Perceived Impacts of Climate Change on Forests and Livelihoods in the Padampokhari Village on the Parsa Wildlife Reserve Buffer Zone, Nepal

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ABSTRACT

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Livelihoods in rural communities in Nepal depend on the condition of local natural resources. Rural communities are especially vulnerable to climate change because of their ecological fragility and economic marginality, which in turn limit their adaptive capacity. There is a pressing need to understand the impacts of climate change and adaptation practices to sustain these communities. I interviewed a wide range of members and representatives in nine different communities with the goal of exploring the most beneficial adaptive strategies to sustain their livelihoods. I prepared a calendar of seasonal and community practices from discussions within nine focus groups and interviews of five key informants within each community. The findings indicate that most of the people in these communities do not understand climate change, but they have personally experienced changes in temperature, rainfall, available water sources, and the condition of agricultural and forest resources. These observations are consistent with documented increases in temperature and fluctuations in rainfall collected by Nepal's Department of Hydrology and Meteorology. Community members attributed those observed changes mainly to non-climatic causes such as emissions from a cement factory and acts of Gods. Changes in climate conditions have adversely affected their livelihoods by negatively impacting agriculture, water sources, forest resources and people's health. Local communities have started to adapt in their own ways, such as through the use of drought resistant crops, the diversification of occupations, and out-migration. This thesis concludes that the local awareness of changes in climate and the local initiation of adaptive measures demonstrate the receptivity by rural communities of more systematic efforts by the government of Nepal and non-governmental organizations to address climate change.

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Abbreviations

BZ	Buffer Zone
BZCF	Buffer Zone Community Forest
CBO	Community Based Organization
CBS	Central Bureau of Statistics
CF	Community Forest
CFAD	Community Forestry and Afforestation Division
CFUG	Community Forest Users Group
FAO	Food and Agricultural Organization of the United Nations
FGD	Focus Group Discussion
GDP	Gross Domestic Product
GoN	Government of Nepal
HH	Household
ICIMOD	International Center for Integrated Mountain Development
IOF	Institute of Forestry
IPCC	Intergovernmental Panel for Climate Change
KII	Key Informant Interview
NGO	Non-Governmental Organization
NTFPs	Non-Timber Forest Products
PWR	Parsa Wildlife Reserve
RECOFTC	Regional Community Forestry Training Center
SAGUN	Strengthened Actions for Governance in Utilization of Natural Resources
UNFCCC	United Nations Framework Conference on Climate Change
VDC	Village Development Committee
WMO	World Meteorological Organization

Table of Contents

List of Figures

List of Tables

Annexes

1. INTRODUCTION

There is an overwhelming scientific evidences that climate is changing. Scientific and general public are well aware of it and the expected consequences due to the information spread in the media and specialized literature. However, rural communities without the access to modern media are learning that climate is changing from their experiences on a daily basis. Climate change produces complex interactions between climatic, environmental, economic, political, institutional, social and technological processes. It is a global problem that commands special attention.

During the past few decades the world has been experiencing significant increases in emissions of carbon dioxide and other greenhouse gases, which have caused changes in the earth's climate. According to the Intergovernmental Panel on Climate Change (IPCC, 2007), countries in temperate and tropical Asia are more likely to have an increased risk of extreme events and suffer severe losses because of high temperature, severe droughts, flood conditions, and soil degradation. According to the Food and Agriculture Organization (FAO, 2008), agriculture and forestry are highly sensitive to climate change, which leads to serious impacts on their productivity. As a result, the production of energy, livestock and forest resources has decreased. South and central Asia are projected to be highly vulnerable to changes in agricultural output. These are projected to decrease crop production by up to 30% due to temperature rise and water stress. Therefore, the subsistence agriculture sector is likely to suffer the most because of warming temperature, climatic extremes and disease outbreak resulting in reduced yields and nutrition (Epstein and Mills, 2005).

Climate change can have serious effects on humans (Easterling and Mehl, 2000). It is also expected to have serious environmental, economic and social impacts on South Asia in particular, where two thirds of the population still depends on forests for water, food, fuel, wood and fodder (Gupta, 2010; Straede and Treue, 2006). South Asian countries are more likely to bear the brunt of adverse impacts of climate change (ICIMOD, 2009) as they are already facing extensive human disturbances in their forests, such as excessive fuel wood extraction, illegal logging overgrazing, and collection of NTFPs (non-timber forest products) (Singh *et al.,* 2011; Hegde and Enters 2000; Pattanayak *et al*., 2003). Moreover, FAO (2005) warns that climate change impacts will tend to increase in arid lands due to increased water stress in developing

countries where irrigation facilities are poor. Countries like Nepal are highly vulnerable to climate change impacts (GoN, 2010) caused by a number of factors: higher rate of temperature increase compared to the global average (Shrestha *et al*.,1999); the exposure to many types of climatic conditions; a high dependency on natural resources; fragile topographies; inadequate human resources; and poor economy (Gurung and Bhandari, 2008).

