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Study on Climate Change Impacts and Adaptation Measures in Palpa District of Nepal

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Abstract

This study was conducted in Madanpokhara village of Palpa district that lies in Nepal aiming to learn the climate change impacts and the new adaption measures at local level. Climate change (CC) has impacted agriculture in the study area and the people have reported decreasing trends of crop production, more flowering and poor fruiting in the fruits and vegetables, explosion of pest and insect in crops, erosion of fertile top soil and shift to use hybrid seeds. Adaptation strategies of the affected people included their engagement in construction of water harvesting pond, agro forestry, water source protection, tier system of cultivation, grafting, alternative energy as a source of energy and initiation of community based micro-credit programs. To address the issues of CC, government of Nepal have initiated its adaptation programmes through the dissemination of CC Policy Nepal 2011.

Keywords: Climate change, adaptation, Madanpokhara, Nepal.

Introduction

Global warming causes unpredictable and extreme weather events impact and increasingly affect crop growth, availability of soil water, forest fires, soil erosion, droughts, floods, sea level rises with prevalent infection of diseases and pest infestations[1]. Nepal's share in climate change (CC) is negligibly small. Some studies cite an increase in temperature in recent years[2]. The major problems associated with agricultural production include drought, flooding, salt stress and extreme temperatures, all of which are expected to worsen with climate change[3]. The major effect of climate change is at the Himalayan areas[4].

There are approximately 9,000 such lakes in the Himalayas, of which 200 are said to be in danger of bursting[5]. High rates of glacial melt due to increases in temperature are adding to this threat, as the rate of such incidents increased between the 1950s and 1990s from 0.38 to 0.54 events per year[6]. The temperature is increasing with more pronounced warming at higher altitudes[7]. Some research quote an amplify in temperature in recent years[8]. As in other regions of the world, climatic and ecological changes caused by global warming have resulted in several negative consequences for people's health, the economy and livelihoods in Nepal[9]. Glacial melting and retreat, rapidly thawing permafrost and continually melting frozen soils in higher elevations is already being observed[10]. As climatic patterns change, so also do the spatial distribution of agro-ecological zones, habitats, distribution patterns of plant diseases and pests which can have significant impacts on agriculture and food production[11]. Western region people of Nepal are most detrimentally affected because they rely heavily on winter rains and cannot depend as reliably on summer monsoon rains, which are not as intense in the west due to the natural pattern of rainfall intensity from east to west[12].

CC is expected to have serious environmental, economic, and social impacts on South Asia in particular, where rural farmers whose livelihoods depend on the use of natural resources are likely to bear the brunt of its adverse impacts[13]. Various studies, including those from the Intergovernmental Panel on climate change indicate that on a general level the summer monsoon (June to August) will become more 'intense', but also more variable, meaning more frequent heavy rainfall events[14]. Climatic patterns changes have major impacts on agriculture and food production[15]. The temperature is increasing with more distinct warming at higher altitudes[16]. The greatest increase is projected to occur during the months of June to August[17].

The population of Nepal is less than 0.4% of the world population and is responsible for only about 0.025% of annual greenhouse gas emissions[18]. Average temperature is predicted to rise significantly by 0.5 to 2.0ºC by 2030, 1.3 to 3.8ºC by 2060, and by 1.8 to 5.8ºC by 2090[19]. The number of days and nights considered hot by current climate standards is projected to increase, occurring on 11 to 18% of days and on 18 to 28% of nights by the 2060s. There is limited understanding on such basic issues as the nature and scale of impacts of climate change on forests governance and livelihood aspect including the carbon sequestration levels of various forest ecosystem types[20]. Nearly 21 percent of the crop area is irrigated in Nepal[21]. The expected effects of climate change on agriculture will be different in various parts of the world[22]. Temperature rise in these areas increase the rate of snow and glacier melt, releasing a higher volume of water to flow into lower region. From the trend observed between 1976 and 2005 it is expected that the regions with already high precipitation will receive more rainfall and those with low precipitation will see further decrease[23]. This will affect irrigation and drinking water supply and hydroelectricity will be less reliable. Furthermore, local and

global environmental issues of biodiversity loss, desertification, glacier melting, and fresh water availability are often interlinked in complex system[24].

