Watershed Management Approach for Climate Change Adaptation

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Abstract

Nepal's temperature is rising faster than global average with high warming rates in the Himalaya. The precipitation is becoming unpredictable resulting extremities. Poor people, whose livelihoods are nature based, have experienced the impacts of climate change and are coping to their best. Adaptation to climate change is an urgent action for the poor communities. Practical Action Nepal is implementing a climate change adaptation project to help the communities. The project is being implemented within a watershed boundary. The project appraised the community perception to climate change, its impacts, the coping strategies and the needs for adaptation through participatory approach. Community based adaptation activities were implemented to respond to climate change and its impacts. The lessons learned from the project indicated that climate change adaptation requires an integrated conservation and development programs together with focus on disaster risk reduction. The integrated programs become effective when implemented within a watershed boundary where the biophysical and socioeconomic systems are interlinked.

Keywords

Climate change, adaptation, vulnerability, watershed, sustainable development, integrated conservation and development, disaster risk reduction

Introduction

Between 1977 and 1994 Nepal's average temperature rose at a rate of 0.03^{0} - 0.06^{0} Celsius per annum with higher in the mountains and lower in mid-hill and Tarai regions (Shrestha et. al., 1999). Another report by Government shows an increase of 0.41^{0} Celsius per decade based on the temperature record analysis between 1981 and 1998 (GoN 2004). Although the analysis are based on short period data, nevertheless they show that Nepal is warming in a significantly higher rate compared to 0.74 Celsius of global average warming in the 20th century (IPCC, 2007). Temperature extremities have also been observed in recent years in addition to increase in annual average. In December 2005, Dadeldhura and Dang, both in western Nepal, recorded the ever highest temperature for the month while during the same month Taplejung, Dhankuta, Biratnagar in east and Nepalganj and Dang in west Nepal recorded the ever lowest temperature for the month (Rajbahak, 2006). Dang showed ever highest and ever lowest temperature for the same month, December in 2005 (ibid).

There is no distinct trend in all-Nepal precipitation (Shrestha, et. al. 2000). There are regional and seasonal variations. Observations show that high rainfall regions and seasons are getting more and more precipitation and becoming wetter, and low rainfall regions and seasons are getting lower and lower precipitation and becoming drier (GoN, 2004). The number of monsoon days, with early onset and late withdrawal, and the intensity of the monsoon rain have shown an increasing trend (Sharma, 2006). The non-monsoon season of November 2005 – May 2006 was the driest period from 1968 – 2006 (ibid). The monsoon extremities have also been observed in recent years. Nepalganj in western Nepal recorded ever-highest rainfall of 336.9 mm within 24 hours on the 27th August 2006 (SOHAM 2006). The 2006 monsoon record showed the wettest for Nepalganj for last 123 years (Sharma, 2006).

Different models have projected different trends of precipitation in Nepal (GoN 2004). But a simple observation of aggregated precipitation and average temperature of five meteorological stations (Dhangadi, Surkhet, Pokhara, Kathmandu and Dhankuta) showed an increasing trend in both temperature and total precipitation in Nepal. (Figure 1)