Nepal's climate rose in maximum temperature at an annual rate between 0.04°C and 0.08°C for the period of 1977 to 1994 (ADB, 2009). Average temperature is predicted to rise by 0.5°C to 2.0°C by 2030 (NCVST, 2009). The average annual rainfall is decreasing at the rate of 1.86 mm per year. The level of winter rainfall is expected to decrease, while summer rainfall will increase. Therefore, the drying of water sources is projected to become one of the most pressing environmental problems because of long dry seasons and irregular rains which lead to drinking water scarcity. Furthermore, extreme weather events such as heat waves and very high rainfall are likely to become more frequent. Overall, Nepal is likely to become wetter in the east and experiencing more rain than the west (Practical Action, 2009).

The continued rise in temperature and erratic rainfalls have significant impacts on agriculture production and livelihood of agrarian communities, especially for subsistence farmers. It is not yet clear how the changing climate will affect agrarian and forest-dependent communities in Nepal. Recent studies have identified trends of change in temperature and rainfall, and forecasting climate change based on the available hydro-meteorological data and regional and global circulation models (Shrestha and Sada, 2013). These studies have contributed to understanding the biophysical processes and impacts of climate change globally and regionally. However, climate change projections have been unable to capture the local-level impacts of climate change (IPCC, 2007).

A Nepali Climate Vulnerability Study Team (NVCST) in 2009 found that global circulation models do not properly represented the topographic features of Nepal (Sada *et al.*, 2014). Most of the climatic data analysis has been concentrated at the national level and generalized to represent the entire country. Given the extensive variation in topography and microclimate, there is a need for site-specific climatic data analysis to understand the climatic variation in the local context. It is also not clear how climate change is perceived by local communities. The body of scientific research is not well available to or understood by the general population. While climate

change is global, its impacts are felt locally. Therefore, the responses to climate changes must be made locally.

Meteorological information is rarely available at the community level in developing countries, and the local people rely on their own observation and subjective interpretation (Devkota, 2014).These interpretations are based on longstanding experience and familiarity with the seasonal patterns of rainfall and a set of local climate indicators that constitute the climate perception (Dahal, 2005, Thomas *et al.,* 2007). Local perceptions of climate change and its causes should not be overlooked, since people frequently act on their perceptions, change their behavior and develop strategies to cope with changes based on their dynamic and evolving knowledge, whether or not it is consistent with meteorological data (Speranza, 2010).

These adaptive strategies, based on traditional knowledge, historical experience and observation, are of short term (Sperling *et al.,* 2003; Bangura *et al.,* 2012; Simatele *et al.,* 2012). However, changing patterns of climate variability can show significant deviations from historical experience, causing the effectiveness of these strategies to be reduced significantly. Therefore, tailored information is required to anticipate future changes at the local level but, in general, such information is not available or accessible to those who need it most. Regardless of all these limitations, local people often demonstrate useful coping strategies (IPCC, 2007). Building adaptive capacity and identifying adaptations are essential approaches to develop future resilience to climate-induced change in local communities. In order to implement these approaches effectively there is a need for rigorous study on the potential socio-economic effects of climate change. Unfortunately, the understanding of climate change at the local level is seriously constrained by the lack of studies and published literature. Figure 1 illustrates the relationship between perceptions of climate change and its impacts in different sectors like agriculture, water sources, forestry and economy. This has led to some of the adaptation strategies in the local community.