The region is also confronted by issues like poverty, environmental degradation, natural resources depletion, shrinking water resources, desertification and climate change[25]. The theoretical potential on the basis of average flow is estimated to be 83000 MW electricity[26]. Out of this 44,600 MW has been assessed to be technically feasible, while 42,130 MW (50.6 Percent) could be economically harnessed [27]. All-Nepal and regional precipitation series showed significant variability on annual and decadal time scales[28]. However, Nepal is highly vulnerable to CC impacts. These environmental problems result to low and unpredictable crop yields, which invariably make farmers more vulnerable, especially in Nepal. CC trend analysis showed that national temperatures since 1962 has significant variations between years, but a progressive increase in maximum temperatures is evident in line with global and regional records. The increasing trend of temperature is higher in Himalayan region compared to other regions and annual increasing trend is 0.06^{o}C and trend is higher than globally (0.02^{o}C). It is reported that all Nepal temperature is increasing steadily and 32 years temperature data analyzed showed about 1.8°C increase from 1975 – 2006 and in 2006 was reported warmest year in record[29].

Paddy is the primary crop in the lower elevation regions of the country, wheat is grown in the Terai and the valleys of the Himalayas, and corn/maize is the principle crop of the hilly regions[30]. Later start dates significantly impacted paddy crops in 2009, as many seedlings were lost due to the delay in rainfall, and many did not have enough time to mature enough for a viable yield [31]. Climate change might induce similar events with increased frequency in the future[32]. The land that can be cultivated varies by location and season, since the vast majority of surface water irrigation systems in Nepal depend on the water flowing at its source[33]. Climate change impacts on water resources will affect Nepal through a number of ways, including disasters, irrigation and domestic water usage. These changes, in turn, could place additional burdens not only the livelihoods of communities in highland regions but equally in the middle mountain and the Terai. In addition, receding glaciers often leave behind growing glacier lakes that can break through terminal moraines causing catastrophic floods. Glaciers and snowfields will recede and may even disappear, reducing Nepal's dry season water resources. It is also reported that over the past decades rainfall has become more intense, highly variable, longer gaps of no rain and delayed monsoon. In addition, receding glaciers often leave behind growing glacier lakes that can break through terminal moraines causing catastrophic floods. Glaciers and snowfields will recede and may even disappear, reducing Nepal's dry season water resources[34]. Global CC will also likely shift monsoon precipitation patterns in ways that will threaten particularly agricultural production in developing countries like Nepal.

The temporal variability of rainfall and runoff is hence very high, and the problem of excess water during the monsoon and water scarcity during the dry season affects all aspects of life in the country. During the 2008-2009 drought, there were power cuts lasting up to 16 hours per day in major areas of Nepal, barley and wheat crop yields dropped, and nearly 2 million people were food insecure[35]. Some studies indicate that multiple variables, including major land use changes, increasing aerosol emissions, and elevated CO_2 levels due to CC, could all potentially trigger abrupt transitions between two stable states of the monsoon in a "roller coaster scenario," leading to either a more dry monsoon, with significantly less precipitation than current levels, or a more wet monsoon, with much greater rainfall intensity[36]. Global warming causes erratic and extreme weather events impact and increasingly affect crop growth, availability of soil water, forest fires, soil erosion, droughts, floods and sea level rises[37].

Analysis of recorded temperature and precipitation data in Nepal are limited due to availability of data for only last 30 years. Studies have indicated that temperature in Nepal is increasing. The warming seems to be consistent and continuous after the mid-1970s. It is stated that the average warming in annual temperature between 1977 and 1994 was 0.06ºC/yr. The warming is found to be more pronounced in the high altitude regions of Nepal such as the middle Mountain and the high Himalaya, while the warming is significantly lower or even lacking in the Terai and Siwalik regions.

