PALGO JOURNAL OF AGRICULTURE

ISSN 2476-8359
Volume 3 Issue 5,October 2016.Page 195-201
http://www.palgojournals.org/PJA/Index.htm
Authors Email: maniaryal7@gmail.com

ANALYSIS OF PERCEPTION AND ADAPTATIONS TO CLIMATE CHANGE BY FARMERS IN NEPAL

M. Aryal[1*], P.P. Regmi[2], R.B. Thapa[2], K.R. Pande[3] and K.P. Pant[4]

Market Research and Statistics Management Program, Hariharbhawan, Lalitpur*
Institute of Agriculture and Animal Science (IAAS), TU, Rampur, Chitwan[2]
Department of Soil Science, Agriculture and Forest University, Rampur, Chitwan[3]
Agricultural Expert, FAO, Hariharbhawan, Lalitpur[4]

Accepted 08 September, 2016

Climate change is posing a warning on present and future food security in low income countries. But, the actual effect of the climate change on food security is still unknown. Using primary and secondary data collected by household survey and reported by different organizations, this study examined the farmer's perception about climate change and strategies employed to adapt. Statistical analysis is used for exploring the adaptations by farmers for the negative impact ofclimate change on domestic production of major cereals. The results are discussed at district level empirically and major variables are found statistically significant. This study conclude that there is a need for adaptations strategy by government authority and private sectors in environmental management and agricultural sustainability in Nepal to come to terms with negative impacts of climate change and likely positive and beneficial response strategies to global warming. The paper suggests some policy measures for improving adaptations in the country and open up some areas for further research.

Keywords: Adaptations, Cereal crops, Climate change, Crop yield and Perceptions

INTRODUCTION

The relationship between climate change and agriculture is two-way; agriculture contributes to it in several ways and climate change in general adversely affects agriculture. Climate change is a phenomenon due to emissions of greenhouse gases from fuel combustion, deforestation, urbanization and industrialization resulting variations in solar energy, temperature and precipitation. Agricultural production and productivity are primarily dependent on climatic factors, and the favorable climatic conditions are to be crucial in generating optimal yield. So, economy of the country is more sensitive to agriculture and climate change (Alam and Regmi, 2004). Though Least Developed Countries (LDCs) did not contribute much in increasing the level of GHGs they are highly affected by climate change and have low adapting capacity (Orindi and Eriksen, 2005 and Glieck, 1989). Climate Change has serious impact on cereal crops and livelihood of farming community.

The agricultural sector with low productivity growth is facing high rate of population growth coupled with the effects of climate change leading to serious consequences for sustainability. Intensive rain concentrated in a particular month has a devastating effect on crop production (McCarl, Adams and Hurd, 2001). The majority of the farmers in hilly region of Nepal depend on the monsoon rain for crop cultivation. In the recent years, intensity, amount and distribution of rainfall are changing in unpredictable manner. So, the changes in the rainfall pattern may be fatal for them. Once the climate is disturbed, the whole agriculture system is affected. Climate change affects food, feed, fiber and fuel (**4"F"**) causing food insecurity .Out of 28 million populations, more than 2.5 million faced food insecurity in Nepal (Mo AD, 2015). If the increase in temperature exceeds by 1.5 to 2.5^0c, there will be the risk of extinction of plant and animal species by 20-30% (IPCC, 2007).

There has been increasing uncertainties in agricultural production due to the disturbances in the natural system such as climate change, environmental degradation and rising competition for land and water. IPCC (1996), predicts that, the earth would warm by 1.4 to 5.8 ^{0}C by the year 2100. Nepal's temperature has increased by 1.7^0C during last 30 years (1975 to 2005) (Malla, 2008).

Climate change affects green sectors more than other sectors of the economy. Agricultural production is the outcome of the freshwater irrigation supplies from rivers and spring and rainfall, fertile soil terraced and maintained by the

farmers for generations. Agriculture production depends on nature and gets affected by the change in the climatic parameters such as expected changes in frequency, duration, intensity and geographic distribution of rainfall and snowfall and increased frequency, duration and intensity of droughts (FAO/NRCB, 2008). Effects of climate change on agriculture are particularly high as the agriculture produces food and provides the primary source of livelihood for large chunks of weaker sections of the society (Pant, 2012). If agricultural production in Nepal is adversely affected by the climate change, the livelihoods of two-thirds of the labor force, particularly of the rural poor will be at threat.

