Research Article

FACTORS AFFECTING ADOPTION OF MAJOR ADAPTATION STRATEGIES AGAINST DROUGHT AMONG SUMMER VEGETABLES GROWERS IN CENTRAL NEPAL

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Received date: 15 January 2021, Accepted date: 10 May 2022

ABSTRACT

Climate change is one of the critical challenges in the field of agriculture and drought is one among the important effects of global climate change affecting summer vegetables in central Nepal. A research was conducted in central Nepal to seek out factors affecting adaptation strategies against drought among summer vegetables growers. A semi-structured questionnaire was used to collect primary data from 300 households adjoining Trishuli Narayani River corridor equally divided among three districts namely Chitwan, Dhading and Nuwakot. Data obtained were analyzed using descriptive statistic and logit model. Irrigation canal, choosing appropriate crop varieties, mulching, adjusting planting time and using organic manure were identified important adaptation strategies for drought within the study areas. Distance of vegetable farm from river, knowledge of climate change with the respondents, training provided to farmers on vegetable farming, access to cooperative was seen significantly affecting farmers to settle on those adaptation strategies against drought. Adopting different practices against drought found to be correlated with topography or agro climatic regions as well. Nuwakot and Dhading with high altitude got less chance of using organic manure and mulching practice in comparison with Chitwan but its opposite with other adaptation practices like adjusting planting times, changing crop varieties and using irrigation canal. Policy makers and extension workers should focus more on knowledge input based on topography or agroclimatic regions as well about climate change adaptation practices among the farmers, hence providing more trainings on vegetable farming, increasing the access to cooperatives and other organizations could ultimately help to strengthen vegetable growers to adopt those adaptation practices.

Keywords: Climate change, mulching, logit, organic manure

INTRODUCTION

Climate on the earth is influenced by several processes and interactions not only within the earth but also on the sun causing climate viabilities (Sharma, 2009). Climate change is the most critical global challenge of this time. Climate change is the change in climatic condition over time occurred either due to anthropogenic or nature induced causes, which remains for decades or even longer period of time showing distinct variation in its mean (IPCC, 2015). Climate change will change the present situation of the hydrologic cycle, and cause the redistribution of water resources in time and space. It will have a direct effect on the evaporation, runoff, and soil humidity as well. Climate change at present has moved from being hypothesis to being reality and has become an important global threat to all economic sectors, being agriculture a major one (Kreft, Eckstein, & Melchior, 2017).

Agriculture in Nepal is the important source of support for the majority of households. Adapting the agricultural sector mainly for negative effects of climate variability is necessary to assure food security for country and to protect livelihood of Nepalese households (CASA, 2020). Adaptation to changing climate is an effective tool at the farm level to reduce climatic vulnerability by making Nepalese farmer able to prepare themselves and their farming to changes and variability in climate along with avoiding projected damages and boosting up them in dealing with adverse events (IPCC, 2015). A study report from Nepal also shows that farmers have adopted some measures as conservation of local landraces, alternative practices to reduce water stress, soil erosion and loss, changes in cropping pattern and crop adjustments. Thus, it has become very necessary to find some adaptation strategies at the local level to cope with the climatic changes which will significantly reduce impacts of climate change & variability on agricultural economy(Reid, Simms, & Johnson, 2007). Climate is one of the most important factors in agricultural productivity, which could directly or indirectly influence productivity since the climate is linked to physiological processes (Adeagbo,

Ojo, & Adetoro, 2021). Nepal is much vulnerable to climate change and it has already started to experience impacts of climate change in a number of ways, affecting the agricultural production and food security in the country. Despite those facts, due to various reasons the process of adaptation to climate change is slow and discouraging (Karki & Gurung, 2012).

Vegetable sub-sector is an integral part of the farming system in Nepal and many farmers are diversifying away from cereal crops in search of better returns. The increase in the number of vegetable farmers indicates that they have seen an opportunity to improve their incomes. More than 3.2 million households in Nepal are cultivating vegetables and the vegetable sector contributes 9.7% of the country's GDP and is dominated by small produces (CASA, 2020). Drought is one of the major effect of climate change in vegetables which is directly affecting its productivity (Ayyogari, Palash, & Pandit, 2014), the drought impacted the livelihoods of the farmers (Muralikrishnan et al., 2021). Thus, the objective of this study was to analyze the factors affecting the adoption of major adaptation strategies against drought among summer vegetables growers in central Nepal.

