Assessment of Climate Change Impacts and Local Adaptation Measures in the Livelihoods of Indigenous Community in the Hills of Sankhuwasabha District

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Assessment of Climate Change Impacts and Local Adaptation Measures in the Livelihoods of Indigenous Community in the Hills of Sankhuwasabha District

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Climatic complexity, agriculture based economy, marginality and topographical adversity of hilly region of Nepal makes it the most vulnerable area to the impacts of climate change. A survey was carried out in 50 households of Makalu and Pathivara VDCs of Sankhuwasabha district in 2010 to assess the impacts of climate change in the livelihoods of people living these areas. This study examined the consistency of local peoples' perception about climate change with climate observation data recorded by meteorological stations. It documented the local adaptation measures using a semi structured questionnaire. Data on climate parameters and productivity of major crops were collected from the Department of Hydrology and Meteorology and Central Bureau of Statistics. Almost all respondents reported changes in climate and farming system in their locality. Respondents experienced erratic rainfall pattern, decreased length of winter, increased frequency and length of droughts associated with decrease in water sources in recent years. The analysis of climatic data showed similar results. Landraces of many crops had disappeared and new invasive weeds had appeared. Farmers were forced to adopt new cultivars and change in planting time to adapt with changing conditions. Incidence of human, plant and animal diseases and natural hazards in recent years are major threats to livelihood. The linear trend line of productivity of rice indicates decreasing productivity. Analysis of climate data of Sankhuwasabha district showed 0.034^{0}C increase in maximum temperature and 0.048^{0}C decrease in minimum temperature per year in past 22 years. Precipitation has shown decreasing trend and erratic pattern. The correlations between temperature and productivity of rice, wheat and maize were significant. The study showed that people started adaptation measures autonomously. Adoption of new crop varieties, construction of stone walls and local irrigation canals and cultivation of some cash crops were the major adaptation measures observed.

Key words: climate change, adaptation, livelihood, perception, temperature, rainfall

1. Introduction

Climate change refers to any change in climate over time, whether due to natural variability or as a result of human activity (IPCC 2007). It is a long-term change in the statistical distribution of weather pattern, including average temperature and rainfall over periods of time. In case of Nepal, the temperature has increased by 1.8^{o}C during last 32 years and the average temperature increase was recorded as 0.06^{o}C per year. Similarly the rainfall pattern is also experienced as inconsistent with higher intensities of rain and less number of rainy days creating long drought for some time and heavy rain in some other periods (Malla 2008). Nepalese economy being greatly dependent on agriculture, it is very sensitive to climatic variability.

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Agriculture is the mainstay of Nepalese people which contributes nearly 33% to Nepal's GDP and supports the livelihoods of more than 86% of the population (CBS 2007). Nepal's agriculture is very much dependent on rainfall. The recently observed extreme weather events between 2006-09 including droughts and floods have significantly affected food production in Nepal (WFP 2009).

Studies on temperature trend in Nepal have identified increasing trend in annual mean and annual maximum temperature in high altitude more than that of lower altitude (Baidya et al. 2008). The hilly region is vulnerable to climate change. Even a slight change in climatic variables can potentially cause amplified and devastating impacts in these ecologically fragile hills. The impacts of climate change can be much greater for indigenous communities living in the remote and ecologically fragile zones and relying directly on their immediate environments for subsistence and livelihood (UNFCCC 2004). Lower level of awareness to disasters and climate change and its adaptation and mitigation options are associated with higher vulnerability (WWF Nepal 2008). The diverse and complex topography of the hills of Nepal makes the study of climate change difficult.

2. Objectives

The major objective of this research is to analyze the climatic trends and changes in agricultural production, farming system and livelihood in hills of Sankhuwasabha district and to document the adaptation measures adopted by the local people. The specific objectives are:

- To document the farmers perception about climate change and impact on the livelihoods in hills of Sankhuwasabha,
- To study the changing farming system and crop yields in a changing climate,
- To study the local adaptation measures adopted by the communities,
- To study the trend of climatic variables i.e. temperature, rainfall and relative humidity in Sankhuwasabha and
- To correlate crop production data and climatic variables.