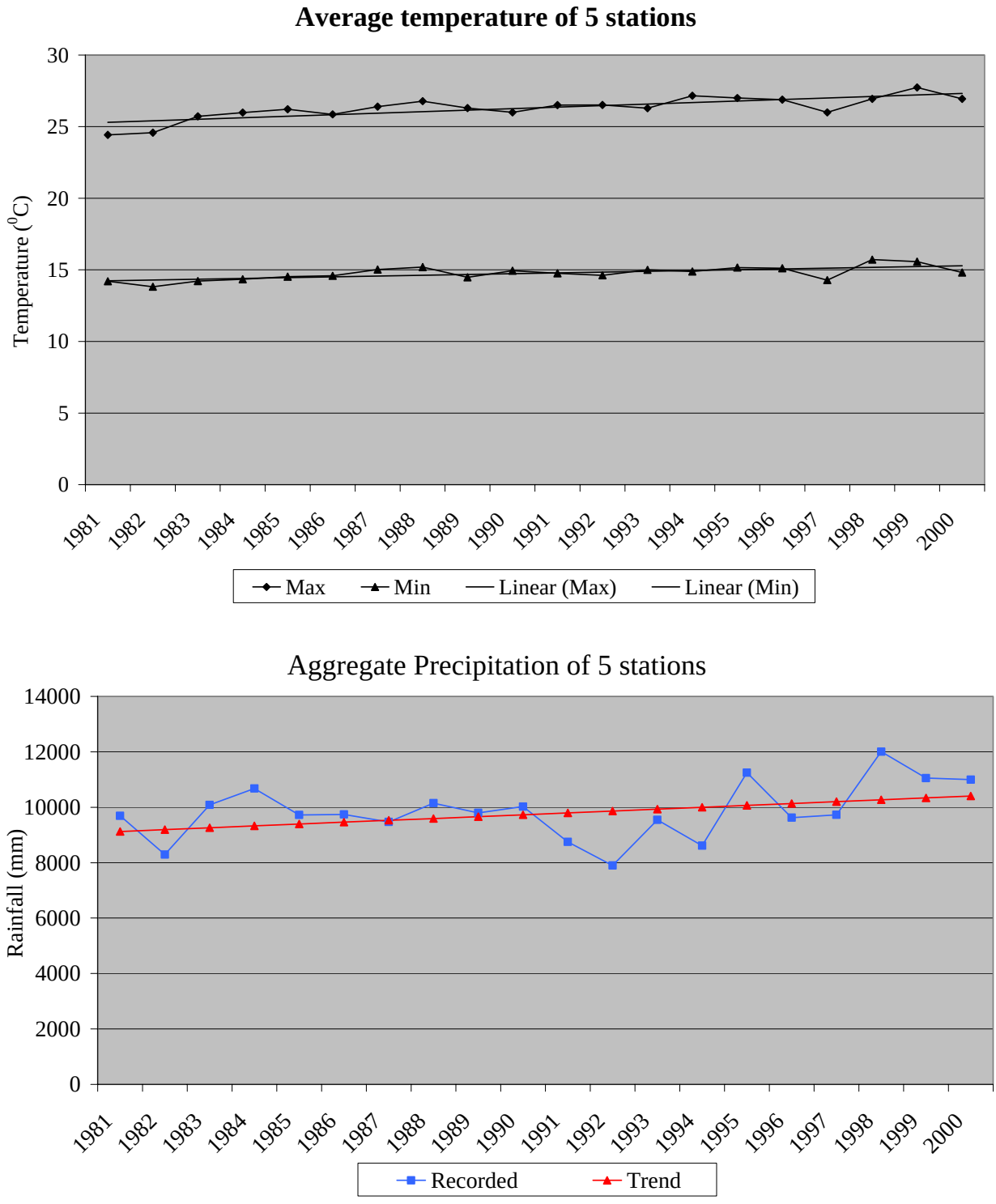

Figure 1: Temperature and total precipitation records of five meteorological stations (Dhangadi, Surkhet, Pokhara, Kathmandu and Dhankuta) of Nepal.

Data source: DHM 1984, 1986, 1988, 1995, 1997, 1999, 2001, 2002

Impacts of climate change in Nepal

Climate change has impacts on every aspect of nature and human life which have been predicted to continue for several decades ahead. This section highlights some of the impacts of climate change on 1) Glaciers 2) Agriculture 3) Biodiversity and natural resources 4) Water induced disaster and 5) Water resources of Nepal. Attempts have been made to highlight the impacts rather than making predictions.

Glacier is the much highlighted subject when climate change subject is discussed in Nepal. Compared to other sectors under impacts of climate change, more studies have been done on glaciers in Nepal. Studies show that Nepal's glaciers are retreating faster than the world average (Dyurgerov and Meier 2005) and the number and size of glacier lakes are increasing along with increase in temperature. Glacier AX010 in Shorong Himal retreated by 30 m from 1978 to 1989 (Fujita et. al. 2001), and majority of glaciers in Khumbu region retreated by 30 to 60 m from 1970s to 1989 (Yamada et. al. 1992).

Glacial Outburst Flood (GLOF) is the main hazard out of increasing sizes and numbers of glacial lakes. In the past, Nepal has experienced disasters from such GLOFs. One of such floods occurred in 1985 in Dig Cho Glacial Lake in Kumbu region which washed away Namche Hydro Power Plant, several hectares of cultivated land, bridges, houses, livestock and human life (WWF 2005). The flood lasted for 6 hours, surged 10 – 15 meters deep and affected more than 90 km downstream (ibid). Not only formation and outburst of glacier lakes, there are also evidences of disastrous avalanches and icefalls which could be associated with increasing temperature. A massive icefall in August 2003 blocked the Madi River in Sikles village of Kaski district in its source for several hours and made a disastrous damage on agricultural lands and crops, livestock and killed at least one person and affected more than 50 km downstream when the blockade was burst (personal field experience).

Agriculture, the mainstay of over 80% Nepalese (CBS 2001), has been affected both by warming and uncertainly of monsoon. The increase in temperature has both negative and positive impacts on agriculture.