MATERIALS AND METHODS

Study area and sampling

The study was done in three districts of the Bagmati Province; Chitwan, Dhading and Nuwakot districts. This region is one of the most affected areas of the country due to frequent climatic hazards such as erratic rainfall and even drought in dry seasons (Regmi & Pandit, 2016). From each district, 100 farmers were interviewed using a semi-structured questionnaire. Respondents were selected using a randomized lottery, with lots draw from a listing of farmers within the district compiled by local agriculture office.

Analysis of data

SPSS and STATA were used to analyze the collected data including descriptive statistics- such as mean, number, standard deviation, range, and percentage and econometric analysis.

Adaptation is a dependent dummy-variable in the data. The dummy was determined by assigning a value of 1 for farmers who indicated that they had taken adaptive measures in response to negative effects of climate change and a value of 0 for farmers who indicated they did not engage in any adaptive measures at all in response to negative effects of climate change. For instance, if a farmer uses at least one coping strategy to abate the negative consequences of climate change then that famer is considered to have "adapted" (1). During the enumeration of the survey, respondents were presented with an scripted explanation of practices and behaviors vis-a-vis climate change adaptation strategies, then presented with a simple dichotomous ("yes/no" response) question about whether or not they had adopted any of these behaviors due to changing climate in the region, making results here self-reported.

Different strategies are practiced by various farmers, which enhance the farmer's adaptation to climate change. However, adaptation strategies to climate change effects also depend on the socioeconomic characteristics of the farmers (Tiwari, Rayamajhi, Pokharel, & Balla, 2014). For instance literate farmers may take different adaptive measures compared to those who are illiterate. Moreover, annual family income, farm size, farming experiences, and contact with extension service agents influence the famers' use of adaptive measures to adjust to environmental degradation and severe weather events resultant from climate change effects. Regardless of the strategies applied by farmer, it is predicted that taking adaptive measures reduces the negative effects of climate change on farm production, household income and farmer livelihoods.

In determining the econometric form to employ for this analysis, three options traditionally utilized to evaluate qualitative dependent variables, such as the dichotomous outcome of "Adapted" and "Not Adapted", were considered: Linear Probability Models (LPM), probit models, and logit models.

Logit model was used to identify the socio-economic factors affecting the farmers' adoption of adaptive strategies, using the functional form of Logit model expressed by (Gujarati, 2004) as:

$$Pi = 1/1 + e^{-(\beta 0 + \beta iXi)} \quad \ldots\ldots (1)$$

For simplicity equation 1 can be expressed as

$$Pi = 1/1 + e^{-Zi} \quad \ldots\ldots (2)$$

Where,

Pi = Probability of adaptation of the i^{th} respondent

e^{-Zi} = stands for the irrational number e raised to the power of Zi

Zi = is a function of N-explanatory variables and expressed as:

$Zi = ß_0 + ß_1 X_1 + ß_2 X_2 + \ldots\ldots + ß_n X_n + \mu_i \quad \ldots\ldots (3)$

Where,

$ß_0$ = Constant term

$ß_1 \ldots ß_n$ = Regression co-efficient

Therefore,

$$Zij = \beta 0 + \beta 1Xij + \beta 2Yij + \beta 3Wij + \mu ij \ldots\ldots\ldots\ldots\ldots\ldots (4)$$

Where,

Xij = Social capital (sex, age, education, gender of household head)

Yij = Capital assets (farm size, income, economically active member)

Wij = Institutional factor (access to credit, training and extension, information)

μij =Error term

Thus, the binary regression model will be expressed as;

$Y_i = f(ß_i X_i) = f$ (gender of household head (X_{1i}), no. of years experience in summer vegetable farming (X_{2i}), annual income of household (X_{3i}), distance of agriculture farm from river (X_{4i}), number of training received by family members on vegetable farming (X_{5i}), family member involvement in cooperatives (X_{6i}), water unavailability affecting vegetable production (X_{7i}) and knowledge of climate change with respondent (X_{8i}).

