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Determinants of the Climate Change Adaptation in Rural Farming in Nepal Himalaya

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Abstract

Climate change (CC) impacts on rural farming and adaptation practices are new areas of study in the rural farming systems. This study focused on better understanding the CC impacts and adaptation practices in rural farming in three different agro-climatic regions (Trans-Himalayan- Mustang, Mid-Mountain- Dhading and Inner Terai- Chitawan district) of Nepal. Household survey, key informant interview and focus group discussion methods were applied to collect primary information at household and community levels supplemented with national climate data. Soil moisture or irrigation deficiencies are the main limiting factors for farm production of the upland framers, particularly, in the mid-mountain region. It is observed that adaptation to CC is location specific and determined by different factors. Logistic regression model indicated different factors such as resources availability, family labor availability, farm income, institutional activities and involvement in the community level organization of households influenced adaptation practices. Local institutions are found to have limited capacity to implement the adaptation practices in the rural areas. Planners and development workers should formulate location specific adaptation programs and activities focusing on water management for minimizing the impacts of climate change in rural farming.

Key words: *socioeconomics, institution, upland farming, water management, farm production, livelihoods.*

1. Introduction

Climate change adaptation is the major development agenda in many developing countries like Nepal where majority of the population depends on farming. It is reported that agriculture dependent communities are more affected by the climate change impact. There is a significant risk that many of the trends will accelerate, leading to extreme climatic events and to an increasing risk of abrupt or irreversible climatic shifts (IPCC, 2007, 2013). Global climate change can be expected to threaten food production and its supply, for example through changing patterns of rainfall, increasing incidence of extreme weather and changing distribution of diseases and their vectors (IPCC, 2007). Findings from the National Adaptation Program of Action (NAPA) showed that Nepal is extremely vulnerable to climate change impacts because it heavily depends on natural resources, particularly water, soils, and forests (MOE, 2010). The situation is made worse by poverty, population pressures, land degradation, food insecurity, and deforestation.

Adaptation to climate change impacts is an emerging area of research and development (R&D) in Nepal and similar developing countries. However, most of the local government and communities in developing countries have limited knowledge and capacity to adapt to impacts of climate change. In order to improve the ability of communities and households (HHs) to adjust to ongoing and future climate changes, improved understanding of the risks they are facing is needed (H. Heltberg et al., 2009) and adaptation capacities at local level. Climate change may significantly impact on access to assets, activities, outcomes and incomes of households throughout the rural areas. This is particularly true for households with low adaptive capacity, i.e. having constrained abilities to cope with the impacts and risks of climate change (B. Smit et al., 2001). Climate change adaptation in rural farming is the location specific and local-level analyses to gain a better understanding of the fundamental processes underlying adaptation and for better targeting of adaptation policies by national and local governments (T.B. Below et al., 2012). A better understanding of processes that shape farmers' adaptation to climate change is critical to identify vulnerable entities and to develop well-targeted adaptation policies. However, what determines farmers' adaptation and how to measure it are currently poorly understood. Understanding the determinants of a Household's decision to adopt a particular practice among the available choices may provide insights into the