The Climate Change Risk Atlas 2010 ranked Nepal as the 4th most vulnerable country worldwide (out of 170 countries). More than 4,000 people died in Nepal over the last ten years in climate induced disasters, which caused economic losses of USD 5.34 billion. Every year more than 1 million people are directly impacted by climate-induced disasters such as drought, landslides and floods in the mid- and far-west Nepal. Hence, Nepal as a climate vulnerable country has to develop capacity to cope with uncertainties.

Over the last few years, it has been experienced the occurrence of frequent and intense floods, droughts and extremes throughout the country. Studies conducted by the Department of Hydrology and Meteorology show that average temperature in Nepal is increasing approximately 0.06 per year. The temperature in the Himalayas, however, is increasing at a faster rate, which is resulting serious impacts on the glacial lakes-the sources of water for Nepal. Many glaciers are retreating at a faster rate and rapidly melting glaciers means more seasonal variation in river flow. Nepal has a complex, mountainous landscape, floods and landslides have also become more frequent and severe. The high dependence on natural resources for livelihood and inadequate resources to cope with are other reasons. These factors collectively contribute to result the vulnerable situation of the rural poor and disadvantaged communities. The ongoing climate change and changes projected to occur are likely to have impacts on different

sectors. Impacts on some sectors are likely to be more severe than others. The sensitive sectors are agriculture, forestry, water and energy, health, infrastructure, tourism, industry and overall livelihoods and economy of the people.

Irrigation is the major input for the better agriculture production. It is estimated that about 80% of all water in Nepal is used for irrigation. But the changes in temperature and precipitation will alter the hydrological cycle. Changes may result in unpredictable and unreliable runoff, posing potentially serious risk to water supplies in the lean season. Increased variability would severely impact irrigation and the farming livelihoods dependent on it.

The scientific knowledge on impacts of climate change is increasing all the time, as are practical experiences in responding to adaptation needs. This knowledge needs to be exploited. In Nepal lack of research and credible evidence on the impacts of climate change is a major challenge. So, this study is intended to study the impacts of climate change and adaptation measures in Palpa district of Nepal.

Study area: Palpa is one of the seventy-five districts of Nepal. The latitude is 27.81°N and longitude is 83.56°E. This district, with Tansen as its headquarters, covers an area of 1,373 km². Madanpokhara is a village development committee (VDC) in Palpa District as shown in the figure 1.

Methodology

Climate change impacts and adaptive strategies at the household and community levels were gathered through field observations, personal interviews, key informants interviews as well as consultation with institutions and community based organizations. Secondary information was collected from Central Bureau of Statistics, District Agriculture Development Office and Department of Hydrology and Meteorology.

Agricultural production: Nepal is considered one of the agriculture dominated countries and livelihood of the people is entirely dependent on agriculture. *Oryza sativa L.* (Paddy), *Zea mays L.* (Maize), *Triticum aestivum L.* (Wheat), *Eleusine coracana L.* (Millet) and *Hordeum vulgare L.* (Barley) are the common crops to grow in the Palpa district of Nepal. The mean yield of Paddy, Maize, Millet, Barley and Wheat is 2160 Kg ha^{-1}, 1536 Kg ha^{-1}, 992 Kg ha^{-1}, 931 Kg $ha^{-1}$and 1392 Kg ha^{-1} respectively. Most of the irrigable land is the Terai. There is some irrigation in the middle hills and mountains, but it is primarily limited to small-scale surface irrigation and micro-irrigation, such as drip or limited sprinkler systems. Unfortunately, this sector is particularly vulnerable to the vagaries of the weather. Temperature, humidity, solar radiation and precipitation are important climatic factors for crops. Permanent changes in these factors can lead to failure of crops and subsequent low crop production.