Farmers in Jumla district (2700m asl) have found positive impacts of warming as they can now grow two crops a year (rice – barley) comfortably. However, thinning in snow deposition and retreat of snow line are causing water shortage for irrigation in Jumla and Manang districts (personal field experiences). The relationship between the crop yield and climate change has yet to be investigated although statistical models predict increase in yields of C4 crops because of increase in atmospheric CO_2 concentration together with warming.

Out of a total cultivated land of 2.64 million ha in Nepal, only 43% (1.13 million ha) has access to irrigation facilities, of which only 70%, 20% and 10% get actual irrigation in monsoon, winter and spring seasons respectively (ADB 2004). The remaining agriculture completely depends on natural precipitation. The crop yields have strong association with the amount of precipitation on right time. Good paddy harvesting is associated with good monsoon rain (Anonymous, 2005) while the yield of wheat and rice in Kaski district declined in 3 consecutive years (2003 – 2005) because of decrease in precipitation (Regmi and Adhikari, 2007). But excessive rainfall causes flooding and the yields are adversely affected (Gharti Chhetri, 2005).

Studies have shown early onset and late withdrawal of monsoon (GoN 2004). But the actual monsoon month and the main rice-planting month, July, is becoming drier. Farmers from Kabilash VDC in Chitwan Nepal could not transplant rice in two consecutive monsoons of 2004 and 2005 because of dry month. Some farmers changed crops from paddy, the main food grain, to banana, as banana is more resilient to erratic precipitation (Gurung 2007). The late withdrawal of monsoon is affecting the crops at harvesting stage. In 2006, the October rain destroyed the paddy crops at harvesting stage. The farmers are experiencing an increase in such incidences.

A plant disease vectors, Citrus Scylla, was recorded at around 1,500m asl which was usually recorded only in the region below 1000 m asl (Dr. Suresh Pokhrel, Agriculture Development Officer, Chitwan District, Nepal, a personal communication, 2006). Although there could be some genetic reasons behind its adaptation in higher altitude, but warming in the higher altitude could be a strong reason. This has increased

the probability of extension of plant diseases in higher ecological zones which were free in the past from vectors borne diseases.

Crops in higher altitudes are more likely to become failure as they shift to higher zones. The soil in the higher region is not mature enough for crop production. Farmers are experiencing reduction in irrigation water due to reduction in snow deposition in the mountain region.

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The changed monsoon pattern has affected water-induced disasters in the country showing a positive association with intensity and amount of rain. The water-induced hazards like floods and landslides in Nepal are in increasing trend (Min of Homes quoted in DWIDP 2006). Precipitation extremities are responsible for increase in such hazards. High intensive rainfall was the main cause of landslides in Laprak (Gorkha district) in 1999 and Nepane (Kaski district) in 2006. Laprak received 341.8 mm of precipitation between 4 -7 am on 3 July 1999 and Nepane received 128 mm between 11 pm – 12.30 am on 15 July 2006 (Gurung 2006). A heavy downpour of rain on 26 – 27 August 06 in western Nepal exceeding 300 mm within 24 hours was responsible for extensive flooding in Nepalganj area costing millions of rupees for relief and rescue activities (SOHAM 2006). Although anthropogenic activities might have contributed to some extent to water induced disasters, they are increasing despite the increasing focus of the government, communities and development organizations to minimize such disasters. Local people have also perceived the increase in frequency of intensive rainfalls which is supported by increasing climate extremities in the recent days.

There is a lack of study in Nepal on impacts of climate change on biodiversity. However, local people have observed some anomalies in flowering and sprouting behavior of plants. Aita Bahadur Lama a farmer from Kabilash, Chitwan has observed that Pipal (*Ficus religiosa*) and Simal (*Bombax ceiba*) have sprouted and flowered early respectively compared to their normal seasons (personal communication). Gyalpo Gurung a local resident from Humde, Manang has also observed that the pastures in high altitude (3000 – 4000 m asl) are greening early to their normal season (personal interaction). He has also experienced that the alpine grassland is shifting towards higher altitude and new pine forests are generating on de-glaciated and glacial retreated areas. The impacts of such phenomena on human life have yet to be understood. However, it is

more likely that the biodiversity in the higher altitude would be much affected by climate change as the soil characteristics in higher altitude is poor to support plant growth and there is a limit for space for further shifting upwards. Both fauna and flora will be affected by such vertical shifting of ecological zones in the high altitude regions.