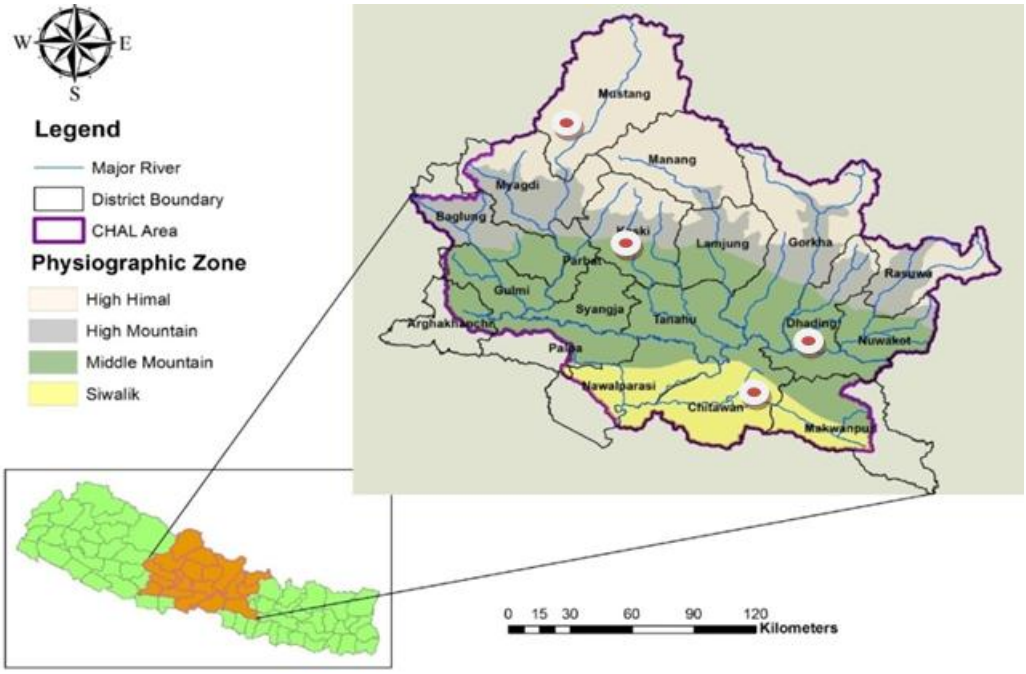

Figure 1. Map showing Study Areas

factors that enable or constrain adaptation.

1.1 Theoretical context of adaptation

Adaptation to climate change is a complex, multidimensional, and multi–scale process (Bryant et al., 2000; Bryan and Behrman, 2013). The climate change adaptation process is in terms of type, scale, timing, and outcome of the responses, as well as the factors that influence adaptation (B. Smit et al., 1996; E. Bryant et al., 2000; B. Smit and M.W. Skinner, 2002; A. Agrawal and N. Perrin, 2008; R. Heltberg et al., 2009).

The adaptation responses has been classified according to the spatial scale at which they occur (such as from top–down, state–led investments in infrastructure to community investments in food storage facilities to changes in individual farming practices); intent (either reactive or proactive); timing with respect to the climate stress; duration (short– or long–term); form/type (for example, technological developments, government programs, behavior change, and insurance); and effect (enhanced stability or resilience) (B. Smit et al., 1996; E. Bryant et al., 2000; B. Smit and M.W. Skinner, 2002; A. Agrawal and N. Perrin, 2008; R. Heltberg et al., 2009). Furthermore, According to A. Agrawal and N. Perrin (2008), group adaptation strategies according to their form or type—mobility, storage, diversification, communal pooling, and exchange and function with respect to risk (that is, pooling, avoiding, or reducing risk). Examples of adaptation decisions that are likely to have positive outcomes include changing farming practices, livelihood diversification, asset accumulation and diversification, investments in human and social capital formation, insurance, and natural resource management. It is now commonly accepted that immediate investment in adaptation will be essential to buffer the worst climate impacts (M. Parry et al., 2008). Recognition of the adaptation imperative has led to a rapid increase in the rate of development in adaptation thinking and also, in the policy context.

Adaptations generally include changes in: (i) production, such as crop mix; (ii) irrigation practice; (iii) time of planting; (iv) locations; (v) dryland and irrigated areas; (vi) irrigation infrastructure; (vii) water use and trade (buying and selling water); (viii) environmental Management (e.g. planting trees); and (ix) farm management strategy, such as use of insurance to protect against potential loss (B. Smit and M.W. Skinner, 2002; K.R. Tiwari et al., 2010; T.B. Below et al., 2012) They found production factors, natural and physical capital, education and gender of household head, and social and financial capital were all significantly associated with adaptive capacity.

In theory, diversification can serve to buffer farm business risks, be it yield risk associated with variable climatic conditions or price risk associated with variable commodity markets (B. Fleisher, 1990; J. Hardaker et al., 1997), and this benefit would appear to be especially vital in an era marked by less dependable government support (B. Bradshaw and B. Smit, 1997). As Ronald A. Fisher emphasized in 1930, adaptation is characterized by the movement of a population towards a phenotype that best fits the present environment (H.A. Orr, 2005). Additionally, household adaptation choices are found to be determined not only by the environmental variables or geographic features, but also by household

socioeconomic characteristics; farm characteristics or infrastructures; social, institutional, and finally farm income (K.R. Tiwari et al., 2008; T.B. Below et al., 2012).

