2.32	0.021
ASCservice	1.0443	0.0649	0.70	0.486
Disastdum	1.1725	0.0633	2.95	0.003
Constant	1.6060	0.1586	4.80	0.000
/lnalpha	-1.0854	0.0869		
alpha |	0.3377	0.0869		

LR test of alpha=0: $chibar^2(01) = 497.31$ Prob >= $chibar^2 = 0.000$

4. CONCLUSION AND POLICY IMPLICATIONS

This paper has identified the determinants of the adoption of package of climate adaptation practices in agricultural sector of Nepal. It has also examined the appropriateness of the Poisson and Negative Binomial regression (NBR) models for analyzing count data. Due to the presence of overdispersion, NBR was used to correct it.

Twenty practices were adopted by the farmers at varying level. Around 90% farming households adopted one or more adaptation practices with an average of 6 practices. The most frequently adopted adaptation component was increased quantity of inorganic fertilizers use while the use of risk minimizing measures such as insurance for crop and livestock was the lowest. The adoption was influenced by the variables associated with demographic, institutional and farm characteristics. Those were the operational landholding of the household, household head's number of years of experience in farming and number of years of schooling, membership in cooperatives and community level organization, households experiencing one or more number of disasters in the last five years, gender of the household head, and household receiving remittance.

As climate change has affected the agricultural sector more than other sectors in Nepal, it is worth to consider variables influencing the adoption of practices as a package through policy interventions to increase agricultural productivity and reduce farmers' risk exposure. Policies should be geared towards enhancing the capacity of farmers through education and skill training on multiple climate change adaptation practices. The significant effect of social network like association with cooperatives and community level organizations indicate the need for strengthening social ties that promotes network and relationships among households within and outside community by enhancing their capacity to organize, coordinate and communicate in using adaptation practices. The adoption of a number of climate adaptation practices among the farming household is very low at present. In this context, it is necessary to increase the investment for generation and dissemination of climate resilient agricultural technologies suitable ~~to~~ for varied agro-climatic condition and enterprises, and facilitating the quality production inputs such as seeds, breeds, fertilizers and other materials for irrigation through the joint effort of public-private-cooperative sectors. Furthermore, additional on-farm and off-farm activities need to be implemented to increase the income of the households so that they can relieve from the cash constraint to invest in adaptation practices and their management. The access to physical resources, education and information to female headed households need to be improved for enhancing adoption. Availing quality climate information accessible to farmers will also ease their adoption challenges, including the right combination of practices to adopt that will have positive synergistic effects on farm performance and reduction of risk exposure.

Comment [SM3]: Please consider revision

REFERENCES

1. MoAD. Agriculture Development Strategy (ADS), Ministry of Agricultural Development, Government of Nepal;2014.
2. MoF. Economic Survey 2020/21, Ministry of Finance, Government of Nepal;2021.
3. Joshi, G.R. (2018) *Agricultural Economy of Nepal: Development Challenges & Opportunities*, Sustainable Research & Development Center, Kathmandu Nepal; 2018.
4. Joshi, GR and Joshi B. Climate change impact on agricultural sector of Nepal: implications for adaptation and resilience building, in Thapa et al (Eds.), *Agricultural Transformation in Nepal: Trends, Prospects and Policy Options*, Springer Nature. Singapore.2019; 119-155.
5. WBG and ADB. *Climate Risk Country Profile Nepal*, World Bank Group Washington D.C. and Asian Development Bank, Manila Philippines; 2021.

6. Germanwatch. *Global Climate Risk Index 2021. Who suffers most from extreme weather events? Weather-related loss events in 2019 and 2000-2019*, Germanwatch e.V. Germany;2021.
https://www.germanwatch.org/en/19777
7. FAO. *Implications of climate change for agriculture and food security and adaptation priorities in Nepal*, Food and Agriculture Organization of the United Nations Rome, Italy, June;2010.
8. Joshi GR and Uprety BK. Climate adaptation: a survival strategy for mountain people, *Proceeding of Eastern Regional Organisation for Public Administration (EROPA) Seminar 2010*, Kathmandu, Nepal, 2010; 30-39.
9. IPCC. *Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, in Parry et al (Eds.), Cambridge: Cambridge University Press; 2007.
10. Deressa, TT, Hassan RM, Ringler C, Alemu T, and Yesuf M. Determinants of farmers' choice of adaptation methods to climate change in the Nile Basin of Ethiopia. *Global Environmental Change*. 2009; 19(2):248–255.
11. Gbetibouo GA. *Understanding farmers' perceptions and adaptations to climate change and variability, the case of the Limpopo Basin, South Africa*, Environment and Production Technology Division, International Food Policy Research Institute, Washington D.C. USA, Discussion Paper No. 00849; 2009.
12. Aryal JP, Rahut DB, Maharjan S, and Erenstein O. Factors affecting the adoption of multiple climate-smart agricultural practices in the Indo-Gangetic Plains of India. *Natural Resources Forum*. 2018; 42(3): 141–158.