3. Research Methodology

The research was conducted in two VDCs namely Makalu and Pathivara of Sankhuwasabha district in 2010. Sankhuwasabha is identified as a vulnerable site for the impacts of climate change by vulnerability assessment conducted by National Adaptation Programme of Action (NAPA) (MoEnv 2010). Agriculture is the main source of livelihood in these VDCs. Tourism, small business and government jobs are the secondary occupations. Foreign remittance has significance contribution to income.

Pre-field visit to selected VDC was conducted and a community profile was prepared. Twenty-five farmers were selected in each VDC through random sampling method. Key informants survey was used for sampling frame. Farmers were selected after key informants survey and a pre-field visit. Moreover resource poor and indigenous people were given the first priority in sampling. A semi structured questionnaire was prepared consistent with the objectives of study. The pre-testing of the

questionnaire was done by interviewing 25 respondents near the study area and some necessary adjustments were made. For primary data collection, different techniques such as face to face interview, group discussion, and informal interaction were used. Secondary information was collected from Central Bureau of Statistics, District Agriculture Development Office and Department of Hydrology and Meteorology. The collected data were analyzed using both descriptive tools like mean, standard deviation, percentage etc. and inferential statistical tools. Overall analysis was carried out by using Statistical Package for Social Science (SPSS) and Microsoft -Excel program wherever necessary.

4. Description of study area

4.1 Sample Characteristics

Twenty five respondents were interviewed from each VDC. Eighty-two percent of the total respondents were male and 18% were female. It was difficult to get a female respondent primarily because interviews were conducted during the peak period of rice and cardamom harvesting. Respondents were categorized on the basis of age group. Forty-six percent of the total respondents were 40-60 years old followed by 25-40 years old (40%) and 60 years above (14%). Most of the respondents (90%) were residing in the study sites for more than 30 years and had long experience of climatic trend, cropping pattern, agro-biodiversity, ecosystem and the major changes occurred. During this period sixty-two percent of the respondents owned private forest at a range of 0.1-3 ha. Buffalo, cow, pig, poultry and goat were the major livestock of the study sites. Almost all (96%) respondents owned livestock. Fourteen percent of the respondents used to cultivate crops by slash and burn cultivation (Khoria).

4.2 Landholding and Farm Characteristics

The average landholdings in Makalu and Pathivara were 1.17 ha and 0.984 ha respectively. The range of landholding in Makalu was 0.1-4.75 ha and 0.1-2.5 ha in Pathivara. Of the total cultivated land, 59.33% was irrigated (Khet) and 40.66% was non irrigated (Bari). Farmers largely depend on rainfall for crop cultivation. Irrigation is done by local canals (Kulo) in case of droughts. The major cereals grown in the study area are rice, maize and finger millet. Buckwheat, wheat and barley are also grown in smaller quantities. The cropping system in the study sites is rice based. Generally rice is planted only during monsoon season. Cardamom is the most important cash crop of the study area. Ranges of productivity of rice, maize and finger millet in the above two VDCs were found to be 1000kg-3600 kg/ha, 800kg-2600 kg/ha, 600kg-1600kg/ha respectively. This variation was due to microclimate characteristics, geophysical variation and adoption of new varieties.

5. Results and Discussion

5.1 Local People's Perception on Climate Change

All of the respondents perceived change in the microclimate of the localities. The study revealed that 88% of respondents experienced the occurrence of monsoon rain after the usual time, 2% before the usual time whereas 8 % experienced no change. Similarly, 62 % experienced occurrence of winter rain after the usual time

and 36 % experienced no change. Table 1 shows the changing climatic trends in the study area as perceived by the respondents.

Table 1 Changes in microclimate as perceived by respondents

Responses	Increased (%)	Decreased (%)	Same (%)
Change in hotness of summer days	26.5	-	73.5
Change in degree of winter coldness	23.5	21.4	55.1
Change in length of cold winter	6.1	79.6	14.3
Change in drought pattern	82.7	1	16.3
Change in length of drought	100	-	-
Change in no of water sources	-	80.6	19.4
Heavy rainfall in short period	56	4	40

5.2 Changes in Farming System and Agro-biodiversity

Most of the people have experienced changes in agro-biodiversity and farming system. Many cultivars of different crops have disappeared due to their low productivity in recent years, especially of rice crop. New cultivars are being introduced to increase production and local cultivars are becoming extinct.

