ANALYSIS OF PERCEPTION AND ADAPTATION TO CLIMATE CHANGE BY FARMERS IN GULMI DISTRICT, NEPAL

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ABSTRACT

Climate change is a global challenge, highly affecting the developing countries with low adapting capacity, of which Nepal is not an exception. Climate change highly affects agriculture and livelihoods of farmers in Nepal. Its objectives are farmer's perceptions, witnesses and experiences on effects of climate change on agriculture and adaptations by farmers. Primary informationscollected through structured questionnaire of household survey by selecting samples randomly. Information on primary and secondary data sourcesverified scientificallyby trend analysis of climatic data. Most farmers depending on subsistence agriculture have a perception of climate change and respond to the changes based on their own local knowledge and experiences on farming. They are practicing both agricultural and non-agricultural adaptations at individual level. Consequently, appropriate technologies and sustainable community based adaptation strategies built on farmers' knowledge, experiences and situation to cope with increasing effects of climate change on agriculture are necessary in the coming years.

Key words: Agriculture, Adaptation, Climate Change, Perception

BACKGROUND

Nepal is a small landlocked country with diverse ecology and climatic variation. The northern frontier is mostly rugged terrain adorned by snowcapped Himalayas experiencing alpine climate while a few hours down in the south it is hot and humid with very different landscape. Changing temperature and erratic rainfall pattern have affected crop production in Nepal (Malla, 2008). Therefore, it is important to know perception of climate change and adaptation measures followed by farmers (Bryan et al., 2009).

Climate change is a global challenge for today's growing world. Developing countries are more sensitive to climate change despite their low contribution to global warming and because of their weak coping capacity. Rising temperature, erratic rainfall patterns and other climatic extremities have triggered its impact on agriculture. Farmers depending on subsistence agriculture for their livelihood have been greatly affected by the changed climate.

According to Intergovernmental Panel on Climate Change (IPCC), "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, 2007). Of the many impacts,

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temperature and rainfall irregularities are major ones, which have disturbed many natural eco-systems. It is predicted that global temperature will increase further by between 1.4°C and 5.8°C by 2100 if the current trend of global warming continues. Sea level rise, glacier melting, extreme weather events as storms, floods, droughts and spread of infectious disease as malaria, extinction of world's endangered species, warming of 1.5-2.5ºC beyond today's levels would put as many as 20-30% of plant and animal species at increased risk of extinction (European Commission, 2012). Agriculture, the major source of food for human, playing vital role in development as an economic instrument, a livelihood and a provider of environmental services is becoming vulnerable to increasing threats of climatic uncertainties. There has been increasing uncertainties in agricultural production due to the disturbances in the natural system as climate change, environmental degradation and rising competition for land and water(Orindi and Eriksen, 2005). As a result, the food price in global markets is also rising up slowly. The effects of climate change are inevitable and will have serious long-term risk to development affecting social as well as economic systems. Therefore, necessary adjustments areneeded in natural and human systems to cope up with the moderate harm and to reduce potential damages as an adaptation strategy to climate change (OrindiandEriksen, 2005).

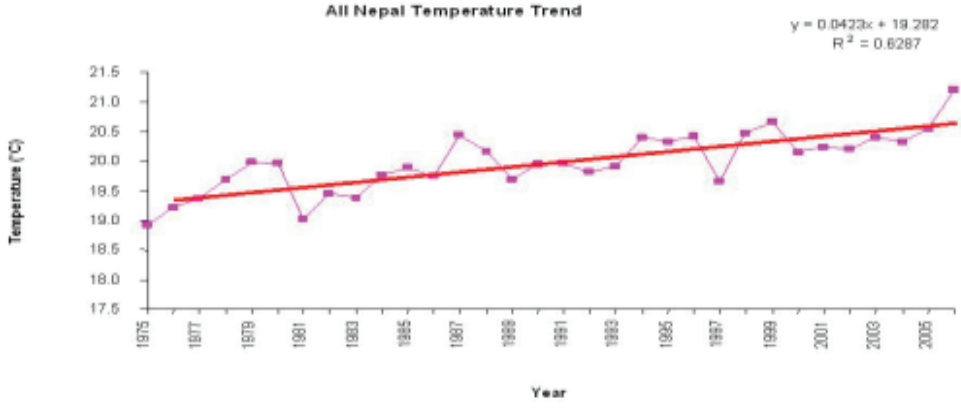

Figure 1. Trend of average annual maximum temperature of Nepal (1975-2006) (Source: Malla, 2008)