The climate change has impacts on water resources, both qualitative and quantitative. The discharge of snow fed rivers is declining in Nepal (Anonymous, quoted in WWF 2005). However, different studies in different rivers have different reporting as well. River discharge analysis between 1947 – 1994 in Koshi basin in eastern Nepal showed a decreasing trend during the low flow season (Sharma et. al. 2000) whereas Kali Gandaki River in western Nepal increased by about 1% annually for 1964 - 2000 (Shrestha 2004) It is expected that the discharge of glacier fed rivers will increase in the first some years, then will decrease after the snow and glacier becomes smaller and smaller (ibid). This will have serious impacts on hydropower plants, ground water recharge in the plains and agriculture in downstream together with disturbances on local hydrology and aquatic life. The decrease of water volume in reservoirs for some of the electric power stations in Nepal might have a correlation with change in precipitation behavior that result lesser and lesser net water deposit both because of erratic rainfall and increase in evaporation despite the increase in total annual precipitation.

The water springs in mid-hills of Nepal are also drying. The GoN has publicly announced a decrease by 45% in spring flow, the sources of drinking water for Kathmandu valley (Nepal Drinking Water Supply Corporation, Public Notice in Annapurna Post, 15 April 2007). Deforestation might have a relationship with drying of springs. But disturbance on groundwater recharge due to erratic precipitation is also equally responsible. The intensive monsoon does not help proper recharge to groundwater as most of the precipitation leaves the site through surface runoff although the total precipitation looks high. On the other hand, the decrease in precipitation during the dry season might have also an adverse impact on ground water recharging to maintain the springs during dry season.

The frequent floods and landslides due to intensive rainfall have impacts on water quality. The heavy flood on 26-27 August in 2006 in western Nepal was followed by several people suffering from diseases such as gastroenteritis, eye infection, and pneumonia (SOHAM 2006). As the wet season is becoming wetter, it is more likely that the water quality would be worst. On the other hand, the human health will also be affected adversely in dry season because of severe lack of water for sanitation if the dry weather becomes drier where there is already lack of sufficient water for sanitation (Erickson 2006).

The Initial Communication Report of Nepal to IPCC shows that evidences of Malaria, Kalajar and Japanese Encephalitis are increasing (GoN 2004). However, their correlation with climate change or global warming is yet to be understood. The number of human death due to cold wave in winter in Tarai Nepal is increasing in the recent years where the people are experiencing extremely cold weather.

The project area

Chitwan district was selected for the project as the district's total annual precipitation was above average in last few years (Koirala and Thapa 2005) showing that there were extreme precipitation events exceeding 300mm in 24 hours. Jugedi Khola watershed was selected as the project implementation area based on following criteria (Koirala and Thapa 2005):

1) severity of climate induced disasters
2) vulnerability of the community to the disasters
3) priority of the District Development Committee (DDC)
4) ability of the project to address the community expectations

The watershed is located at 27^0 45' 31" to 27^0 47' 41" N and 84^0 29' 03" to 84^0 30' 45" E with an area of 12.21 sq. km. (Shrestha et. al. 2007) in lower Mahabharata zone. The climate of the area is monsoon sub-tropical. The meteorological record at Rampur, approx 19 km south-west, shows an annual maximum temperature from 29 to 32 ^{0} C and minimum temperature from 16 to 19 ^{0} C (DHM data 1971 - 1986). Highest and lowest 24 hours temperature have been recorded 43 ^{0} C and 1.6 ^{0} C respectively at the station

between 1987 and 2000. The average annual rainfall of the area was 1995.5 mm for the period from 1971 to 2000.

The watershed includes parts of ward no. 1, 7 and 9 of Kabilash VDC of the district. There were 183 households in 2005 (Gharti Chhetri, 2005), 185 in 2006 (Practical Action Nepal, 2006) and 187 in 2007 (Shrestha et. al. 2007) showing population increasing trend.

Agriculture and livestock keeping are the mainstay of the majority of the people. Daily wage, vegetable farming, employment, fruit farming and pension were found to be supporting income activities (Table 1). Although local liquor making and selling has not been reported during the discussion with the communities, this activity was found to be a major source of income generation for the communities from field observation. Only 31% households produce sufficient food grains to meet their whole year need (Practical Action Nepal, 2006). The rest 69% households have to purchase the food to meet the year round need.

Table 1: Livelihood options of the households in the project area

S. No.	Livelihood options	No. of household involved
1	Agriculture	187
2	Livestock (poultry excluded)	173
3	Daily wages	46
4	Vegetable farming	42
5	Employment	36
6	Fruit farming	16
7	Pension	8

Source: Gurung, 2005

A vulnerability context analysis of the area indicated that 99% respondent responded landslides and floods as the major hazards of the area (Practical Action Nepal 2006).The communities have perceived that the

erratic rain pattern in the area has stimulated landslide. Floods have affected over 25 households in the area since 1966. The soil erosion, landslides, flood, lack of irrigation facility and seasonal draught are strongly related with change in climate. These vulnerability contexts have high importance to wellbeing indicators of the communities.