Twelve percent of the respondents experienced decrease in rice production and 36% experienced increase. Farmers did not experience any significant change in maize and millet production. Twelve percent experienced increase in maize production while 8% experienced decrease. Eight percent observed decrease in millet production and 92% experienced no change. The increase in productivity was due to the adoption of new cultivars and the reduction was due to the inability of local cultivars to adapt in the changing climate.

Table 2 Disappeared or rare and newly introduced cultivars of different crops

Crops	Makalu VDC		Pathivara VDC	
	Disappeared and rare cultivars	**Newly adopted cultivars**	**Disappeared and rare cultivars**	**Newly adopted cultivars**
Rice	Atte, Rato Takmaru, Tauli	Belkuti, Hajarmure, Makawanpur, Malaya, Gola, Seto Takmaru, Bhotedhan	Gudure, Marsi, Atte, Madale, Bhangeri, Tauli, Anadi	Makawanpur, Khumaltar, Belkuti, Malaya
Maize	Seti makai, Ashare	Hybrid(Unknown), Sathiya	Chepte	Hybrid(Unknown)
Finger millet	-	Fyakre kodo	Pangdur	Fyakre kodo

Vegetables	-	-	Chuche karela,	Cauliflower, Cabbage
Potato	-	-	Kusume	-
Radish	-	-	Local mula	Hybrid(Unknown)

Thirty eight respondents experienced change in planting time in cereals crops. Rice was previously planted in Jestha (April/May); nowadays it is planted up to last week of Ashad (June/July). According to them, it was due to delayed monsoon. Respondents had not experienced change in planting time of maize, millet and vegetables. Some of the farmers found early ripening in maize.

Respondents had not experienced any major changes in flowering time of major cereals. Some of the respondents observed change in flowering time in pear and Sisno (Urtica dioca). Previously flowering time of pear was Falgun (March), nowadays flowering occurs in Ashoj (September). Similarly, in case of Sisno flowering time has changed from Bhadra (August) to Jestha (April/May).

Farmers have experienced appearance of new weed species. Ilame Jhar (Ageratum sp.) having dull leaf, Parpare Jhar, Tike Jhar, etc. are becoming dominant in the crop fields. Ilame Jhar (Ageratum conyzoides), Banso, Ratnaulo, Alu Jhar etc. have almost been disappeared.

5.3 Impact on Human Health and Livelihood, Wild Animals and Medicinal Plants

The impacts of climate on human health could limit the availability of labor for agricultural production. Forty-two percent of the respondents observed increase in frequency of human diseases. They experienced increase in frequency and duration of common cold and increased incidence of typhoid, diarrhea, jaundice, eye infection and mosquito related diseases. Pneumonia in poultry (Rudha) has killed almost all domestic birds in recent years. In cardamom chirkey and furkey diseases, yellowing of leaves and lack of seed setting were major problems identified. Several large and small rainfall induced landslides were observed in the study sites which had destroyed a large area of cultivated land and forest.
Leopard, jackal, bear and other wild animals were abundant until a few years ago in the study areas. Nowadays they have become rare. Previously medicinal plants e.g. Chiraito (*Swertia chirata*), Bikhumba, Padamchal, Panchaule were abundant in the hilly parts of these VDCs. But nowadays they have become less abundant.

5.4 Adaptation Activities of Local People for Their Livelihood Security

The initiatives of the local people to adapt changing climate and the constraints are listed in Table 3. In focused group discussion, people showed interest on possible adaptation measures. Some of the measures were already being followed by the local people.

Table 3 Impacts of climate change, community adaptation strategies and constraints

Impacts	Local adaptation measures	Constraints
Landslides	• Stone walls • Afforestation	• Lack of funds and manpower

Food insecurity	• Skill development for alternative income activities • Market facility	• Lack of knowledge and resources
Human diseases	• Following traditional practices	• Lack of health facilities
Drought	• Local irrigation canals(Kulo) • Adoption of drought resistant cultivars	• Lack of fund, resources and manpower • Unavailability
Appearance of mosquito, other harmful insects and related diseases	• Mosquito nets	• Unavailability
Decrease in Agriculture production	• Adoption of high yielding crop varieties suitable to changed microclimate • Develop skills for alternative livelihood e.g. income generation activities, awareness raising etc. • Cultivation of cash crops (Cardamom)	• Unavailability of seeds, fertilizers • Lack of relevant knowledge and skills
Incidence of plant diseases	• Local pesticides • Synthetic pesticides • Disease resistant varieties	• Lack of knowledge • Expensive • Unavailability
Incidence of animal diseases	• Veterinary facilities	• Unavailability

During the pre-testing of the questionnaire some adaptation measures prevalent in the study area were identified. Respondents were asked about the suitability of those adaptation measures in their locality. The respondents expressed that using new cultivars of crops, cultivation of cardamom and construction of local irrigation canals were useful adaptation measures in the study area.