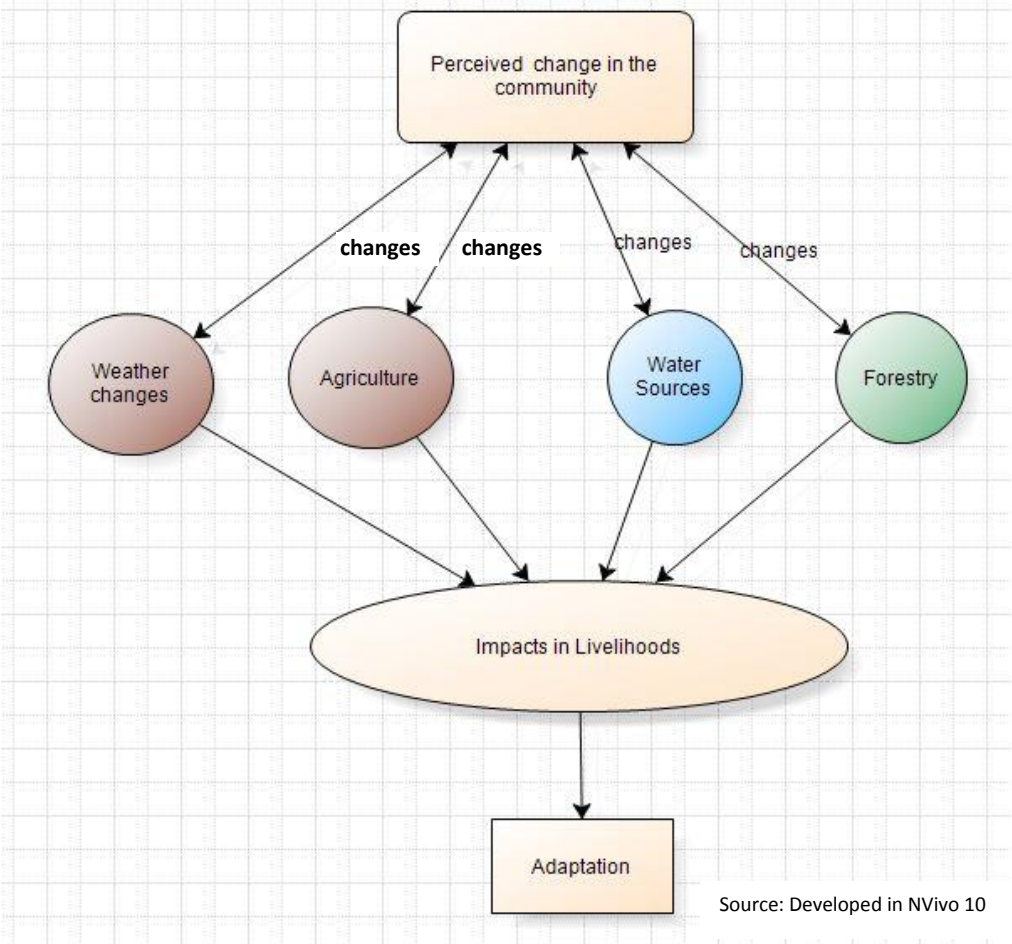


Figure 1: Conceptual model of climate change, its impacts on livelihoods.

This study endeavors to better understand climate change impacts in the study area of the Padampokhari Village Development Committee (VDC) of Nepal. The study is intended to describe patterns in climate change through meteorological data analysis, community perception of climate change and its causes at the local level, impacts to livelihood practices, and adaptation responses to sustain livelihoods.

2. OBJECTIVES

The main objective of this research is to explore the local knowledge of climate change, its impacts, and the responses at the community level to deal with the changes on the basis of their experience and perceptions. This research was conducted on the communities living on the Padampokhari buffer zone of the Parsa Wildlife Reserve. More specifically, this research seeks to:

- Assess the awareness of climate change by the rural populations in the Buffer Zone
- Compare the perceptions of changes in rainfall and temperature with the data collected from Department of Hydrology and Meteorology (DHM)
- Identify the impacts of climate change on livelihoods
- Identify the current adaptation practices in the community
- Explore the implications of my findings for efforts to mitigate and adapt to climate change in the study area in particular, and for climate change adaptation in general

3. BACKGROUND

3.1 Country background: Nepal is a country of 26.4 million people in an area of 147,181 square kilometers (CBS, 2012). Nepal is located on some of the most complex terrain in the world. It shares a border with China in the north and with India in the east, west and south. The elevation of the country ranges from 60 meters above sea level to the highest peak on Earth – Mt. Everest at 8848 meters. The climatic conditions of Nepal range from sub-tropical to arctic (HMG/MoFSC, 2003). Mountains, starting from the high Himalayas in the north to the small Churia mountain range in the south, cover about 77% of the country. About 23% of the land in the south bordering India consists of plains, locally called the Terai. Because of the fertile Ganges River plain and relatively developed infrastructure compared to the mountainous region, the Terai supports about 48.5% of the total population. Of the remaining population, 44.2% live in the hills and 7.3% in the mountains (HMG/NPC/CBS/UNFPA, 2002).