Due to unscientific cropping systems, inappropriate infrastructure and poor technology, Nepalese agriculture is equally sensitive to the long dry spell and high temperature during spring season. As Nepal is an agricultural country practicing mostly conventional system of farming with inadequate infrastructures, the effects of global climate change are expected to be very serious (Maharjanet al., 2011). In fact, a series of regular and extreme weather events in Nepal have caused a significant decline in the country's crop yield.

Most of the works have taken changes in temperature and rainfall as proxy indicators for climate change and have tried to show that alteration to those variables affect the 'mean' annual crop yield. To approach the issue appropriately, accounting local communities is essential', since they perceive climate as having a strong spiritual, emotional, and physical dimension. They have an inborn, adaptive knowledge from which to draw and survive in high-stress ecological and socio-economic conditions. Human response is critical to understand and estimate effects of climate change on production and food supply for adaptation. Thus, it is vital to seek adaptation strategies to cope the effects on crop yield. The effect of climate change on crop yield and adaptation strategies are the predominant interest in recent literature.

The study analyzes the perception about climate change and its impact on agriculture in Nepal and farmers adaptations based on household survey data. The scope of the paper is limited to the analysis of perception and adaptations against climate change by the farmers. It is evidenced that climate change will have a strong impact on Nepal-particularly in the areas of agriculture; land use, energy, biodiversity, health and water resources. Nepal, like all the countries of South Asia, is highly vulnerable to the impacts of Climate Change (IPCC, 2007). It was also, noted that Nepal specifically ought to be concerned by climate change because of the country's high vulnerability due to its highest mountains that is prone to unpredictable rainfall and the risk of snow melting causing the flooding in the lower belt.

Recent research has focused on regional and national assessments of the potential effects of climate change on agriculture (Lobell, *et al*, 2008; Hassan and Nhemachem, 2008; Fischer *et al*, 2002). This research intends to investigate the effects of climate change at the grassroots', the communities' perception and adaptation to changing in climate. This will helps to have a better understanding of the communities' perception of climate change and existing adaptation strategies in Nepal.

MATERIALS AND METHODOLOGY

Area of Study

Nepal shares its boundary with Republic of china in northern part and India in east, west and south. The central bureau of statistics put the country population to be over 28 Million in 2015 (CBS, 2015). Study area is Rupandehi district of Western development region and is also known for its arable food crop production. Purposive sampling was used to select district and two Village Development Committees namely Manmateria and Hatti Bangaibased on previous information. Random sampling was used to select sample households, while communities that are prone to climate change were purposively selected.

Data and Methods

The study administered questionnaire and held Focus Group Discussions to elicit information, where 70 valid responses from household survey were used for further analysis. Both structured questionnaire and interviews were held with indigent and local government officials and all other stakeholders on climate change knowledge and adaptation. The study uses logit regression analysis to examine the characteristics that best explain variation in the measures of attitudes of the indigent perception and adaptation level to climate change and factors that influences such decisions. The study decomposes various measures of climate change adaptation. In addition, the study also uses Focus Group Discussions (FGDs) to find out the level of understanding of climate change and the communities perception and level of preparedness'. Panel data was adapted and data were collected during the late rain of September–October and early rain of march-April, 2014. This is done to have an understanding of the variation of climatic conditions and its effect on agricultural outputs and other form of activities of food crop farmers.

Analytical Approaches

Logit model was adopted and used to analyze the determinants of the perception and adaptation level of climate

change. The choice of the explanatory variables in the model was based on literature review (Ghazouani and Goaied 2001; Rodriquez and Smiths, 1994; Mendelsohn et al., 1994). The estimating logarithmic equation is

$Ii = ß_0 + ß_1 \ln X_1 + ß_2 \ln X_2 +, \ldots, + ß_{19} \ln X_{19}$ ………………………………..........................(1)

The dependent variable Di is a dichotomous variable, which is one when a respondent perceive any of the climate change variations and adapt to the changes and zero otherwise.