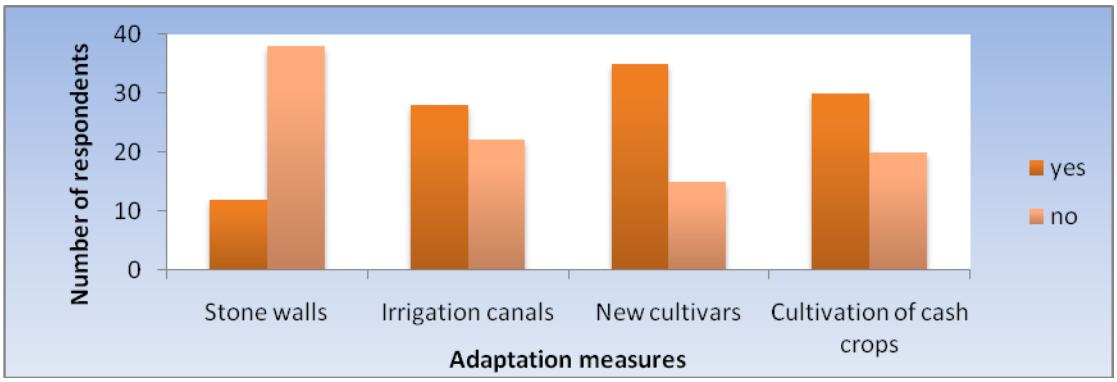

Fig. 1 Usefulness of adaptation measures

Despite these impacts of climate change in livelihood of the people, very little work is done by the governmental and non-governmental agencies. Rural Reconstruction Nepal (RRN) is the main organization working in these areas. It conducted trainings and awareness programs about climate change. Agriculture service centers in these VDCs are non functional.

5.5 Productivity Trend of Major Crops in Sankhuwasabha District

The productivity trend for the last 29 years showed fluctuations in rice, maize and wheat whereas it was almost stagnant for finger millet over those years.