Farmers in Nepal have already experienced changes in temperature (Figure 1) rainfall patterns and occurrence of erratic monsoon. Rainfall starts earlier and ends late, as a result,paddy-planting month has been dry and late planting resulted in reduced yield. Farmers have been trying to adapt the changing climate to maintain the yield of rice, the main food in Nepal (Reid et al., 2007). It has become necessary to find some adaptation strategies at the local level and conducive policy environment at the centre level to cope with the climatic changes that will significantly reduce effect of climate change and variability on agricultural economy.

PROBLEM STATEMENT

The effect of climate change is found to be real and is disturbing human life. Nepal is one of the least developed countries depending on rain fed agriculture as a major source of livelihood; hence, even a small change in the climatic condition for a short period could largely affect the food security situation in the country (Bhandari, 2008). Unusual climatic changes and variability have led to crop failure, ultimately decreased agriculture production and directly affected food security and livelihood of people in Nepal (Regmi et al, 2008). Local-level impacts as loss of local landraces, plant and animal species, changes in cropping patterns, scarcity of water due to drying of wells, decrease in agriculture productivity have been noticed in Nepal (Regmi et al., 2008). Though the Nepalese farmers have very insignificant role in increasing green house gases globally, they will be affected by the climate change and its variability. They lack strong climate change adaptation and mitigation strategies that have further added to a range of factors that contribute to increased vulnerability and poverty. Thus, it is vital to seek adaptation strategies to cope the effects of climate change on agriculture in Nepal.Nepalese farmers have been confronting the effects of climate change on agriculture. Farmers have started various adaptation measures to cope with the effects of climate change and variability on agriculture. Thus, it is important to study whether the adaptation measures undertaken by farmers are heading towards positive direction or not. For the positive impacts on agriculture, we should learn from farmers coping strategies and use them as an important adaptation tools to cope with the effects of climate change and variability on agriculture. On the other hand, for the negative impacts, further studies are necessary to carry out forappropriate adaptation strategies. The objectives of this research are to analyze farmer's perception of climate change; different adaptation measures practiced by farmers and assess impacts of adaptation measures practiced by farmers.

CONCEPTUAL FRAMEWORK

The conceptual framework deals the steps to identify and verify the perception of farmers about climate change and farmers' knowledge, experiences to minimize the effects of climate change on agriculture through different activities (Figure 2).

MATERIALS AND METHODS

As the study focused on analysis of perception, impacts of climate change on agriculture and adaptation measures followed by smallholder farmers in the district, areas with previous evidences and records of impacts of climate change on agriculture selected as study area. Research sites selected from each ecological zone within the district based on the previous year's data of the district taking different criteria (farmers' awareness towards climate change, evidences of impacts of climate change in agriculture) into consideration and checking the availability of long-term (15 years) climate data. During last 15 years, unusual temperature and erratic rainfall pattern observed in Gulmidistrict, which are the major changes, noticed. Gulmidistrict has 79 Village Development Committees (VDCs) with different ecology (464-2600m above the mean sea level) in the western development region

of Nepal. The population of the district is 297,316 including 54.73% male. Cultivated area of the district found 60.07% of 124,938 ha (DADO Gulmi, 2011). The six Agriculture Service Centersare different with each other in terms of their natural environment. As an example, Baletaksar is a dry upland area whereas Johang is a low wetland area. Because of erratic rainfall pattern, farmers have been facing problems of drought and flooding in these areas and have already started responding to the changes by adapting new farming and non-farming practices.