The explanatory variables used in the Logit Models and hypothesized as determinants of respondents poor in the level of perception and adaptation to climate change (that is specialized in only (mono) cropping)are:, 1 for mono and 0 otherwise. Increased temperature (X_1), fall temperature (X_2), altered climate range (X_3), changed timing of rains (X_4), frequency of droughts (X_5), noticed climate change (X_6), cereal/legume intercropping (X_7), mulching (X_8), practiced zero tillage (X_9), making ridges across farms (X_{10}), farm size (X_{11}), own heavy machines (X_{12}), household size (X_{13}), farming experience (X_{14}), education (X_{15}), age of farmers (X_{16}) access to extension facilities (ACEXT) (X_{17}) Dummy, if access 1, otherwise 0, access to credit facilities (ACCRE) (X_{18}) and Sex (X_{19})

RESULTS AND DISCUSSION

Figure 1 and 2 presents farmers' perception about temperature change and precipitation in Rupandehi district in 2014. Majority of the respondents (46%) expressed that they perceived the increased temperature in 2014. Majority of the respondents (30%) perceived the decreased rainfall and 33% perceived the change in timing of rains in Rupandehi district(Figure 2).

Table 1 presents farmers' *actual* adaptation measures and practices actually followed, thus, grouped into different categories (Table 2). These strategies, however, are mostly followed in combination with other strategies and grouped into the following adaptation options: diversifying into multiple and mixed crop-livestock systems, and switching from crops to livestock and from upland to irrigation, practicing zero tillage, making ridges across farms and cereal/legume intercropping.

Table 2 reveals that multiple cropping mixed with livestock rearing under upland conditions is the dominant system (27.75%). Cereal/legume intercropping is the second most common strategy (21.28%), and multiple cropping without livestock under dry land (13.1%) comes third.

Diversification from farming to non-farm the most common adaptation practice (23%) (Table 2). The implication is farmers are gradually moving away from farming to non-farm activities. The main adaptation strategic measures followed Food and Agriculture Organization (FAO) classification (Dixon et al., 2001) and were used to classify the strategic measures into thirteen.

Table 3 presents the estimated marginal effects and t-levels from the logit model. The results show that most of the explanatory variables considered are statistically significant at 10%. This study uses specialized (mono) cropping as the base category for no adaptation and evaluates the other choices as alternatives. The results show that altered climate change, noticed climate change frequency of droughts, age and sex all had no significance effect on adaptation. While the increased temperature, intercropping of cereal/legume, mulching, zero tillage making ridges, farm size, farming experience, educational status access to extension and credit facilities are factors influencing adaptation positively (Table 3). However, fall in temperature, change timing of rains, own heavy machines and household size are also significant factors but influence adaptation negatively. This result suggests that the larger the occurrence of these variables, the poorer the adaptation.

Summary of the results revealed that fall in temperature influences the probability of switching away from mono-cropping more than changes in increased temperature. Similarly, the magnitudes of the marginal coefficients suggest that low outputs warming is a strong factor influencing the probability of switching to other systems that are better adapted to changes in temperature. Better accesses to extension and credit services seem to have a strong positive influence on adaptation. In addition, access to other farm assets such as heavy machinery is found to promote the use of large –scale farming. These results suggest that capital, land and labor serve as important factors for coping with adaptation. The choice of the suitable adaptation measure depends on factor endowments (i.e. family size, land area and capital resources). The more experienced farmers are, the more likely to adapt. Sex of the farmer did not seem to be of significance in influencing adaptation, as the marginal effect coefficient was statistically insignificant and signs do not suggest any particular pattern. These results suggest that it is the experience rather than sex that matters for adapting to climate change.

FOCUS GROUP DISCUSSIONS (FGDS) –FINDINGS

The people were asked whether they noticed changes in their environments; below are their responses: The

temperature is higher (91%); Water evaporation from the ground is so fast (69%) Spread of agricultural pests and weeds on crop land (82%); Violent rain and hailstorms (77%); Delayed rainfall (53%); Less clearly defined seasons (rains sometimes arrive a month late or finish early, rains quickly gave way to sun or dry periods during the rainy season) (49%). The costs associated with crops damaging weather events double each decade as the people (78%) indicated that their crops were devastated by unpredicted rains and a series of freak hailstorm. Downpours (Rainfall) were more intense in the past years that always leave a trail of destruction on the farms (69%). On the other hand lack of water or delayed downpours threatened crop production activities. The adverse effect of this is that many (73%) have abandoned their crop farming activities due to low outputs to other sectors. Many of the communities/farmers (76%) do not attribute these changes to climate change but the soil no longer productive.