Here, same explanatory variables (variables affecting adoption strategy against drought) determined the different dependent variables (adaptation strategy), so we used logit model to gauge the factor affecting adaptation strategy.

Table 1. Operational definition of variables with description

Variables	Description of Variable	Range	Mean	Std. Dev.
Dhading#	Dhading dummy: 0= Farmers from other district, 1 = Farmers from Dhading district	0-1	0.333	0.472
Nuwakot#	Nuwakot dummy: 0= Farmers from other district, 1 = Farmers from Nuwakot district	0-1	0.333	0.472
HH_Sex	Sex of the household head: 0= Male 1 = Female	0-1	0.170	0.376
HH_Literacy	Literacy of Household Head: 0 = Illiterae 1= Litterate	0-1	0.766	0.423
Ethnicity	Ethnicity of respondents: 1=Brahmin, 2= Kshetri, 3 = Thakuri, 4= Ethnic group and 5 = Occupational Caste	1-5	2.570	1.425
Income	Income of household in thousand Rs: continuous	100-1000	228.833	137.691
Experience	Household involvent in summer vegetable growing in yrs: continuous	10-60	17.136	9.614
River_distance	Distance of vegetable farms from river in Km: continuous	0-5	1.867	1.630
Knowledge	Knowledge of Climate Change: 0 = No, 1 = Yes	0-1	0.683	0.465
Training	No. of training given to HH members on agriculture: continuous	0-12	0.55	1.031
Cooperatives	Involvement of HH member in cooperatives: 0 = No, 1 = Yes	0-1	0.760	0.427
Water_ unavailability	Water unavailability affecting the vegetable production: 0 = No, 1 = Yes	0-1	0.553	0.497

RESULTS AND DISCUSSION

Among all respondents, 37 percent were Brahmin, 17.3 percent were Kshetri and one percent were Thakuri. This ethnicity distribution among the respondents were seen one percent level significant. Mixed ethnic communities were found in the study areas.

Table 2. Distribution of respondents according to the ethnicity

Ethnicity	Chitwan	Dhading	Nuwakot	Total	Chi square
Brahmin	27(24.3)	39(35.1)	45(40.5)	111(37)	35.856 ***
Kshetri	6(11.5)	21(40.4)	25(48.1)	52(17.3)	
Thakuri	1(33.3)	2(66.7)	0(0)	3(1)	
Ethnic group	61(49.6)	33 (6.8)	29 (23.6)	123(41)	
Occupational Caste	5 (45.5)	5 (45.5)	1 (9.1)	11(3.6)	

Note: *, ** and *** indicate significant at 1 percent, 5 percent and 10 percent levels, respectively. Figures in parentheses indicate percentage.

Farmers' perceptions on experiencing climate change

Going through the household survey in three districts, it was found that 48 % perceived there is high impact in livelihood due to climate change, 29.33% perceived less impact in livelihood, 22.33 perceived no impact in their livelihood and 0.003 percent respondents perceived there was positive effect of climate change in the livelihood. According to the feedback of the farmers, we could conclude that there was effect of climate change in the field and farmers are fighting against climate change with different adaptation strategies.

Similarly, severity of impact due to climate change on agriculture was seen high in Nepal (Dhakal, Silwal, & Khanal, 2010).

Table 3. Perception of respondents on the effect of climate change on crop field

Effect of CC in livelihood	Chitwan	Dhading	Nuwakot	Total	Chi square
High Impact	58 (40.3)	42 (29.2)	44 (30.6)	144 (48)	42.499***
Less Impact	31 (35.2)	16 (18.2)	41 (46.6)	88 (29.3)	
No Impact	10 (14.9)	42 (62.7)	15 (22.4)	67 (22.3)	
Slightly benefitted	1 (100)	0 (0)	0(0)	1(0.3)	

Note: *, ** and *** indicate significant at 1 percent, 5 percent and 10 percent levels, respectively. Figures in parentheses indicate percentage.