> Over the past decades, local people have experienced hotter summer. The winter season is shortening slowly. The rainfall is erratic and there is an increasing trend of occurrence of intensive rainfalls causing landslides and floods. Ninety eight percent of the people have perceived that there is a change in climate of which 95% have used increasing draught and erratic rainfall as the main indicators. Although people have experienced change in climate and its impacts, they lack knowledge and understanding on specific issues of climate change, its causes and impacts on different aspects of life and ecosystem.
> Practical Action Nepal, 2006, Baseline Study Report

The local people have experienced that the frequency of flood hazard has increased in the recent years. Although there are anthropogenic causes such as deforestation, cultivation of marginal lands due to increase in population, they have perceived that erratic rainfall is also equally responsible to intensify the problem. Destruction of lands and declining in the productivity by flood and landslides compel them to occupy forest area and go for steeper lands for cultivation and other alternatives means of living.

Despite various vulnerability contexts, the communities are adopting a number of coping strategies. The first preference of coping and adaptation strategies are short term in nature which give immediate impacts and relief. Because of lack of resources and awareness on chronic impacts of climate change, the communities have not been able to undertake long-term strategies.

Table 2: Occurrence of flash flood in Jugedi watershed, Chitwan

Year	Event	Effect	Solution

Year	Event	Effect	Solution
1966	• People were washed away by floods in Jugedi khola1	Human loss	No support from any organization
1983	• Productive irrigated lands (Khet) and water turbine damaged by the floods of Kholaghari river	Land and water turbine loss	No support from any organization
1993	• Productive irrigated land (Khet) damaged and 3 persons killed by Jugedi khola	Productive land loss	No support from any organization
2003	• 5 persons, 25 goats and some buffaloes killed due to flooding in Isti-khola • About 7.8 ha of cultivated land destructed by flood in Bharlang khola • 8 persons, 55 goats, 3 buffaloes, 3 bulls killed and 5 houses and about 2.6 ha of cultivated land was destroyed by flood in Jugedi khola	Massive Property losses	District Development Committee and Red Cross Supported the victims.
2006[1]	• Loss of 12.33 ha of land with a minimum value of NRs5.55 million by flood and landslides [2]. • Destruction of 5 irrigation channels	Massive land loss and wash away of irrigation channels	None from other organizations; rehabilitation of irrigation channels by Practical Action Nepal

Sources: Practical Action Nepal (2006)

[1]: Information from field visit

[1] *Khola* is a stream
[2] US$1.00 = NRs66.00 (approximate)

Watershed management approach for climate change adaptation

Climate change has already affected the communities in Nepal. The impact is expected to increase in the days to come as the temperature is increasing and the precipitation is becoming more unpredictable. Nepal is highly vulnerable to impacts of climate change because of several reasons including the following.

1. high rate of temperature increase compared to global average
2. exposure to all type of climatic conditions
3. highly nature based livelihood and economy
4. steep topography
5. fragile geology
6. inadequate human resources and
7. poor economy

The impact of climate change is a product of intensity of climate change, natural set-up of the country and anthropogenic activities. Climate change has the potentiality to affect to all aspect of human life and natural systems. The adaptation and coping strategies to climate change therefore demand integrated approach. It needs integration within the natural ecosystem, within the socio-economic system and between natural ecosystem and socio-economic system. At the grassroots level, the integration can more effectively be carried out in watershed-based approach. In this paper, lessons learnt will be discussed based on activities carried out on watershed management approach.

This approach also addresses the livelihood assets. In the adaptation process, coping strategies form the short-term activities and the adaptation strategies form the long-term activities. Following comprise the major activities for both coping and adaptation programs.

1. Water resources management
2. Forest and land conservation
3. Agriculture and livestock management

4. Local infrastructure repairmen

5. Awareness and education

6. Institutional development

The ultimate strategy is to develop the capacity of the communities to cope to impacts of and adapt to climate change through conservation of natural resources, diversification of livelihood options and reduction of disaster risks associated with climate change.