Nepal is largely a rural country. Nearly 81% of the population depends on subsistence agriculture and natural resources for its livelihood. This rural population is highly dependent on forest resources for meeting basic needs including firewood (for cooking and heating), timber for construction and furniture, and fodder for cattle. Forest resources significantly contribute to the economic and social development of the country. The forest also supplies 42% of digestible nutrients for cattle (HMG/MOPE, 2000). Nearly 40% of the population lives below the poverty line with more than half making less than US$1/day.

In addition to poverty, the country suffers from deep social and cultural divisions based on ethnicity, caste, gender and rural-urban disparities. In the past, when the size of the

population was small compared to the vast area of forest, deforestation only marginally impacted the economy and the environment. However, rapid population growth has increased the pressure on forest resources, such as for the expansion of agriculture. In the past two decades, forest cover in Nepal has decreased from 35% to 29% of the total land area. Deforestation in the Central Development Region of Nepal continues today, particularly in areas outside national parks and wildlife reserves (Bhattarai and Khanal, 2005).

Figure 2: Location of Nepal in the World map

3.1.1 Ethnic groups of Nepal: According to the census of 2012, there were about 125 ethnic groups in Nepal (CBS, 2012). These ethnic groups have different cultures and spoken languages that have created distinct patterns over time. The distribution of different ethnic groups reflects the geographical diversity of the country. The majority of people are of Indo-Aryan origin, the remaining are of Tibetan and Bhotia, inhabitants of northern Nepal and Mongoloid inhabitants of the central belt (www.visitnepal.com).

There are three major zones of ethnic groups that are divided according to geographical location, shown in Figure 3. The first major group is comprised of those who live in temperate (middle hill or Churia and valley) zone. The major ethnic groups are Thakalis

(originated from central region and Muktinath area), Newars (mainly from Kathmandu valley), Gurungs (western part), Tamangs and Magar (central and western part). In the Tibetan language Tamang means horse traders. It is believed that they originally came from Tibet. The majority of Tamangs live in the hills surrounding Kathmandu Valley. Their social practices and customs are based on Buddhism and they have their own language. They work mainly as farmers, laborers and porters. The second major group consists of communities occupying the alpine hills from the west to the east, mostly dominated by the Sherpas from Solu Khumbu region of glacial valley near Everest, Dolpa people from west of Kaligandaki, and Manang Bas from Manang. The third group lies in the subtropical zone, inhabiting the more fertile low hills, river valley and Terai plains (www.visitnepal.com).

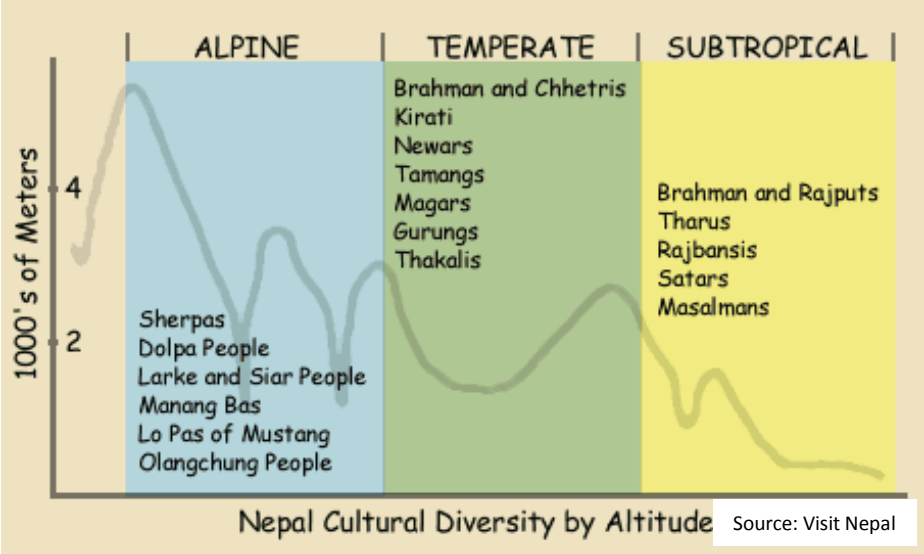


Figure 3: Ethnic groups based on geographical location

3.1.2 Climatic conditions /monsoons in Nepal: The country has a subtropical monsoon climate. The orientation of the mountains and deep valleys is responsible for a number of micro-climate regions that are found in the short distance from south to north. The Terai plains are subtropical, whereas the mid hills are warm and temperate. The mountains between 3000m and 4000m are alpine and those above 4000m have an arctic climate.