Adoption of different adaptation strategies was seen prevalent in the research districts against drought. Among 300 respondents from three districts, 53.7% farmers were using irrigation canal as adaptation practice against drought, 26.3% respondents used the selection of crop varieties to adapt against drought, 36.7% respondent farmers adopt to sue adjustment in planting time as adaptation practice against drought, 39% respondents were using mulching as adaptation strategies to fight against drought. Among all, four adaptation strategies were seen statistically significant in three districts, changing the crop varieties was not seen statistically significant.

Table 4. Status of adaptation strategies being practiced in three districts against drought

Different Adaptation Strategies	Chitwan	Dhading	Nuwakot	Total	Chi square
Irrigation canal	36 (22.4)	58 (36)	67 (41)	161 (53.7)	20.457***
Crop varieties as adaptation practice to drought	22 (27.8)	24 (30.3)	33 (41.7)	79(26.3)	3.54
Mulching as adaptation practice to drought	63 (52.9)	29 (24.36)	27 (22.6)	119 (39.7)	34.208***
Adjustment in planting time as adaptation practice to drought	23(20.9)	33 (30)	54 (49.1)	110 (36.70	21.560***
Organic mulching as adaptation practice to drought	86 (40.7)	54 (25.5)	71 (33.6)	211 (70.3)	24.570***

Note: *, ** and *** indicate significant at 1 percent, 5 percent and 10 percent levels, respectively. Figures in parentheses indicate percentage.

Significant variables such as household size, dependency ratio, frequency of extension visits, access to extension, and non-farm income were factors influencing the adoption of climate change adaptation strategies (Adeagbo et al., 2021)which could directly or indirectly influence productivity since the climate is linked to physiological processes. It is, therefore, essential to understanding the various strategies used by farmers to mitigate the adverse impact of climate change and the factors that influence maize farmers' adoption and intensity of climate change adaptation strategies among smallholder maize farmers in South-west Nigeria. In all, a sample of three hundred and thirty (311. Among listed variables, Dhading dummy, Nuwakot dummy, sex of household head, knowledge on climate change of respondents, numbers of training received by household members, involvement on cooperative found to be positively affecting using irrigation canal as adaptation practices against drought whereas experience of household on summer vegetables found to be negatively affecting the chance of adopting the adaptation strategy. Similar results were found in regards to information dissemination and community level extension services, which are very effective to inform the people about such changes and to convince them to take necessary adaptation actions (Piya, Maharjan, & Joshi, 2012). Development of irrigation will benefit the agriculture sector by facilitating adaptation to climate change, increasing agriculture productivity and incomes, and improving rural livelihoods (Adhikari, 2016); (Gnanasubramaniam & Hemachandra, 2020). Among many explanatory variables affecting change in

cropping varieties as an adaptation strategy for drought control, experience in growing summer vegetables, found negatively significant using crop varieties as adaptation strategies against drought, but number of training household members received and perception of water unavailability affecting vegetable production found statistically significant positively. Among them, if household members got one more training on vegetables farming, there would be chance of utilizing this adaptation strategy increased by 4.9%. The intensive agro-advisories and training programs may improve the farmers' motivation level in drought adaptation (Muralikrishnan et al., 2021).

There is 25.3% more chance from Chitwan than Dhading and 31.1% more chance in comparison to Nuwakotto adopt mulching by farmers, 14.5 % more chance to adopt mulching practices against drought if respondents were literate and 21.7% more chance to adopt the mulching practice if they got access to cooperatives. In contrary to mulching, farmers from Dhading got 16.7% more chance and Nuwakot got 24.5% more chance to choose adjusting planting time as adaptation practices against drought than farmers from Chitwan. Similarly, if respondents were knowledgous about climate change in advance, there was chance of using the adaptation practices like adjusting planting time increased by 24.6%. In the case of organic manure application, in comparision of farmers from Dhading and Nuwakot, chance of utilizing that adaptation practices seemed 96.4% and 69.8 % more respectively to adjust against drought. One year more experience on vegetable farming showed chance of using organic manure could be increased by 4.4%.