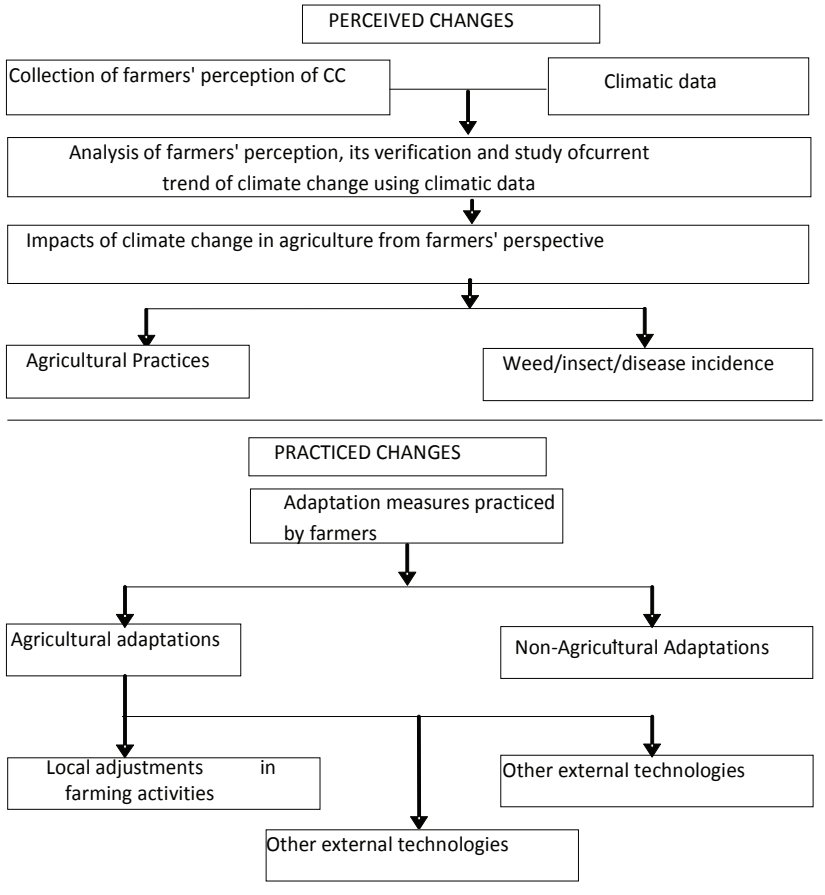

Figure 2: Conceptual framework dealing with perceived and practiced changes

As the study focuses on perception of and adaptation to climate change by farmers, simple random sampling technique used to select samples including more than fifty percent of farmers in the district. Individual household represented one sampling unit and the sample size was determined by using formula (Akin and Colton, 1963 cited from Gautam and Shivakoti, 2001; Shrestha et al., 1999 cited from Sunwar, 2003):

$$n = [Nz^2p(1-p)]/[Nd^2+z^2p(1-p)]$$

where,

n = Sample size (number of households for household survey),

N = Total number of households,

z = Confidence level (90%),
p = Estimated proportion of population included, and
d = Error limit (10%).

In absence of pilot study information, the estimated proportion of population was taken as50%, which was considered as a conservative estimate.For the population of Gulmi district, Baletaksar VDC
Determination of sample size,

N = 74, z = 1.64, p = 0.5, d = 0.10 (n = 35)

Thirty-five farmer's including 51% small land holding, 34% medium land holding farmers and 15% large land holding farmers were selected from Baletaksar Agriculture Service Center. Altogether 151 farmers' of six Agriculture Service Centers with agriculture as a major source of livelihood selected as sample. Other methods applied include five key informants' interview andone focal group discussion from each service centers,transect walk, agricultural calendar and time line.

Weather data were collected from Pokharameterologicalstation. The research was exploratory which includes collection of both qualitative as well as quantitative data from the primary or secondary sources. All the data were defined into variables as far as possible and entered into the data sheet of Statistical Package for Social Science.Climatic data were processed by using Microsoft Office Excel-2007.Both descriptive and analytical methods were used to analyze the data collected from various sources both quantitatively and qualitatively. From the analyses, farmer's perception on climate change, change pattern, its effects on agriculture were assessed, appropriate indigenous adaptation strategies/innovations and agricultural practices practiced by farmers to cope up with the climate changes were interpretedanddocumented.