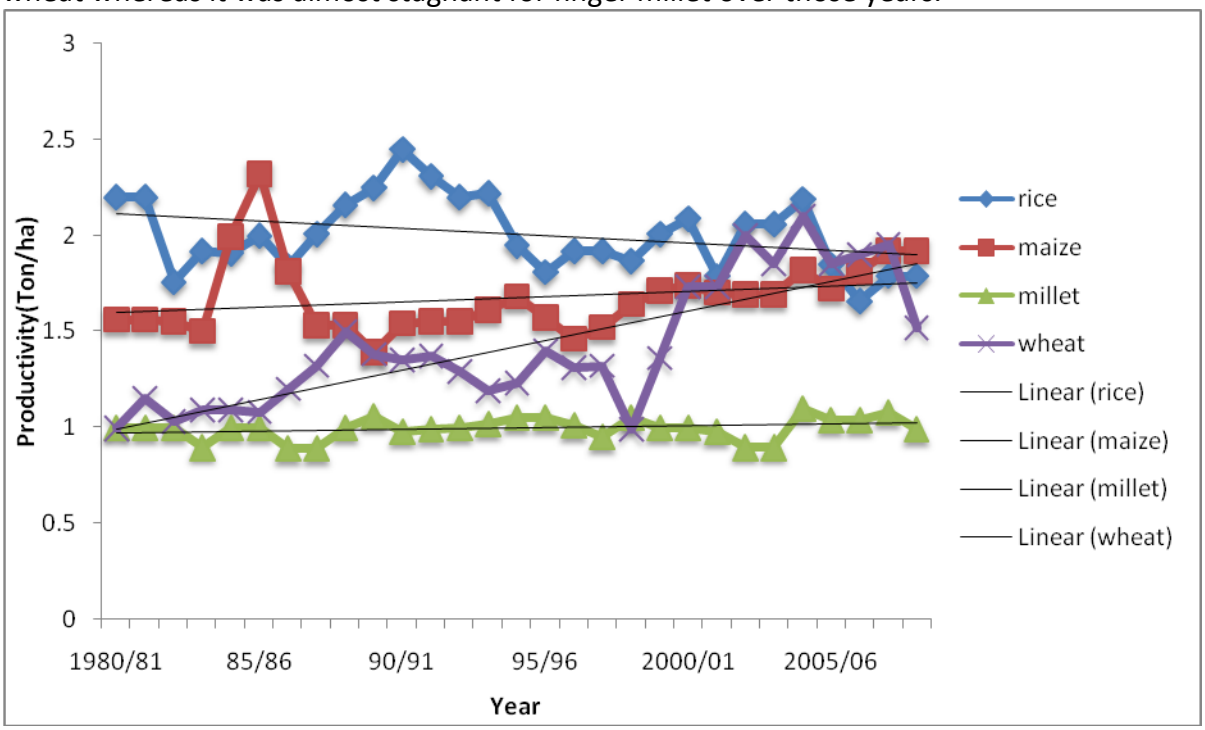

Fig. 2 Productivity trend of major cereals in Sankhuwasabha

Linear trend line of annual productivity of rice indicates decreasing productivity. Linear trend line of annual productivity shows increasing productivity in case of wheat and maize whereas stagnant productivity of millet over past 29 years.

5.6 Trend of Climatic Variables in Sankhuwasabha District

The data on weather parameters (precipitation and temperature on monthly basis) were collected from the Department of Hydrology and Meteorology from six nearest stations of the district. Missing data for few months were filled by mean of the data using SPSS. Precipitation data were collected from Num, Chepuwa and Tumlingtar stations and temperature data were collected Chainpur, Pakhribas and Terhathum stations and then arithmetic mean were calculated for precipitation and temperature of the district. Humidity data were not available for Sankhuwasabha. Data on precipitation and temperature from 1987 to 2008 were analyzed.

5.6.1 Trend of precipitation

The recorded data indicate that 70% of total rainfall occurs during the monsoon (June-September). The correlation between precipitation and time is insignificant

(P=0.05 Pearson's correlation, N=22) but annual, monsoon and winter precipitation show decreasing trend with large fluctuations. The perception of local people about rainfall was found in accordance with the statistical records.

Table 5 Analysis of precipitation data from 1987 to 2008

Rainfall	Annual	Monsoon	Winter
Mean(mm)	2822.19	1958.66	97.78
Standard deviation(mm)	245.87	196.54	50.96
Maximum rainfall(mm)	3209.90	2336.60	202.73
Minimum rainfall(mm)	2392.93	1679.90	13.03
Trend(mm/year)	-6.243	-7.733	-2.671
Correlation with time	-0.165	-0.256	-0.34

5.6.2 Trend of temperature

The temperature data recorded indicate that there is increasing trend in annual maximum temperature and decreasing trend in annual minimum temperature. There is significant correlation between time and maximum and minimum temperatures. (P=0.05 Pearson's correlation, N=22) However, average annual temperature is almost stagnant in past 22 years.