This paper conducts a quantitative analysis of the determinants of household adaptation decisions over a range of socio-economic variables, and perception on climate change, in addition to the social and institutional factors emphasized by the earlier studies. The study explored the factors, which encourage or discourage rural HHs' adaptation to climate change from the perspectives of personal, socioeconomic, physical as well as institutional factors.

2. Methodology

2.1 Study Area

The study was conducted in three different eco-region sites, namely, High Mountain, Mid- Mountain and Terai. The study areas are considered to be the most suitable sites in order to study climate change impacts, adaptation practices and farming practices as they lie in different regions and are inhabited by different communities and ethnic groups in Nepal (Figure 1).

2.2 Research Approach

The study was conducted with multidisciplinary team in a participatory manner involving local institutions, such as Village Development Committees (VDCs), Non-Government Organizations (NGOs), Community Forest User Groups (CFUGs) and households (HHs) as the unit of analysis. The research methods adopted include literature reviews, detailed planning of the research including site selection, household survey, group discussion, key informant interview, and field observation. Sixty HHs were taken in each region to cover different wealth groups and vulnerable groups and a total of 180 HHs survey were done to determine the factors influencing the adaptation on climate change in rural farming. Traditionally, there are also some variations in farming practices in each region based on their socio economic conditions. Therefore, representation by each socioeconomic group was also taken into consideration during sampling. For the purpose of this study, the head of the selected HHs (usually the HH head is implicitly assumed to be the decision maker) was interviewed using a structured questionnaire, which covers a broad range of personal, social, economical, institutional and resource management issues relevant to the process of adaptation practices in their farming.

Data on the determinant variability factors in the study sites such as: demography, income level, social status, location, vulnerability, asset holding, institutions, etc. were gathered through questionnaire surveys, key informant interviews and group discussions. Structured questionnaire was prepared and pre-tested in an area outside the sampling frame. Information about climate related shocks whether recurrent or periodic events on agriculture and livestock production such as hail storm, drought, heavy rain, frost, change in rainfall pattern, thunder, pest and disease outbreak were also collected through questionnaire survey. Both positive and negative, perceived and actual shock, and response to coping were gathered using short memory recall and choice experiment method using the questionnaire survey. Additionally, both plan and autonomous adaptation at HH level were identified and their factors of adaptation were assessed.

2.3 Data analysis methods

Quantitative information collected through personal interviews was processed using the computer-based software called Statistical Package for Social Sciences (SPSS). Frequency tables were generated for general information, and binary logistic regression was applied to find out the degree of relationship between independent and dependent variables for the determinants of adaptation on climate change impact on rural farming. Qualitative information collected through focus group discussions and key informant surveys was processed manually and used in the analysis to complement the quantitative information.

2.4 Development of a logistic regression model to explore the factors influencing climate change adaptation practices on rural farming

A logistic regression model (A. Agresti, 1996) was developed to explore the personal/ social, economic, institutional, and geographical factors influencing the improved adaptation practices in the rural farming. A regression model, and its binary outcomes, help the researchers to explore how each explanatory variable affects the probability of the occurrence of events (S.T. Long and J. Freese, 2006). This model helps to explore the degree and direction of the relationship between dependent and independent variables in the climate change adaptation practices at the household level.

The dependent variable for the climate change impact adaption model in rural farming indicates whether or not a household has adopted improved adaptation practices. Improved adaptation practices for mitigating climate change impacts on rural farming include use of irrigation facilities, water harvesting, crop diversification, farm diversification, change in cropping pattern, planting time and varieties, etc. Improved and indigenous adaptation practices were identified based upon field observation and discussion with farmers. In this study, a farmer who has adopted at least one climate change adaptation practice at farm level, either as recommended by extension workers or with some modification, is defined as an adopter. A value of '1' was assigned to households adopting at least one adaptation practice (the 'adopters') and '0' was assigned to households using only indigenous

measures or none (the 'non-adopters'). Whether or not to adopt any adaptation measure is influenced by personal, social, economic, institutional and expose from the stress factors. These variables were treated as independent variables in this study.