RESULTS AND DISCUSSIONS

FARMER'S PERCEPTION OF CLIMATE CHANGE

Farmers' responses of increasing incidence of drought and flood, number of hot days in summer and erratic rainfall pattern are common in the district. More than half of the respondents have perceived the climate change but are unaware of the science behind it (Table 1).

Most farmers in Gulmihave perceived climate change (Table 1 and 2). Almost half of them have been experiencing gradual increase in temperature and hot days year after year. They opine that summer days are too hot and winter is not as cold as it used to be in the past. The chi-square test shows that farmers have perceived temperature change admists the changing climate and climatic variability.

Farmers report that they have observed the changes in regular rainfall pattern. The intensity and timing of rainfall has shifted resulting in erratic rainfall. Farmers recall that rice production was poor due to continuous drought for 5 years from 2004 to 2010 and that they had confronted a big loss. However, since last year there has

been normal rain, which has been observed after 15 years interval. Farmers make a guess that there might have been less rain due to the loss of forests.Rice and maize are the major crops grown in this district and because of erratic rainfall pattern; farmers have been facing problems as excess rainfall at seeding time and water deficit during transplanting of paddy. There has been delay in planting time and changes in rice yield due to late planting.

Table 1. Farmers' perception onchangein temperature

Perceive climate change	Do not perceive climate change	Perceive temperature change		Test statistics	Noticed any changes					
					Summer Temperature			Winter Temperature		
		Yes	No	x^2 value=5.106	I	D	NC	I	D	NC
				df=1						
65.7	34.3	51.5	48.5	P-Value=0.024	54.2	37.3	8.5	80	11.5	8.5
				Sig. at 0.05 level						

(I: increased; D: decreased; NC: no change; all the values are expressed in percentage of the respondents)

Table 2. Farmers' perception on change in rainfall

Perceive climate change	Do not perceive climate change	Perceive rainfal change		Test statistics	Noticed any changes			
					Timing of rainfall		Intensity of rainfall	
		Yes	No	x^2 value=7.441	Yes	No	Yes*	No
				df=1				
65.7	34.3	48.5	51.5	P-Value=0.006	43	57	46	54
				Sig. at 0.05 level				

(Yes*: decreased rainfall in past years but this year there has been normal rainfall; all the values are expressed in percentage of the respondents)

Climate change has been perceived as an important factor affecting the livelihood of farmers in Gulmi district. Farmers reveal that they are feeling the rise in temperature and in their experience, 2006 was one of the hottest years. There has been an unpredictable rainfall; timing and the intensity of the rain are changing. They share that there has been long duration monsoon precipitation in the year 2007 that destroyed the maize during the harvesting period. Farmers also experienced heavy rainfall during the nighttime and shared that usually water starts to flow in the canal soon after rainfall but now a days it starts late and the runoff is very low. They have also noticed decrease in winter rain and remarked 2005 and 2006 as the driest years in the recent past. They also shared that the frequency and intensity of hailstorms has been increasing and there occurred an intense hailstorm in 2010 that damaged the winter crops and vegetables.

ANALYSIS OF CLIMATE DATA FROM POKHARA AIRPORT

Farmers do perceive the erratic rainfall and changes in monsoon precipitation patterns, rainfall intensity and duration. As mentioned by farmers, the graph also showed 2005 and 2006 as the driest years in past 31 years (Figure 3).