There is a need of agricultural insurance (75%), Weather alert (Radio and Television for daily weather forecast and relevance to agricultural activities) (83%) to help for effective adaptation. Also, effective meteorological facilities in keeping adequate records of weather forecast are provided. Extension agents should educate more on zero tillage, organic agriculture, and better land management techniques.

CONCLUSION

Due to low outputs from farms, as a result of low rainfall and increased temperature, farmers appear to be abandoning mono-cropping for mixed and mixed crop-livestock systems. Farmers in the area of study rely on rainfed agriculture, while considering risky, mono-cropping practicing under upland. Farming experience and access to education were found to promote adaptation. This implies that education to improve awareness of potential benefits of adaptation is an important policy measure.

Focus Group Discussions revealed lack of effective access to information on climate change. Thus, there is need for effective and reliable access to information on changing climate to dissuade farmers mind from spiritual angle. In addition, empowerment (credit or grant facilities) is crucial in enhancing farmers' awareness. This is vital for adaptation decision making and planning. Combining access to extension and credit ensures that farmers have the information for decision making and the means to take up relevant adaptation measures. Recommendations are :

- Policies must aim at promoting farm-level adaptation through emphasis on the early warning systems and disaster risk management and also, effective participation of farmers in adopting better agricultural and land use practices.

- There is an urgent need for meteorological reports and alerts to be made accessible (when necessary) to farmers in an understandable forms.

- Massive campaign on the reality of climate change and its serious consequences on food production is highly recommended so as to persuade against farmers' believe from spiritual angle.

- Need of readily availability emerging technologies and land management practices that could greatly reduce agriculture's negative impacts on the environment and enhancement of its positive impacts.

It is evidenced from this study that arable food crop farmers are experiencing change in climate and they have already devised a means to survive. It is from this point that policy of reliable and effective measures of adaptation need to be implemented and must be accessible to the end users. Looking at the issue of climate change adaptation, the role of agricultural extension in this regard is significant to raise both the consciousness of the need to climate change adaptation and possible methods of mitigation to both the end users and policy makers. Thus, there is a need by agricultural economists and extension workers to design strategies that could help the farmers/rural communities' responses effectively to global warming. This is in line with the recognition that other stakeholders in agricultural sustainability must be worked with: like the Agro climatologist, Meteorologists, Agricultural Extensions and Rural Sociologists for early warming alerts and interpretations in the language useful to farmers/rural communities.

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LIST OF TABLES

Table 1 : Farmers' perceived adaptations

SN	Variable	Percent of Respondents
1	Planting different crops	3
2	Planting different varieties	5
3	Practicing crop diversification	4
4	Different planting dates	7
5	Shorten length of growing period	6
6	Move to different site	2
7	Change amount of land	1
8	Changes from crops to livestock	2
9	Changes from livestock to crops	1
10	Adjust livestock management practices	1
11	Farming to non-farming	23
12	Non-farming to farming	2
13	Increase irrigation	3
14	Change use of chemicals, fertilizers and pesticides	5
15	Increase water conservation	8
16	Soil conservation	5
17	Shading and shelter	8
18	Use insurance	2
19	Prayer	3
20	Other adaptations	2
21	No adaptation	7

Table 2 : Actual adaptation measures used by farmers

SN	Adaptation measures	Percent of Respondents
1	Specialized crop under upland	2.21
2	Specialized crop under irrigation	1.03
3	Specialized livestock under upland	1.02
4	Specialized livestock under irrigation	0
5	Multiple crops under upland	13.1
6	Multiple crops under irrigation	0.27
7	Mixed mono-crop/livestock under upland	4.95
8	Mixed mono-crop/livestock under irrigation	2.04
9	Mixed multiple crops/livestock under upland	27.75
10	Mixed multiple crops/livestock under irrigation	4.24
11	Practiced zero Tillage	9.73
12	Making ridges across farms	12.38
13	Cereal/legume intercropping	21.28