The logistic regression model is an appropriate statistical tool to determine the influence of independent variables on dependent variables when the dependent variable has only two groups (dichotomous), e.g. adopters and non- adopters, and the explanatory variables are continuous, categorical and dummy (S.T. Long and J. Freese, 2006). In the logistic model, the coefficients are compared with the probability of an event occurring or not occurring. It is bounded between 0 and 1 and exhibits a sigmoid curve conforming to the theory of adoption. The dependent variable becomes the natural logarithm of the odds when a positive choice is made. Hence, if the estimated values of these variables are positive and significant, it infers that the farmers with higher values for these variables are more likely to adapt in rural farming.

The model is specified as (A. Agresti, 1996):

$$\ln [P_x/(1-P_x)]=\beta_0+\beta_1X_{1i}+\beta_2X_{2i}+\ldots\ldots\ldots\ldots\ldots+\beta_kX_{ki}$$

Where,
The subscript i is the i^{th} observation in the sample,
P_x is the probability of an event occurring for an observed set of variables X_i,i.e the probability that the farmer adopt the adaptation practices, and $(1-P_x)$ is the probability of non-adoption.
β_0 is the intercept term, and
$\beta_1,\beta_2\ldots\ldots\ldots\ldots\beta_k$ are the coefficients of the explanatory variables X_1, $X_2\ldots\ldots\ldots X_k$.

3. Results and Discussion

3.1 Socio economic Characteristics

Socioeconomic characteristics of the local communities in the study areas relate to the vulnerability and adaptation capacity at the Household level. The diversity of the ecological regions from High mountain (Transhimalayan region) to Flat lowland (Inner Terai region), and highly diverse socioeconomic conditions were found in the three study areas in terms of ethnicity, cropping pattern, land holding size and HH income (Table 1). However, in all sites majority of the HHs were dependent on farming. It is found that off-farm income mainly remittance has major role for their livelihood that also minimized the vulnerability at the HH level. In the high mountain area, remittance and off-farm income had significant role for their livelihood than farm income (Table 1). Livelihood diversification within agriculture and outside agriculture, migration to urban centres and out of the country to India and Arab countries, commercialisation and increased consumerism and employment were some of visible changes observed in the areas. Remittance economy has become the most powerful force to transform the rural life and livelihoods, which contributes almost half (46%) of the household income (WWF-Nepal, 2013). It is noticed that off- farm income has played major role for reducing different sock and vulnerability particularly poor HH.

Vegetables farming is another important cultivation activity as an adaptation practice in the study areas due to market and road facilities particularly Marpha village in High Mountain and Dhading in Midhills. Change in cropping pattern from Cereal crops to intensive vegetable farming in high mountain and mid mountain region was found to significantly improve HH income and means of adaptation practices on climate change as well as improve the food security (K.R. Tiwari et al., 2008). Food self- sufficiency of the studied communities was analyzed, and found that almost one-forth (24%) of the total population produced food sufficient for one year. Besides vegetable production, some HHs have livestock farming, such as sheep and goat farming (High mountain), poultry, goat and fish farming as well as dairy farming in Mid mountain and Terai regions. It was observed that in High mountain region (Marpha village) some HHs have also operated hotel business due to Touristic area.

Table 1: Socio economic characteristics of the three study area

Variables	Chitawan-Terai	Mid-Mountain-Dhading	High mountain-Mustang
	Mean	Mean	Mean
Age	52	46	52
Farming experiences (Yrs)	26	28	30
No of Schooling (Yrs)	4	3	4
Family members (no)	6	6	5
Family member work (no)	5	4	4
Land area (Ropani)	4.2	12	9
Farm income(Nrs)	29142	69813	21500
Off-farm income (Nrs)	239298	97966	700000

(Source: Household survey, 2012)

3.2 Determinants of Climate change adaptation practices using Binary logistic regression

Binary logistic regression analysis of the HH data showed that different factors affected climate change adaptation practices at HH level in all three different regions. The adaptation practices were found location specific. Moreover, there were some common factors, which significantly determined the adaptation practices (Table 2). Family members available for farming, farm income, land holding size, market opportunities, and local institutions (CBOs) were found to have significant role for climate change adaptation in all sites. Furthermore, available loan facilities for farming, subsidies in technology as well as training facilities on improved

technology also were significant factors for adaptation practice (Table 2).