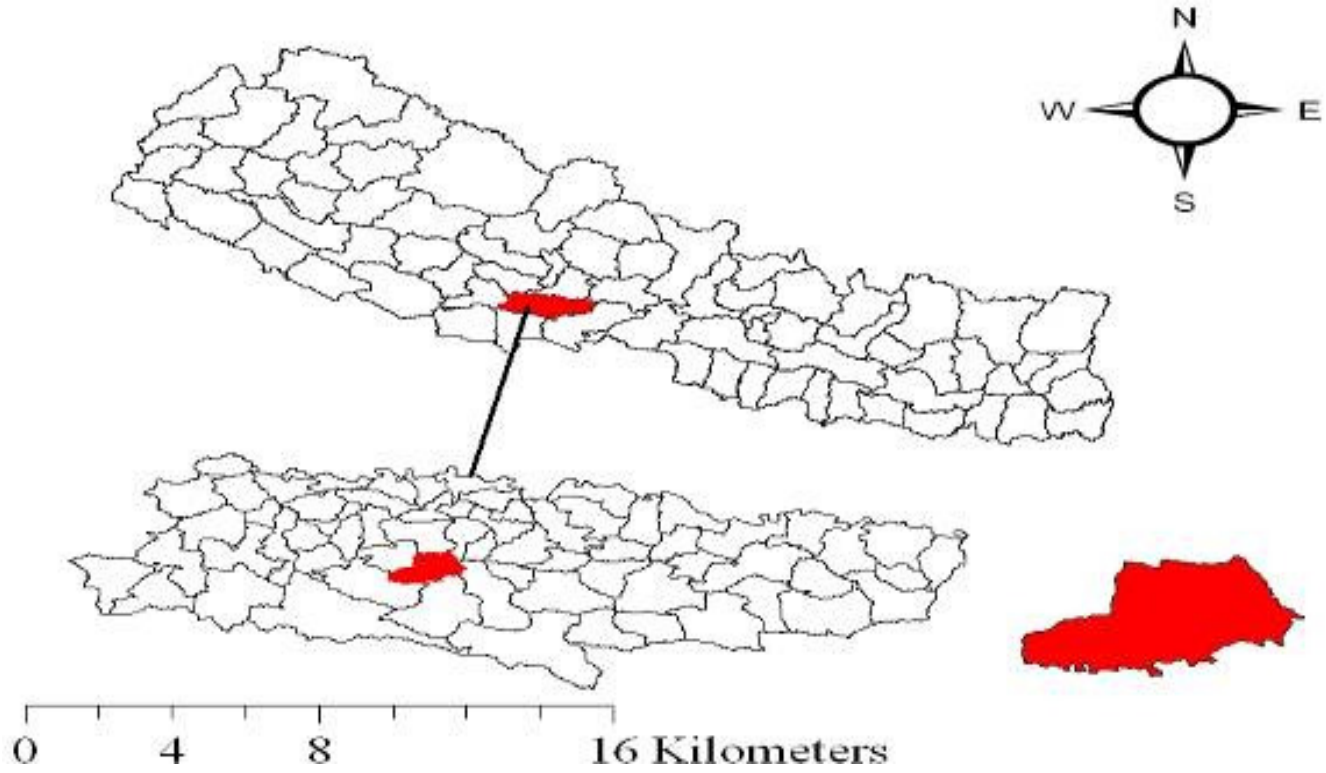

Figure-1
Map of Nepal and location of Madanpokhara VDC in Palpa district

Climate change impacts on Agriculture: Climate is one of the most important limiting factors for agricultural production. Frost risk during the growing period and low and irregular precipitation with high risks of drought during the growing period are common problems in agriculture. The critical agrometeorological variables associated with agricultural production are precipitation, and air temperature. Several studies in the past have argued that for the better crop production, the role of temperature, humidity, solar radiation and precipitation is important as they all are necessary climatic factors. It is obvious that permanent changes in these factors can lead to failure of some crops and can reduce in yield. Reduction in the yield will make the farmers to alter their agricultural practices to adapt in the changing environment. Similarly, another study suggested that temperature rises beyond 2°C are, according to the IPCC, likely to result in reduced crop yields in most tropical, subtropical, and mid-latitude regions. Apart from these, with increasing temperature, more cases of flooding in low-lying areas will be high, declines in food production and increase in crop diseases. Increasing variability of precipitation patterns will have a significant effect on crop productivity, as farmers will have to adapt to changing onset and termination dates of the monsoon. The impacts of less water during the dry months are much easier to visualize, as recent winter droughts have continued to show the effects of low water supply. During the drought of fall 2008 to spring 2009, agricultural systems experienced significantly reduced crop yields, resulting in food insecurity for millions. Such effects would be augmented by a more intense dry season.