Table 5. Determinants of farmer's decision to adopt different adaptation strategies against drought adopted by farmers

Variables	Irrigation Canal	Crop varieties	Mulching	Planting time	Organic manure
Dhading#	0.161**	0.023	-0.253 ***	0.167 ***	-0.964 **
	(0.067)	(0.066)	(0.062)	(0.063)	(0.441)
Nuwakot#	0.197 ***	0.038	-0.311 ***	0.245 ***	-0.698
	(0.065)	(0.632)	(0.060)	(0.056)	(0.448)
HH_Sex	0.003 **	-.0109	0.082	0.030	0.280
	(0.063)	(0.068)	(0.068)	(0.065)	(0.454)
HH_Literacy	0.003	0. 022	0.145 **	-0.031	0.523
	(0.063)	(0.058)	(0.062)	(0.056)	(0.363)
Experience	-0.006 **	-0.005 *	0.003	-0.0003	0.044 **
	(0.003)	(0.003)	(0.002)	(0.002)	(0.021)
Income	0.0002	0.0002	0.0002	0.0003 **	0.002 *
	(0.001)	(0.0001	(0.0001)	(0.0001)	(0.001)
River_distance	0.017	-0.022	0.007	-0.011	0.046
	(0.016)	(0.015)	(0.016)	(0.014)	(0.091)
Knowledge	0.123 **	0.079	0.015	0.246***	0.932 ***
	(0. 058)	(0.059)	(0.058)	(0.056)	(0.328)
Training	0.150 ***	0.049 **	0.008	0.003	0.033
	(0.045)	(0.023)	(0.023)	(0.022)	(0.134)
Cooperatives	0.161 ***	0.070	0.217***	0.214 ***	0.209
	(0.061)	(0.062)	(0.064)	(0.062)	(0.378)
Water_unavail-ability	0.009	0.207	-0.062	0.221 ***	1.693 ***
	(0.054)	(0.050)***	(0.053)	(0.044)	(0.314)
N	300	300			
LR chi 2 (11)	63.99	36.44	60.41	97.73	93.47
Prob>chi2	0.00	0.000	0.0000	0.0000	0.0000
log likelihood	-175.14	-154.73	-171.286	-148.282	-135.671
Pseudo R2	0.15	0.105	0.1499	0.2479	0.2562

Note: *, ** and *** indicate significant at 1 percent, 5 percent and 10 percent levels, respectively. dydx indicates marginal effect after Logit. Figures in parentheses indicate standard error.

CONCLUSION

Adaptation practices among farmers are one of the best strategies to fight against the climate change and its direct and indirect effect on vegetables productivity. So we need to understand the various strategies used by farmers to fight against adverse impact of climate change i.e. drought among summer vegetables farmers in Central Nepal. In total, three hundreds smallholder summer vegetables farmers were interviewed. The primary data was collected through a household survey of vegetable farmers in the study area. A logit model was employed to estimate the factors influencing farmers' adoption of adaptation strategies against drought. Significant variables such as sex of household head, literacy or illiteracy of head of household, access to cooperatives, and training provided to the farmers were important factors influencing the adoption of adaptation strategies against drought among vegetable farmers.

Farmers from Chitwan showed higher chance of probabilities to adopt adaptation strategies against drought. Similarly, distance of farm from river, knowledge of climate change with the respondents, training provided to farmers on vegetable farming, access to cooperative shows statistically significantly affecting to choose different adaptation strategies against drought. Adopting different practices against drought found to be correlated with topography or agro climatic regions as well. District like Nuwakot and Dhading with high altitude got less chance of using organic manure and mulching practice in comparison with Chitwan but its opposite with other adaptation practices like adjusting planting times, changing crop varieties and using irrigation canal.This study therefore concluded that agriculture extension service provider must focus on such findings regarding the drought and its adaptation strategies. Training on vegetable farming and climate change effect should be given side by side which would positively affect the farmers' choice or adoption on the adaptation strategies. Extension service provider should also focus on particular adaptation practice based on the topography and agroclimatic regions as well. Thus, government, stakeholders, and extension agencies must provide capacitybuilding innovations within the agricultural extension system on climate change using information and its effect on summer vegetables farming.

ACKNOWLEDGEMENTS

Authors greatly acknowledge reviewers and editorial team of the Journal of Agriculture and Forestry University, Rampur, Chitwan, Nepal for providing the feedbacks and comments on this manuscript.