Table 2: Determinants of Climate change adaptation practices

Variables	High Mountain-Mustang	Mid-Mountain-Dhading	Inner Terai Chitawan
	Sig-p	Sig-p.	Sig-p
Sex	.56	.56	.12
Age	.46	.46	.26
No of experience in farming	.05	.12	.42
Education*	.11	.09	.56
Male female members available in farming**	.05	.01	.08
Land area**	.03	.01	.06
Farm production sufficiency *	.06	.02	.63
Farm income	.08	.06	.09
Off-farm income	.83	.66	.47
Monsoon unpredictable	.32	.32	.17
Summer temperature increase	.58	.77	.63
Members in CBOs*	.07	.08	.03
Training	.08	.90	.06
Loan receive*	.73	.05	.08
Market (Income)	.04	.06	.34
Subsidies/technology	.03	Na	Na

*Significant at 5 % level.

Local farmers reported that subsidies for improved technology (plastic shed for vegetable production), small irrigation facilities, loan availability, and training on improved farming (bee keeping, goat farming, vegetable farming) enhanced the farm production, and reduced the vulnerability of the rural farming. Many studies also reported that adaptation practices were location specific and affected the socioeconomic conditions at the HH level (K. Vincent, 2007; J. Hinkel, 2011; T.B. Below et al., 2012). K.R. Tiwari et al. (2008) expressed that land holding size, availability of family labour, farm income and members in the local CBOs were the positive factors for adoption of improved technology. Additionally, farmers with more land can take more risks, including relatively high investment, if required, and survive crop failure due to pests, hailstones and excess rainfall. Institutional membership demonstrates the significant influence of membership in the adoption of improved technology. A.A. Adesina et al., (2000) also reported the positive and significant sign on farmers' association in Cameroon to adopt Agroforestry technology. CDGs are village level institutions where all members participate in regular monthly meetings, share their experiences about farming and the market price of their farm produce, discuss problems, explore new opportunities on farming, encourage women and occupational caste members to participate in decision making during the meeting, plan and implement other community development programs such as construction of schools, and small scale irrigation canal and regulate their savings and credit programs at the local level. These activities increased confidence among the members to adopt improved farming practices. CDG thus represents social capital where self-motivated households participate for their common interests. Additionally, use of credit encouraged farmers to grow more crops and earn more income from the farmland, which favored adoption of improved technology (K.R. Tiwari et al., 2008). The provision of support services, such as credit, training and extension services, also increased adoption (G. Paudel and G. Thapa, 2004).

3.3 Adaptation practices in three eco-regions

Different types of adaptation practices were found from High Mountain to Inner-Terai region at HH level. In high mountain region adaptation measures were found very limited. Construction of the plastic shed as an adaptation practice for vegetable production during the winter season was found very common among majority of the HHs. Additionally, crop diversification, such as multiple cropping (vegetable, potato, cereal crops as well as planting fruit trees- apple) was also an adaptation measure in their farm land. Farm diversification such as crop production, livestock farming and horticulture (apple farm) farming was also observed in some HHs. Similarly, some HHs also operated hotel business and majority of the HHs members were abroad who sent remittance as an income diversification. I. Jones and E. Boid (2011) also reported that in Western Nepal, different wealth class and ethnic groups HHs adopted different strategies to cope with climate change. It is reported that due to degradation of the grassland and low grass production farmers have reduced the livestock number as well as practiced rotational grazing in the High mountain region. Some respondents reported that due to hardship of the livestock and agriculture farming they either changed the occupation to such as hotel business or migrated from that place.