13. Kurukulasuriya P and Rosenthal S. *Climate change and agriculture: A review of impacts and adaptations,* Agriculture and Rural Development Department, World Bank; 2013. https://openknowledge. worldbank.org/handle/10986/16616

14. Isgina T, Bilgic A, Forster DL and Battec MT. Using count data models to determine the factors affecting farmers' quantity decisions of precision farming technology adoption. *Computers and Electronics in Agriculture. 2008; 6:*231–242.

15. Sharma A, Bailey A and Fraser I. Technology adoption and pest control strategies among UK cereal farmers: evidence from parametric and non-parametric count data models. *Journal of Agricultural Economics. 2011; 62(1):*73-92.

16. CBS. *National Climate Change Impact Survey 2016 - A Statistical Report*, Central Bureau of Statistics, Kathmandu, Nepal; 2017.

17. Cameron AC and Trivedi PK. *Regression Analysis of Count Data,* Cambridge University Press; 1998.

18. Greene WH. *Econometric Analysis*, 6th ed. New Jersey: Prentice Hall; 2008.

19. Winkelmann R. *Econometric Analysis of Count Data*, 5th ed. Berlin Heidelberg: Springer-Verlag;2008.

20. Baum CF. *Models for Count Data and Categorical Response Data,* Boston College and DIW Berlin;2010.

21. Awuni JA, Azumah SB and Donkoh SA. Drivers of adoption intensity of improved agricultural technologies among rice farmers: evidence from northern Ghana. *Review of Agricultural and Applied Economics.2018;21(2):* 48–57.

22. Pedzisa T, Rugube L, Winter-Nelson A, Baylis K, and Mazvimavi K. Abandonment of conservation agriculture by smallholder farmers in Zimbabwe. *Journal of Sustainable Development*. 2015; 8(1): 69–82.

23. Happy FA, Begum IA and Dhar AR. Impact of remittance on agricultural technology adoption and employment generation in Lakshmipur district of Bangladesh. *American Journal of Agricultural and Biological Sciences. 2019; 14:*16-22. DOI: 10.3844/ajabssp.2019.16.22

24. Pandit M, Paudel KP and Williams D. Effect of remittance on intensity of agricultural technology adoption in Nepal, *Proceedings of the Southern Agricultural Economics Association Annual Meeting, Feb. 1-4,* Dallas, Texas. 2014; 1-18.

25. Obisesan A. Gender differences in technology adoption and welfare impact among Nigerian farming households. *Munich Personal RePEc Archive Paper,* University Library of Munich, Germany; 2014. https://mpra.ub.uni-muenchen.de/58920/1/MPRA_paper_58920.pdf

26. Hossain M. Does gender influence farm households' decision to adopt technology and commercial agriculture: implication for household food security in rural Bangladesh, *SAARC Journal of Agriculture. 2019;* 17(1): 219-226.

27. Manda J, Khonje MG, Alene AD and Tufa AH, Abdoulaye T, Mutenje M, Setimela P. and Manyong, V. Does cooperative membership increase and accelerate agricultural technology adoption? Empirical evidence from Zambia. *Technological Forecasting and Social Change*. 2020; 158: 1-12 https://doi.org/10.1016/j.techfore.2020.120160 (Available 20 June 2020)

28. Beyene, A.D. and Kassie, M. Speed of adoption of improved maize varieties in Tanzania: an application of duration analysis. *Technological Forecasting and Social Change. 2015;* 96: 298–307.

29. Katungi E. and Akankwasa K. Community-based organizations and their effect on adoption of agricultural technologies in Uganda: a study of banana pest management technology. *Acta Horticulturae. 2010;* 879:719-726.

30. Aryal JP, Sapkota TB, Rahut DB, Krupnik TJ, Shahrin S, Jat ML and Stirling CM. Major Climate risks and adaptation strategies of smallholder farmers in coastal Bangladesh. *Environmental Management. 2020; 66: 1*05–120. https://doi.org/10.1007/s00267-020-01291-8.