REFERENCES

Adeagbo, O. A., Ojo, T. O., & Adetoro, A. A. (2021). Understanding the determinants of climate change adaptation strategies among smallholder maize farmers in South-west, Nigeria. *Heliyon*, *7*(2), 1–10. https://doi.org/10.1016/j.heliyon.2021.e06231

Adhikari, B. (2016). *Irrigation Engineering Manual*. National Environment Commission & Department of Agriculture, Royal Government of Bhutan, Thimpu, Butan.

Ayyogari, K., Palash, S., & Pandit, M. K. (2014). Effects of climate change on vegetable cultivation-a review. *International Journal of Agriculture, ENvironment and Biotechnology*, *7*(1), 145–155. https://doi.org/10.5958/j.2230-732x.7.1.020

CASA. (2020). *Vegetable Sector Strategy-Nepal*. Kathmandu, Nepal. Retrieved from https://www.casaprogramme.com/wp-content/uploads/CASA-Nepal-VegetablesSector-analysis-report.pdf

Dhakal, K., Silwal, S., & Khanal, G. (2010). *Assessment of climate change impacts on water resources and vulnerability in hills of Nepal: a case study on Dhare Khola watershed of Dhading District*. National Adaptation Program of Action (NAPA) to Climate Change, Ministry of Environment, Government of Nepal, Kathmandu, Nepal.

Gnanasubramaniam, S., & Hemachandra, D. (2020). Perception of Climate Change and Farmers' Adaptation: An Analysis for Effective Policy Implementation. *Asia-Pacific Journal of Rural Development*, *30*(1–2), 27–54. https://doi.org/10.1177/1018529120946177

Gujarati, D. N. (2004). *Basic Econometrics. Fourth Edition* (Vol. 82). McGraw-Hill Higher Education, New York, US. https://doi.org/10.2307/2230043

IPCC. (2015). *Summary for policymakers*. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp*. https://doi.org/10.1017/CBO9781139177245.003

Karki, R., & Gurung, A. (2012). An Overview of Climate Change And Its Impact on Agriculture: a Review From Least Developing Country, Nepal. *International Journal of Ecosystem*, *2*(2), 19–24. https://doi.org/10.5923/j.ije.20120202.03

Kreft, S., Eckstein, D., & Melchior, I. (2017). *Global Climate Risk Index 2017*. *Germanwatch e.V.* Retrieved from www.germanwatch.org

Muralikrishnan, L., Padaria, R. N., Choudhary, A. K., Dass, A., Shokralla, S., Zin El-Abedin, T. K., … Elansary, H. O. (2021). Climate Change-Induced Drought Impacts , Adaptation and Mitigation Measures in Semi-Arid Pastoral and Agricultural Watersheds. *Sustainability*, *14*(6), 1–18. https://doi.org/https://doi.org/10.3390/su14010006

Piya, L., Maharjan, K. L., & Joshi, N. P. (2012). Perceptions and Realities of Climate Change among the Chepang Communities in Rural Mid-Hills of Nepal. *Journal of Contemporary India Studies: Space and Society, Hiroshima University*, *2*, 35–50. https://doi.org/http://doi.org/10.15027/33600.

Regmi, B. R., & Pandit, A. (2016). *Classification of Adaptation Measures and Criteria for Evaluation: Case Studies in the Indus River-Basin*. HI Aware Consortium Secretariat; Himalayan Adaptation, Water and Resilience, ICIMOD, Kathmandu, Nepal.

Reid, H., Simms, A., & Johnson, V. (2007). Up in smoke? Asia and the Pacific: the threat from climate change to human development and the environment. The fifth report from the working group on climate change and development, 1–96. Retrieved from cabi:20083156478

Sharma, K. P. (2009). *Climate change: trends and impacts on livelihood of people*. Jalsrot Vikas Sanstha and Nepal Water Parnership, Kathmandu, Nepal.

Tiwari, K. R., Rayamajhi, S., Pokharel, R., & Balla, M. K. (2014). Determinants of the Climate Change Adaptation in Rural Farming in Nepal Himalaya. *International Journal of Multidisciplinary and Current Research*, *2*(April), 234–240.