In case of market availability area of the Mid-mountain region, majority of the local farmers were practicing vegetable farming instead of cereal crops as a crop diversification, to earn more income than cereal crops. K.R. Tiwari et al. (2008) also found similar result that vegetable farming in the mountain region has increased farm income compared to cereal crops. Optimum utilization of marginal lands by planting fodder trees, fruit trees, and other grasses were also observed. Local farmers reported that they have changed the seed sowing and planting time as well as adopted early ripening and drought tolerant varieties in their farm land. T. Baul et al. (2013) reported that rural farmers adopted different farming practices to cope with climatic

Table 3: Local adaptation practices in three eco regions of the study area

High Mountain	Mid Mountain	Terai
• Construction of Plastic House (Green House) • Crop diversification • Farm Diversification • Income Diversification	• Water management • Crop diversification • Farm Diversification • Income diversification	• Water management • Crop diversification • Farm Diversification • Income diversification

variability. It is found that limited farmers have irrigation facilities for their crop production. Additionally, upstream people in mid mountain region have now started rain water harvesting, conservation pond and utilization of excess drinking water for vegetable production. Local farmers expressed that drought was the major problem and if irrigation facilities would be provided major climate change impact would be minimized. The main alternate adaptation practice in this region is income from remittance to cope with climate vulnerability.

It is observed that Terai area farmers have many adaptation practices compared to the other regions. Water management practices such as surface irrigation and under- ground water use for irrigation, and crop diversification were more options of adaptation practices than in other regions. Similarly, farm diversifications, such as, honey bee raising, vegetable farming, fruit farming, agroforestry, livestock farming, poultry and fish farming were also adaptation measures. Additionally, some HH members have service (local job and small business), and labour work aboard as an income diversification.

3.4 Institutional activities on adaptation practices at local level

Impact of climate change is an immerging issue and different government and non-government institutions have initiated the climate change adaptation programs and practices. National Adaptation Program of Action to Climate Change (NAPA) Nepal highlighted the adaptation practices and adaptation framework from national to local level (MOE, 2010). Additionally, Local Adaptation Program of Action to Climate Change has implemented a pilot program in some selected districts and initiation of the local adaptation practices at the local level. Recently, Government of Nepal approved the Climate Change Policy Nepal 2011. The Policy has focused the interdisciplinary approach to implement the program and 80% fund is to be allocated to the local level (MOE, 2011). In the LAPA framework, District Local Development Office is the main government institution to implement adaptation program by coordinating different government and non-government line agencies at the local level. However, local institutions have found no any capacity to institutionalize any adaptation program and coordination mechanisms. Some district level offices such as District Forest Office, District Soil Conservation Office, and District Agriculture Development Office have now initiated some climate change adaptation activities such as construction of conservation pond or water harvesting pond for irrigation, water source protection, Agroforestry practices in leasehold forestry program, small irrigation program, plastic tunnel for vegetable production, releasing drought and early ripening varieties and training on climate change adaptation and mitigation.

Adaptation capacity and practices were observed to vary from location and communities even at the household level. Climate change adaptation is of the complex and integrated nature and there are many challenges to implement at the local level through capacity enhancement and coordination among the line agencies. It is suggested that integrated approach focusing water management technology with institutionalization of the climate change adaptation plan and program should be implemented at the local level.

4. Conclusions and Recommendations

In rural communities, farming is not only a way of life but a means to livelihood. Diversification of the rural farming, therefore, will have to help in generating more income and more food in addition to reducing the vulnerability of the climate change. The findings of this study have important policy implications for the local adaptation practices on climate change in the farming communities. Any further improved technology on farming initiative should aim at enabling local farmers to adopt technology conducive to increase farm income as well as resilience on climate change.

A range of factors influence the climate change adaptation practices in three regions. The result of the logistic model showed that adaptation practice is significantly influenced by farm size (*Bari* land), family members available for farming, farm income, food sufficiency from farm, and membership in the CDG and use of credit. In some cases, subsidies in the technology from the local organizations enhanced the adaptation technology on climate change. Membership in the CDG, for example, played an important role in improving adaptation practices in the study areas. This implies that for successful implementation of adaptation technology, any program needs to be designed and implemented through multi-sectoral type community based organizations. However, these local institutions should be

strengthened and their members empowered such that they can run effective institutions and promote climate change adaptation practices at the local level themselves.

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