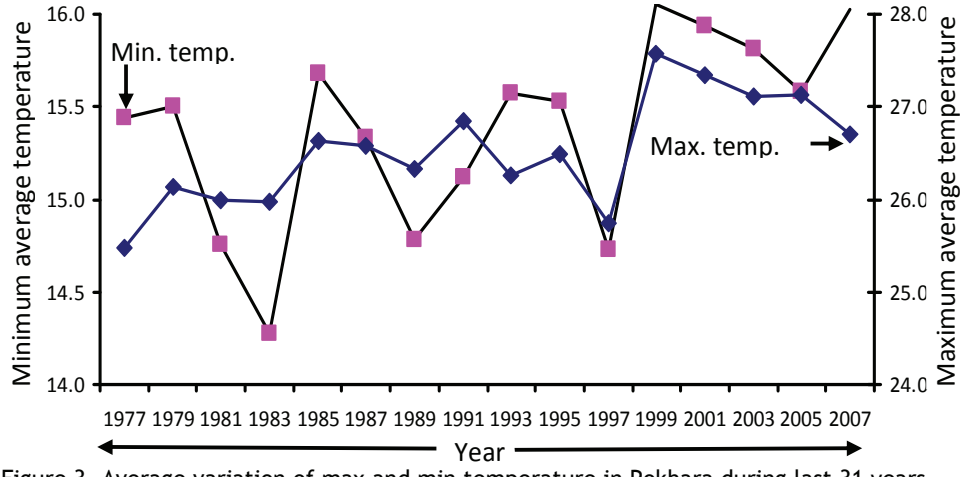

Figure 3. Average variation of max and min temperature in Pokhara during last 31 years

IMPACTS OF CLIMATE CHANGE IN AGRICULTURE

Famers have experienced the erratic rainfall with varying timing and intensity of rain that has highly affected the rain dependent agriculture and local landraces in the area. Local landraces of finger millet such as tail millet and little millet requiring specific timing and intensity of rainfall have been completely lost from Netavillage development committee of Chaurasi Agriculture Service Center. Similarly, the local landrace of Chaite rice had disappeared from the area as the pattern and intensity of rainfall is not favorable for its growth and production. So, farmers have shifted to high yielding and modern improved/hybrid varieties. Amount and the distribution of rainfall are very important for chaite rice. Less rain at the growing season will effect its production (Datta and Vergara, 1975). Due to the decrease in winter rain, mustard and wheat production has been poor so farmers have decreased the area to cultivate them.

The changes in temperature and monsoon precipitation pattern have affected the flowering season of pear, plum, peach, rhododendron, citrus and coffee, early flowering has been observed in these species. The population of mosquitoes and flies has been increased. Similarly, the incidence of disease Kalo poke (black smut) has been increased in rice, loose smut in maize. The erratic rain has also resulted in the drying up of water bodies such as streams, lakes, ponds, rivers and wells. Late and insufficient rain has affected the rice plantation in the area and farmers have adjusted the planting time to escape the problem of water scarcity (Regmi et al., 2008). Cropping calendar for timely and late rainfall are shown in Table 3 and Table 4.

Table 3. Cropping calendar for Khet during timely rainfall

Months/Crops	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1.Main season rice	(SS) May 3rd wk	(T) Jun 3rd to last wk					(H) Nov 2nd wk					
2. Chaite Rice (Rainfed/ used irrigation)			(H) Jun 2nd to lastwk							(SS) Feb 3rd wk		(T) Apr 1st to 2nd wk
3. Wheat							(P) Nov 3rd wk				(H) Mar 1st to 2nd wk	
4. Maize			(H) Jul last wk to Aug 1st wk								(P) Apr 1st to 2nd wk	

SS- Seed Sowing; T- Transplanting; H- Harvesting; P- Planting

Table 4. Cropping calendar for khet during late rainfall

Months/Crops	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr
1.Rice	(SS) May 3rd wk	(T) Jun 3rd wk to Jul 1st wk					(H) Nov 2nd to 3rd wk					
2. Potato							(P) Nov 3rd to 4th wk					(H) Mar last wk
3. Mustard							(P) Nov 4th wk					(H) 3rd to Mar last wk
4. Maize			(H) Jul last wk to Aug 1st wk									(P) Apr 1st to 2nd wk