Hydrology: The hydrology of Nepal is primarily monsoon-driven. Around 85% of rainfall occurs during the four monsoon months of June to September. Yet, in the same year, floods in the following monsoon destroyed significant areas of growing crops.

Many studies have opined that the changes in temperature and precipitation alter the hydrological cycle and water resources. The total water reserve capacity is 200 billion m^3, and runoff provides 72% of water reserve (144 billion m^3) while snow provides 12% (24 billion m^3). In addition, the mean monthly discharges show that global warming would shift the peak discharge month from August to July, due to the fact that the snow cover on mountaintops would melt earlier. This could lead to increased flooding and more pronounced variations in water availability throughout the year in the downstream. Anticipated changes in hydrological cycle and the depletion of water resources therefore are some of the top environmental challenges that Nepal is going to face due to climate Change. The water related problems as such are likely to be more severe in Asian countries like Nepal where the monsoon, characterized by high precipitation variability, is the dominating climatic force.

Climate change impacts on water resources: In the winter months, more precipitation is falling as rain, which also accelerates deglaciation, and in turn means a shorter winter and earlier snowmelt, ultimately affecting river basins and agricultural systems dependant on surface water diversions for the summer growing season.

This will affect irrigation and drinking water supply and hydroelectricity will be less reliable. Furthermore, local and global environmental issues of biodiversity loss, desertification, glacier melting and fresh water availability are often interlinked in complex system. The changes in temperature and precipitation are responsible to alter the hydrological cycle and water resources. Lowering of water table has a direct impact in the functionality of hand pumps. It creates dryness in the ponds and wells. In the recent decades, due to climate change, river basins and wetlands are becoming damaged. As a result, they are not able to provide water supply of adequate quality and quantity to maintain vital ecosystems.

Results and Discussion

Some specific local cases of good adaptation practices in Palpa District.

Water harvesting/ conservation pond: A plastic pond is roughly rectangular in shape which can store more than 17,000 liters of water. The plastic used in the pond is of high density and durable lasting for 7 to 10 years. The sources of water in plastic pond is from kitchen waste water and rainwater during rainy season. After the construction of this pond, it can be used to irrigate agricultural land upon necessary. The water has been used sufficiently in *Swertia chirayita* (chiraito) farming. This method of collecting water is efficient and effective.

Figure-2 A
A pipe connecting kitchen sink (inside)

Figure-2 B
A plastic pond (outside)

Grafting: Grafting is a horticulture technique whereby tissues from one plant are inserted into those of another plant so that the two sets of vascular tissue may join together. Community forests of Madanpokhara VDC have been practicing the technique in 40 Ha of land. One plant, *Pyrus pashia* (Mel) is selected for its roots and this is called the stock or rootstock. The other plant, *Pyrus pyrifolia* (Naspati) is selected for its stems, leaves, flowers, or fruits and is called the scion or cion which contains the desired genes to be duplicated in future production by the stock/scion plant. *Pyrus pashia* is a fruit bearing tree. Its fruit is edible. It looks like the russet apple and has an astringent but sweet taste when ripe. So, to make it more productice in terms of quantity and quality, it has been grown by this technique. The technique is most commonly used in asexual propagation of commercially grown plants for the horticultural and agricultural trades. Grafted hybrids are highly resistant to diseases and bear good taste. It has become a good source for generating income by selling fruits in the market.

Figure-3
Grafting between *Pyrus pashia* (Mel) and *Pyrus pyrifolia* (Naspati)

3-Tier: Cultivation of three different types of crops under the same area is called 3-Tier system of cultivation. For e.g., 3 tier plantation of *Litchi chinensis* (Lychee), *Coffea arabica* (Coffee) and *Curcuma longa L.* (Turmeric) in 5 ropani area is very common in the area. *Curcuma longa L.* (Turmeric) is grown in the shed of *Litchi chinensis* (Lychee) and *Coffea arabica* (Coffee), and *Coffea arabica* (Coffee) under the shed of *Litchi chinensis* (Lychee).