1. Water resources management

Water resource for irrigation is found to be the most affected one in the project area. Landslides and debris flow have destroyed the channels, whereas the water flow in the streams has decreased. Landslide and debris flow are due to increase in events of intensive rains. On the other hand, the streambeds have risen because of deposition of gravels due to flash floods and debris flow, which have covered up the remaining small stream water making it inaccessible for irrigation. Local people have changed the crops from irrigated crops like paddy to less water requiring crops like maize when such irrigation channels are destroyed. In some cases, they have left the land fallow. During the winter, there was no opportunity to cultivate any crop on such lands where landslides and flash floods have destroyed irrigation channels. Where appropriate the people have tried to use alternative techniques, such as wooden conveyers or lifting of water by pumps, to bring the water for irrigation. When discussed with the communities one of their priority demands was to rehabilitate the irrigation channels.

Based on the needs of the communities, rehabilitation of irrigation channel was implemented. Communities were supported for HDPE pipes and PCC for the rehabilitation for six irrigation channels which benefited 30 ha of land. After the rehabilitation of the irrigation channels, the farmers now can grow three crops a year including vegetable cultivation. Before, they could hardly grow one crop, rice, the harvest of which was uncertain because of complete dependence on unpredictable rainwater. This helped the beneficiary households increase the total crop production in the area thereby improving the food security and income generation opportunities and strengthening the resilience of the communities to impacts of climate change or

other likely disasters. Based on the specific site and the preference, the farmers have now options for different cropping patterns – "Rice – Maize or Wheat or Lentil or Vegetables – Maize or Rice or Vegetable".

2. Forest and land conservation

The flood that increased in terms of both frequency and intensity destroyed a considerable quantity of cultivated lands in the past in the area. In 2006 alone, over 8 ha of land was destroyed by landslides and flood. One of the demands of the communities was therefore to protect their land from potential future floods and landslides. In some cases, there were needs for the protection of houses located close to streams where floods occur frequently.

Based on the needs of the communities, gabion boxes were supported to protect the riverbanks and to divert away the stream flow during the flood time. It helped protect the intakes of irrigation channels, lands and houses located at vulnerable sites. However, the flood that occurred in 2006 was several times bigger than the assumption of the communities. Most of the gabion boxes were destroyed and buried by the debris. There were, of course, some needs in technical improvements. Nevertheless, the experience showed that there could be further larger and intensive events of landslides and floods for which the communities must be prepared and protected. The investment, which had been made this time through the project intervention, was too small to enable the communities to withstand the impacts of intensive rainfall and flash flood.

Interventions have now been made to put check dams in upstream micro-catchments together with plantation and forest management. This is to reduce the deepening of gullies, probability of occurrence of landslides, and debris flow from micro-streams thereby reducing the debris flow in downstream.

Plantation works have also been done in upstream to reduce soil erosion and landslides. Communities have formed Forest User Groups (FUGs) to manage the forest in the area which was lacking before the project interventions. The FUGs are now managing the forest. They have controlled in penetration of outsiders and locals to collect the forest products such as timbers illegally.

Plantations have also been done on both community and private lands. The preferred tree species include fodder species, timber species and fruit species. The community members have also promoted grass species for plantation. Grasses have been effective in reducing soil erosion. A forest nursery has been established which is managed by communities and produces seedlings of species preferred by the community and suitable to local environment and economy.

Trainings have been organized for local people for nursery production as well as weaving and filling of gabion boxes.

In case the adaptation and preparedness activities are inadequate, the communities are likely highly vulnerable to hazards like landslides, floods and droughts. Under such circumstances, the government has to be prepared.

3. Agriculture and livestock development

Agriculture has been affected significantly by change in rainfall pattern. Total agriculture land has decreased because of land cutting by landslides, floods and covering by debris. This warrants for intensive farming of the available land by increasing the number of crops a year or increasing the high value crops. The increase in number of crops a year has been possible after the rehabilitation of eroded irrigation channels.

Local people have been encouraged, trained and supported for cultivation of high value crops like vegetables. The community has also been supported in marketing of such crops. This has helped increase the accessibility of the households to income generation activities thereby improving their resilience.

Sloping Agriculture Land Technique (SALT) has been promoted in the area. This technique was selected as appropriate technology for the area as numbers of households are practicing slash and burn agricultural system on un-terraced slope lands. Under such system, the land is exposed to drought when rain does not occur for a long duration and to heavy soil erosion or even landslide when there is intensive rainfall.

Through use of SALT, farmers are able to produce multipurpose crop species including fodder while at the same time arresting the top soil from erosion and minimizing probability of landslides.

Farmers have also been supported in livestock management. Trainings were provided to locals in livestock health management. As per the experience of the communities, there are evidences of increase in livestock indo-parasites which occurred only in lowlands in the past. But, now these parasites have appeared up in the village. Although there is no systematic study on relationship between the climate warming and increase of livestock parasites in the higher altitude, climate warming could be a strong basis to this evidence. The trained individuals are supposed to provide their services to the local people in livestock health care.