ADAPTATION MEASURES UNDERTAKEN BY FARMERS

Climate change has added extra stress to the increasing population and farmers are compelled to seek options to cope with the potential environmental, economic and social impacts. Farmers are experiencing increase in temperature and erratic rainfall. They have started adapting to the climate change by using their local knowledge and practices as possible. Many famers in this area have practiced vegetable farming in plastic tunnel, mulching and organic farming practices such as use of organic treatments (Jholmal-spray prepared by mixing cattle urine, mixture made of local herbal plants such as *Eupatorium sp.,Tagetes sp.etc.*) to control insect pest and compost preparation to increase the fertility of soil and conserve soil moisture. Farmers have practiced water-harvesting technology to collect both rain and wastewater by digging pits in Baris, poly-pipe fitted at the end of the galvanized iron sheet roofing and plastic pond. They have also built reservoir tanks, ponds and collected water to use during dry periods. They have also adapted drought resistant rice varieties in following days but increasing yield has been the major concern for farmers to the flood and drought tolerance. In last ten years rice varieties such as Sabitri, Hardinath, Radha-4, Khumal-4, Chaite, Gorakhnath, Kalkatte and Khumal-8 have been grown in this area. Climate change has been affecting both agriculture and the livelihoods of farmers in one or the other way. Thus, farmers have realized that they cannot solely rely on agriculture for their livelihood and diversified their livelihood to various agricultural and non agricultural activities such as services, business, labor work and foreign employments. Some of them also grow and sell mushroom in the nearby market as an alternative source of income.

Farmers have also practiced conserving soil and water. They have constructed retention walls along terrace risers, drainage canals in bari lands and practiced some bioengineering practices such as planting vegetation barriers of broom grass, mulberry, and Napier grass to check soil loss from sloppy lands. They have also practiced value addition and marketing of local crops, strengthening of local community-based institutions. Similarly, farmers have changedtheir cropping pattern and calendar. Changes in timing and amount of rainfall forced farmers to choose alternative crops and shift cropping time.

Farmers'livelihoods are almost entirely dependent on agriculture. Gradual increase in temperature and erratic rainfall patterns has effectson agriculture. Most farmers have perceived changes and are trying their best to respond usingtheir local knowledge. Long term experiences in farming and interactions between the climate and crops helped farmers to shape their perception of climate change (Dahal, 2007). Traditional knowledge passed on from one generation to another. Therefore, based on traditions and societal norms, local culture and environment friendly strategies should be developed to cope with climate change. Farmers are knocking the door of the concerned authorities to find out the adaptable measures to reduce the effects of erratic weather pattern in agriculture (Malla, 2008).

Farmers in ThuloLumpek have rich local knowledge on rainfall forecasting. Long-term experience in agriculture has sharpened their knowledge on weather forecasting and farming practices. They can make a guess regarding the possibility of occurrence of rainfall. They believe that when the house sparrows play in the dust on the ground and black ants come out from a hole carrying eggs and seek high places, rainfall will occur. Similarly, when large number of fireflies concentrates/revolves around the tree at night there will be possibility of raining. They say that when the eastern wind stops and the western wind starts to blow in the month of August then it will carry rain. If frogs croak, rain will follow. If there is eastern wind in the month of November/December then there may be formation of cloud but no rain. They can also say about rainfall looking at the evening sky, if the sky appears red in the east when the sun moves to west in the evening, the desired rain will fall. They share that the distant smoky circle seen around the sun will bring early rain and visa versa. They have also noticed that buffaloes will be happy and run here and there when it is going to rain. An elephant trunk shaped cloud below the rainbow also foretells heavy rain. This local knowledge has helped them to make their farm plan accordingly.

Agriculture is the main source of livelihood of farmers. Farmers experience tells that untimely and decreasing rainfall had been a biggest threat to the rice growers in this district. Only 5 to 10% financially well off farmers have irrigation facility to raise nursery, prepare the field and transplant paddy while others have to wait for monsoon rain. During the dry years, they must leave their fields fallow. Water has been the major limitation in this area, so that, adaptation to vegetable farming is almost impossible. Most of the farmers have slowly shifted from the local varieties to hybrid, less water requiring and early maturing varieties. To adjust with the climatic extremity of drought and late rainfall, most of farmers have changed cropping calendar, pattern and planting method. They shifted the paddy planting date to end of July instead of June. Along with increasing drought and hot days, weed incidence has increased. Farmers have no alternative besides applying chemical herbicide ignoring its hazardous effects. However, some farmers who do manual weeding have increased its frequency. New varieties are chosedto increase yield. With the decreasing context of forest and pasture, number of cattle and buffaloes has decreased in the farm households. This has resulted in shortage of farmyard manure and increasing dependency on chemical fertilizers. They have also started adapting resource conservation technologies such as zero tillage and surface seeding to some extent. Agricultural production has been insufficient to support the family requirements and shifted to keeping shops and outside employments.