Table 3 : Results of the Logit Regression Model

SN	Variables	Coefficient	t-Values
1	Increased Temperature (X_1)	0.090E-02	4.24***
2	Fall in Temperature (X_2)	-0.298E-01	-2.923**
3	Altered Climate Range (X_3)	0.3911	1.321
4	Changed timing of rains (X_4)	-0.161E-01	-3.3561***
5	Frequency of Droughts (X_5)	-0.8751	-0.2783
6	Noticed Climate Change (X_6)	0.6272	1.6061
7	Cereal/legume Intercropping (X_7)	0.5383	2.5412**
8	Mulching (X_8)	0.22E-05	2.1271*
9	Zero Tillage (X_9)	913E-06	3.112***
10	Making Ridges across Farms (X_{10})	0.699	2.752**
11	Farm size (X_{11})	0.797E-07	2.1242*
12	Owned heavy machines (X_{12})	-0.893E-01	- 4.4272***
13	Household size (X_{13})	-0.133E+11	-4.4252***
14	Farming experience (X_{14})	0.5197E-04	2.5731*
15	Educational status (X_{15})	0.1152	4.12***
16	Age (X_{16})	0.2017	0.2847
17	Access to extension facilities (X_{17})	0.328	2.73**
18	Access to credit facilities (ACCRE) (X_{18})	0.2605	1.962*
19	Sex (X_{19})	-0.3988	-0.918

***Sig. at P<.01, **Sig. at P<.005, * Sig at P<.001, log-likelihood function: -197.68, Sig level P<00001 and constant = 0.62

LIST OF FIGURES

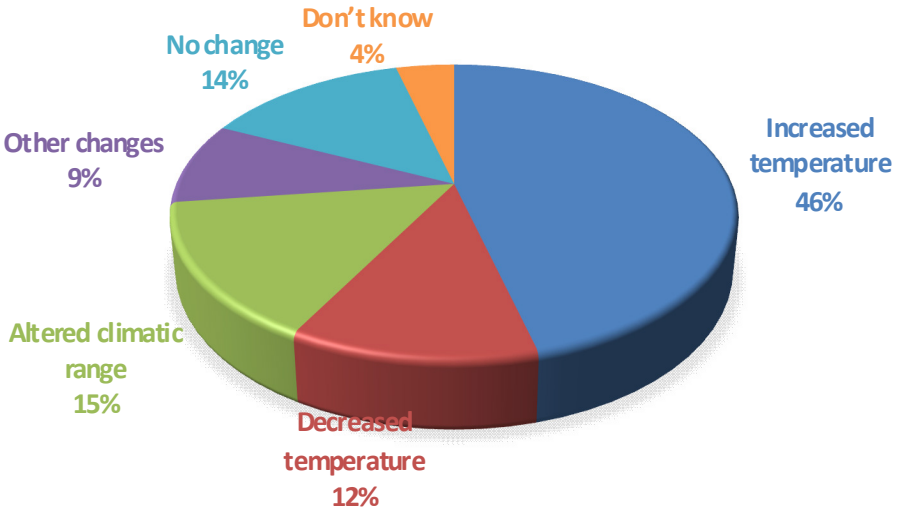

Figure 1 : Farmers' perception about temperature change in Rupandehi district, 2014

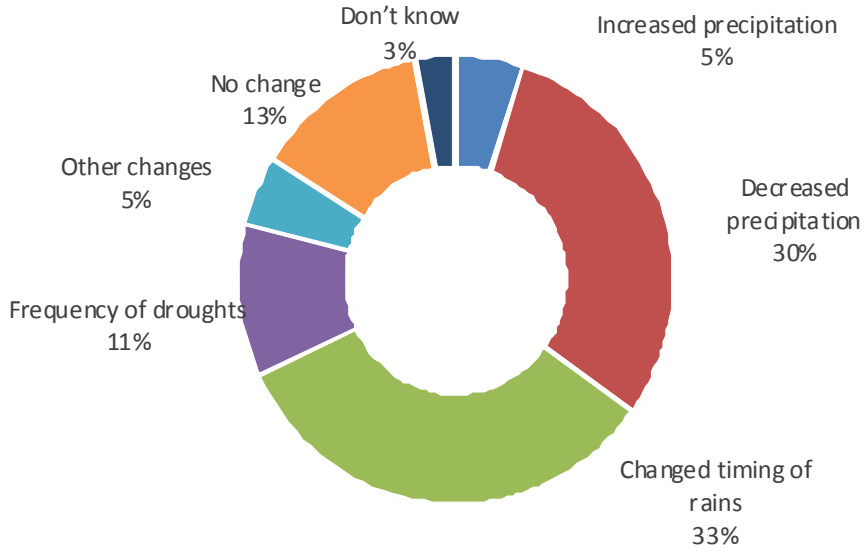

Figure 2 : Farmers' perception about precipitation in Rupandehi district, 2014