Previously, *Litchi chinensis* (Lychee), *Coffea arabica* (Coffee) and *Curcuma longa* (Turmeric) were grown separately. While doing so, the production of *Litchi chinensis* (Lychee) was good but the production of *Coffea arabica* (Coffee) and *Curcuma longa L.* (Turmeric) were less. Later, community started growing these crops in tire. Production was increased and community is benefited. Produced *Coffea arabica* (Coffee) is sold in foreign countries like Korea and Japan.

Figure-4
Three Tier system of cultivation

***Jatropha curcas L.* (Sajiwan/Jatropha) cultivation:** Petrol and diesel used in transportation emit carbon monoxide and cause air pollution and is expensive as well. Biodiesel is an alternative fuel for diesel engine. The esters of vegetable oils and animal fats are known collectively as biodiesel. It is a domestic, renewable fuel for diesel engine derived from natural oil like Sajiwan oil. Biodiesel has an energy content of about 12% less than petroleum-based diesel fuel on a mass basis. It has a higher molecular weight, viscosity, density, and flash point than diesel fuel. Jatropha curcas is unusual among tree crops is a renewable non-edible plant. From jatropha seeds jatropha oil can be extracted which have similar properties as diesel but some properties such as kinematic viscosity, solidifying point, flash point and ignition point is very high in jatropha oil. By some chemical reactions, Jatropha oil can be converted into biodiesel. Jatropha oil can also be used directly by blending with diesel.

People of Jarepipal in Madanpokhara VDC are commercially producing biodiesel to reduce dependency on petroleum products from the seeds of Jatropha that can be used as fuel for cars, buses and trucks. Biodiesel can be used as a low carbon alternative. 8 ltr. of biodiesel can be produced from 125 Jatropha planted in 1 ropani area in a barren land. Moreover, 10 ltr. of biodiesel is produced from 30 kg of Jatropha. People have been using bi-product as manure as it provides phosphorous and urea (urea is used as a nitrogen-release fertilizer and has the highest nitrogen content of all solid nitrogenous fertilizers in common use) and make crop`s higher resistive to pests and diseases. Government of Nepal has not made any policy regarding biodiesel.

Figure-5
A commercial cultivation of *Jatropha curcas L.* (Jatropha)

Conclusion

It is evident from the study that there is a decrease in production due to increase in temperature mostly affecting the major crops and vegetables. An increase in temperature is conducive to a proliferation of pests that are detrimental to crop production. Main reasons for decrease in production are untimely/ill-timed rainfall and increased drought. Long drought especially in flowering-fruiting season heavily reduce the productivity of crops. Various new pests are attacking farming and the natural pesticides and insecticides are disappearing due to an unfavorable climate. Change in agricultural practices, attraction to modern farming and degradation of traditional practices are seen through the changes of water use (irrigation) and agricultural inputs such as herbicides, insecticides and fertilizers. Due to the increase in temperature, the climate has become unfavorable for many species which have become vulnerable to extinction and suffering from new diseases. This has also reduced the production of milk and meat. The major activities for the adaption measures are: i. Agriculture development, ii. Water harvesting water resource management iii. Forest, land and soil conservation iv. Awareness and education v. Change in cropping time vi. Change in crop type.

Therefore, climate change impacts and adaption measures are the two major options that the government of Nepal should focus on immediately. Researches on Nepal's climate change are required at local level as the generalized information is not applicable for local level adaption. The complex topography and microclimates in Nepal makes understanding climate change more complicated. Therefore, further studies are required on climate science as there are opposite trends in temperature within a short geographic region which is important to understand. Action research should be promoted identifying the climate change impacts at local, regional and national level for developing coping strategies and adaptation mechanism to minimize the impacts of climate change in Nepal.

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