Rice based cropping systems are pre-dominant in the low lying area with high water table, which usually face both drought and flood problems. Farmers share that despite hard work and investment; late and less rainfall in some years and flood on the other have affected the paddy production confronting a big loss. Continuous rain for a single day is enough to bring flood in this area and farmers have been facing problem of washing away of paddy plantation in some years. Most of the farmers have used some drought tolerating varieties and practiced slight changes in cropping calendar, pattern and planting method. Many of them have also adapted to resource conservation technology and chemical pest control. Many farmers argued that there

is no change in weed population even using chemical herbicides. The number of plastic ponds exceeded two hundred and fifty in the district.

As narrated by MotiMajhi, a smallholder farmer, there was no paddy production from 2002 to 2006 due to drought and he had no alternatives except taking loans to buy food for his family. He sometimes works in the nearby village on daily wage basis but still life is very hard for him to sustain his family. Few villagers have out-migrated to India, Malaysia and Saudi Arabia to earn foreign currency but most of them continued farming. It seemed that the increasing climatic variability has added more stress and made farmers helpless with limited financial alternatives.

CONCLUSIONS

Farmers perceive climate change and have experienced the changes in climatic pattern since many years, which made them curious to know the causes behind it. While studying farmers' perception and pattern of climate change, it found that temperature is increasing at lower rates in the district. A big change has not been noticed in total monsoon precipitation, though it is slightly increasing. Erratic rainfall is continuing in all and winter rain is decreasing. The proper timing and amount of rainfall is very important in agriculture thathas negative impacts on agriculture. Erratic rainfall is increasing incidences of drought and side by side flooding too. Problems of soil fertility and irrigation management have also increased and farmers have even lost some local rice varieties that were unable to adjust to the changing environment. Similarly, an erratic rainfall and increasing temperature have promoted the incidence of insect pests and diseases directly affecting the growth and development of crops resulted into reduced production. Decreasing winter rain affected negatively the production of winter crops in 59% area in the district. If the change continues in the same manner and timelyappropriate adaptation strategies are not developed, agriculture sector will suffer greater risk in the days to come. Farmers have made adjustments in agricultural practices such as varietal changes, changes in cropping calendar, pattern, planting method, application of pesticideand chemical fertilizers and resource conservation technologies such as zero tillage and farmers in both low and upland areas adopt surface seeding. Farmers are also using some external technologies to cope with the impacts of climate change. In addition,farmers have undertaken non-agricultural adaptations such as outside employment and small business as an alternative source of income. Water harvesting, soil and water conservation practices, organic farming, diversified vegetable farming and off-season vegetable production in plastic houses in thehigh altitude of the district are some of the additional adaptation measures. Community based adaptation measures have recently initiated in the district. The autonomous, short-term adjustments in agriculture helped them to some extent but it seems important to plan sustainable adaptation strategies and make farmers prepared to cope with the increasing effects of climate change in coming days.

The findings indicate that farmers are aware of climate change and its impact on agriculture and capable of adapting to some extent. Efforts are takenfrom both the local level as well as thecenter government level.

RECOMMENDATIONS

LOCAL LEVEL INITIATIVE

- Capacity of local community-based institutionsshould be strengthened in the district to increase community awareness about the effects of the climate change and initiate the community based adaptation measures to cope with the effects of climate change for its sustainability.
- Farmers of drought areas should practice water-harvesting technologies for effective and efficient wateruse.
- The subtropical climate existing in the district favors the cultivation of perennial crops like banana, which requires warm, humid climate and average rainfall of 1700mm and citrus that requires hot, humid summer with warm winter and 2500 mm average rainfall giving good economic return. Hence, farmers may explore the possibilities of perennial agriculture in the face of rice farming being highly affected by erratic rain.

Policy implications

- Appropriate system for weather/climate data collection, forecasting and early warning system for climatic extremities should be developed by the Department of Hydrology and Meteorology, while extreme climate based insect pest and disease forecasting system should be devised by Department of Agriculture.
- Ministry of Agriculture Development should design national level activities to support the management and distribution of resources, extension services and information dissemination to the local level, training and awareness rising in communities and international lobbying.

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