Farmers have been supported in training and goat farming. A "transfer of ownership" scheme has been introduced in goat farming. Under this system, the offspring of goat is handed over to another household once the seed goat gives birth. Communities were provided 24 seed goats to initiate the program. A community livestock insurance scheme has been established in which accidentally dead goats are provided replacement. In this system, the household receiving a goat, deposits Rs100.00 (US$1.50) to the committee for the insurance if the received goat dies accidentally. If there is no such requirement this fund will gradually accumulate with which the communities implement activities for climate change adaptation. The goat raising has been linked with promotion of SALT and fodder plantation to minimize the dependence on natural forest for livestock fodder.

The local people were also encouraged to take their surplus milk to the market to make additional income which has been successfully done. So the diversification and commercialization of agriculture and livestock has increased the income sources of the community which will strengthen their capacity to cope and adapt to impacts of climate change.

4. Local infrastructure repairmen

Destruction of local infrastructure such as bridges, trails, community buildings etc. by landslides and flood is also the usual impact of intensive rain and flood. Although the communities required repairmen of a number

of such infrastructure, a local bridge was repaired under this project which was at the most strategic location. The community provided free labor for collection of local materials such as stones and timbers, whereas the project provided supports for materials and skill labor that require money to purchase. More such infrastructures are likely to be affected in the future from erratic rain, floods and landslides. The communities are to be prepared. There is a need to consider proper engineering and rehabilitation of such infrastructure in view of climate change.

5. Awareness and education to local people and school students

Level of awareness of local communities and stakeholders to climate change and its wide impact is very low at the moment. They think of local environment when discussed on climate change. But the area of coverage of climate is wide and beyond the boundary of local environment (Gurung, 2005). In order to increase the awareness level of the communities and local stakeholders a number of awareness activities were organized. Such activities included slide shows, interactions and educational visits for both school students and community members. A meteorological station has also been established in the site where school students will take records to learn about weather and climate variability in the long run. Information materials such as booklets and posters on climate change, its global and local impacts were also produced and disseminated.

6. Institutional development

A Climate Change Impacts and Disaster Management Group (CCIDMG) has been constituted in the project area. All the households within the watershed are the general members of the group. The members for the executive committee are selected from the general members within the watershed. The group has been registered and formalized at the office of District Administration Office. So formally, the group can prepare plans, raise incomes internally and externally and implement Climate Change Adaptation activities for themselves.

The executive members have been trained in administrative and financial management. They have also been trained in activity planning, implementation and reporting of the achievements or progress. The community members have been trained and made aware of climate change, its impacts and adaptation to it.

In order to enable the committee and the community, a watershed management plan in respect to adaptation to climate change has been prepared through their participation in which their skills and resources will be promoted to make themselves resilient to the impacts of climate change.

Implementation approach of the project

The project was implemented in partnership with local communities (CCIDMG) and ECOSCENTRE (Ecological Services Centre), a local level non-governmental organization. The role of the communities was to mobilize the local resources including human resources to contribute at community level activities such as riverbank protection, community plantation, rehabilitation of irrigation channels, reconstruction of local bridges etc. The local committee also identified the right persons for participation in various trainings and awareness raising activities. They were responsible to identifying their problems related to climate change, prioritize them and propose appropriate activities for responding to such problems. The communities were also responsible for coordination at village level with local level formal and informal village organizations. Such coordination is essential to share the resources and responsibilities. The community is overall responsible to continue the climate change adaptation activities in the future.

ECOCENTRE is a local level NGO who was involved in providing technological supports to the communities. They provided technical supports in agriculture and nursery establishment and management. They were mobilized for a number of trainings, technical advice and inputs required by the communities. One of the underlying reasons to collaborate with local NGO was to develop linkage of the community with local service providers so that after the termination of the supports from the project, the communities will be able to get supports and the local NGO will be a help to the communities. It is also to strengthen the capacity of local NGOs in climate change adaptation as the subject is emerging and new.

Beside local communities and ECOSCENTRE, other individual and institutions were also involved in the project to get their specific inputs. Such individual and institutions included agriculture experts, veterinary

and livestock experts, forestry officers and sociologists who involved in training and socioeconomic survey, data analysis and preparation of management plan for the area.

Conclusion and recommendations

Global climate change has local severe impacts. In Nepal, the most studied impacts are retreating of glaciers and snow lines, formation of glacial lakes. There is inadequate information about the impacts of climate change on drought, landslides and flood, and in other sectors. The most affected are the poor communities. As the communities experience the impacts of climate change, they are also trying their best to cope and adapt to it. They have however, a low awareness level about climate change and its impacts. The level of awareness is also low among the professionals who are working at government and non-government organizations. There is a need to raise the awareness level on climate change and its impacts for all types of stakeholders.