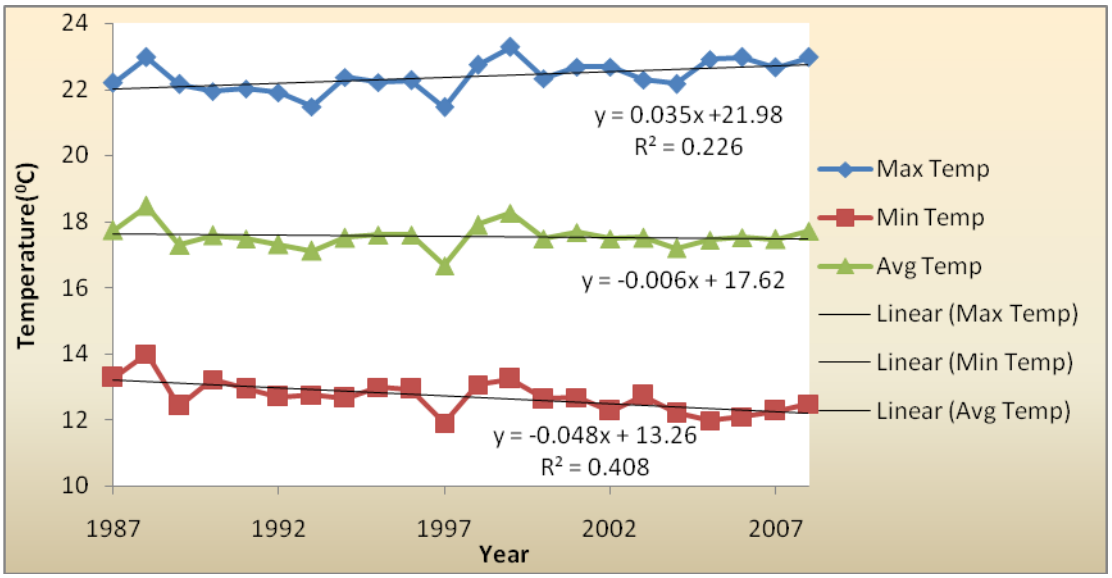

Fig. 3 Trend of temperature in Sankhuwasabha

Analysis showed 0.035^{0}C increase in maximum temperature and -0.048^{0}C decrease in minimum temperature annually in Sankhuwasabha district during the past two decades. This evidence of increase in maximum temperature is supported by introduction of mosquito in the study areas and early ripening of maize. Mixed

responses were obtained about the hotness and coldness perceptions (Table 1). Most of the respondents didn't report having felt these changes directly. The trends of change in climatic variables are consistent with the evidence documented in the National Adaptation Programme of Action (NAPA) document.

5.7 Correlation between Productivity and Climatic Parameters in Sankhuwasabha District

Twenty-two years (1987-2008) precipitation and temperature data for growing seasons and annual productivity of rice, maize, finger millet and wheat were correlated using Pearson's correlation. In Sankhuwasabha growing season (sowing to harvesting) of rice is June-November and growing seasons of other crops are November-April for wheat, March-July for maize and August-November for finger millet.

Statistically significant negative correlation (-0.432) was found between productivity of rice and maximum temperature of growing season of rice but there was no statistically significant correlation with minimum temperature, mean temperature and rainfall of the rice growing season. (N=22, P=0.05). It indicates that there is decrease in rice production with an increase in maximum temperature. It may be caused by failure of existing varieties to adapt in increased temperature and introduction of new weeds e.g. Ilame jhar with dull leaf, Tike jhar, etc. The correlation between productivity of wheat and minimum temperature of growing season was statistically significant (-0.526).

There was no statistically significant correlation with maximum temperature, mean temperature and rainfall of growing season of wheat (N=22, P=0.05). It indicates that there is increase in wheat production with a decrease in minimum temperature in Sankhuwasabha district. Cultivars previously cultivated may be well adapted to decreasing minimum temperature. The correlation between productivity of maize and maximum temperature of growing season of maize was statistically significant. Positive correlation (0.510) was found. No statistically significant correlation of productivity of maize was found with minimum temperature, average temperature and rainfall of growing season of maize. (N=22, P=0.05). It indicates that there is increase in maize production with an increase in maximum temperature. It may be caused by the presence of suitable temperature for metabolic activities for existing cultivars. There was no statistically significant correlation of productivity of finger millet with average temperature, maximum temperature, minimum temperature and rainfall of growing season of finger millet.

This indicates that, the increase in maximum temperature is not favorable for rice production but it is favorable for maize production and decrease in minimum temperature is favorable for wheat production in Sankhuwasabha. The trend of precipitation was found to be decreasing but precipitation has no significant impact in the productivity of these crops in the district.

6. Conclusion

There is very limited understanding about climate change and its impacts in these remote areas. Institutional actions are required to prepare the local people and the whole country to face the unavoidable impacts of climate change. There should be improvement in climate and crop forecasting system. Sufficient number of meteorological stations should be established to monitor the climatic conditions. Major part of crop cultivation is rain fed so irrigation investments are required to help farmers to adapt the long and unpredictable droughts. Awareness program in community level, inclusion of climate change related issues in planning and designing of developmental activities, crop insurance program and strengthening agriculture research centers can be good strategy for fighting climate change. More specific studies should be conducted to document and validate the adaptation strategies.

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