The communities have practiced coping and adaptation strategies by default. Nevertheless, most of such practices are short-term coping strategies. The long-term adaptation strategies are lacking because of lack of understanding of climate change and its impacts in one hand, on the other hand, it is because of lack of resources in the communities' possession. The impacts of climate change at local level have to be systematically understood and subsequent coping and adaptation strategies are to be developed for implementation.

Climate change does not exclude any system from its impacts on the earth including natural system and human life. In order to make the communities resilient to impacts of climate change a single sector or program approach does not work. The adaptation to climate change should therefore be integrated and multi-sectoral or multidimensional approach. However, in a certain given location the severity of the impact on different sectors could be at different levels. It is therefore suggested that the most affected sector should be taken as the entry point on which the integrated program should be developed and promoted.

Similarly, from geographical point of view the natural systems should have inter-linkages between the sectors. This is best observed within a watershed system. Adaptation to climate change can be more effective and practical if it is based on watershed management approach. However, the conventional watershed management mostly focuses on natural systems. But climate change equally affects social and economic systems. The experience from this project suggests that the climate change adaptation approach should include a diverse range of conservation and development activities including disaster risk reduction strategies. These approaches might be promoted as "Integrated Conservation and Development" or "livelihood strategy approach" with ultimate goal to achieve a "sustainable development".

The impact of climate change has already become severe and there are more severe impacts likely to come. The adaptation to climate change program should keep this projection in mind to address the future likely disasters. If the future likely disasters are not taken into account, the investment done on coping strategies will be merely a waste of resources, as they would be destroyed by larger future disasters. Therefore, in climate change adaptation program, disaster risk reduction (DRR) should be an integral part.

Adaptation to climate change requires huge investment than thought. The investment is required in human resources development, to undertake development and conservation programs, and activities for disaster risk reduction. The resource poor countries have limited capacity and resources for adaptation to climate change. On the other hand, these countries are already paying the cost of global pollution made by rich countries through impacts of climate change.

Nepal is extremely vulnerable to impact of climate change because of her poor economy, inadequate human resources, fragile geology, steep topography and high rate of change in temperature and precipitation behavior. Nepal should give a high priority and importance on adaptation to climate change with taking account of future climate change and its impact in all development programs. Improperly planned development can amplify the impacts of climate change (Gurung 2006 and Pant et. al. 2006).

Impacts of climate change on health has not been discussed in this article. It is because this subject is little known systematically till to date in Nepalese context although there is a strong relationship between the warming and spread of diseases. This is an area of high importance.

Little is known about adaptation technologies. There is a need to explore for identifying technologies that already exist and can fulfill the need for adaptation to the best. As the climate is changing, there is a high and persistent need to invest on development of technologies for adaptation. The best adaptation technology today in the same ecosystem and socio-economic environment may not be appropriate tomorrow as the climate changes. By the time the technologies reach to the target beneficiaries they might become inappropriate, and this is highly likely to happen because of slow extension services prevailing in the country. So development and extension of technologies need to be in a high speed and it requires a high investment. Otherwise, any investment on technology development will be waste of resources if the research outcomes do not move with the speed of climate change before the changed climate demands next technology.

Climate change also brings opportunities, especially in cold regions where increase in length of growing season help to grow more crops and the productivity of pastureland may increase. However, harnessing of such opportunities will take time, by the time the negative effects will have already impacts.

Climate change adaptation is to be embedded into development and conservation programs. It has been experienced that currently development sectors have not adequately addressed the impacts of climate change. Experience shows that climate vulnerability assessment should be an integral part of development planning.

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Acronyms

CBS:	Central Bureau of Statistics
CCIDMG:	Climate Change Impacts and Disaster Management Group
CDO:	Chief District Officer
DDC:	District Development Committee
DHM:	Department of Hydro and Meteorology
DRR:	Disaster Risk Reduction
DWIDP:	Department of Water Induced Disaster Prevention
ECOSCENTRE:	Ecological Services Centre
FUG:	Forest Users' Group
GLOF:	Glacier Lake Outburst Flood
GoN:	Government of Nepal
HDPE:	High Density Polythene Pipes
ICDP:	Integrated Conservation and Development Programs
IPCC:	International Panel on Climate Change
NGO:	Non-government Organization
PCC:	Plain Cement Concrete
PRA:	Participatory Rural Appraisal
SALT:	Slope Agricultural Land Technique
SOHAM:	Society of Hydrologists and Meteorologists
VDC:	Village Development Committee

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