Nepal's climate is greatly affected by the Himalaya mountain range. The southern part of the country is hot and experiences high temperatures, which decline as one moves north and

gains altitude. As well as with changes in altitude, average temperatures vary among the different ecological regions. Overall, the maximum average temperature is increasing, particularly during the months of January to April (MOPE, 2004).

Rainfall in Nepal is greatly influenced by the South Asian Monsoon System. The highly varied topography over a short distance causes the rainfall patterns to be inherently complex. In general, there are four seasons: the monsoon, which is a wet season between June and September; the post–monsoon period with little rainfall between October and November; the cool, dry winter season between December and February with occasional snowfall in the high mountain and the Himalaya regions; and the hot, dry pre-monsoon season between March and May (NCVST, 2009). In the pre-monsoon season, moderate to strong winds prevail throughout Nepal. Scattered rainfall occurs during this period and there is a marked decrease in temperature of about 2-3ºC in the month of March. Atmospheric instability during this period weakens the sub-tropical westerly jet–stream flow over Nepal. As summer approaches, there is less mixing of air and haze predominates from the south to the hill regions of Nepal.

The summer monsoon is the most important season in Nepal for agriculture when between 60 and 90 percent of annual rainfall occurs from June to September (Practical Action, 2009). During the summer monsoon, the easterly flow of the jet stream influences the upper level of the atmosphere and the sub-tropical jet stream shifts to the north side of the Tibetan plateau, around an anticyclone called the Tibetan high which is produced by the thermal effect of this heat source. At the surface, an elongated zone of low pressure develops along the Indo-Gangetic plains of North India. This area of low pressure is known as the monsoon trough, which advances northward in the summer monsoon months and retreats southward in the post-monsoon period. Therefore, the onset and withdrawal of monsoons are associated with northward and southward movement of the equatorial trough. Generally, a sub-tropical depression forms in the Bay of Bengal twice per month during the summer monsoon season.

The post-monsoon season is the harvest time of rice. Strictly speaking, this is the transitional period from one season to another. At this time the subtropical westerly jet stream retreats from the northern side of the Tibetan plateau to the southern side of the Nepalese Himalayas.

In the winter season, the lower troposphere wind blows mostly from the west-northwest in the western part of Nepal and east-northeast in the eastern part of Nepal. These are continental, dry winds and bring a settled, dry period to Nepal. The southern part receives more rainfall than the north with the heaviest rainfall in the hills. The Himalayas act as a barrier for monsoon and the rain shadow effect is obvious in the Trans-Himalayan region. The mean annual rainfall across the country ranges from 250 to 4500mm, with more than 80% of the total rainfall occurring during the monsoon period. These rainfall events can be extremely intense, many of which flow quickly through watersheds and cause flash floods.

3.2 Livelihoods: Chambers and Conway (1992) defines livelihood as comprising the capabilities, assets (including both material and social resources) and activities required for a means of living. A livelihood is sustainable when it can cope with and recover from stresses and shocks and maintain or enhance its capabilities and assets both now and in the future, while not undermining the natural resource base. The importance of capturing multidimensionality is also evident in DFID (2000), framing of sustainable livelihoods, which posits that people's livelihoods will improve if they have: an access to basic rights established through quality education, information, supportive cohesive social environment, access to better management of natural resources and a better access to basic and facilitating infrastructure financial resources. Furthermore, the sustainable livelihood emphasizes the varying access of each household to a bundle of capitals or assets as a determinant of livelihoods success (Aalst *et al.,* 2008). These assets can be categorized in human, natural, physical, financial, social and financial capital. They are explained as below as described by Dulal *et al.,* (2010).

- *Human capital* refers to the level of education and productive skills of people. It enhances human capabilities in the sense that higher levels of education improve available livelihood options and adaptive capacity.
- *Natural capital* refers to natural resources such as water, soil, air, forest, biodiversity and environmental services, like hydrological cycle and the services used for livelihoods.
- *Physical capital* is needed to engage in effective productivity. It includes the assets such as land, infrastructure, livestock and equipment used in production.

- *Social capital* is linked to human capital and emphasizes the relationship and network between individuals and groups.
- *Financial capital* plays an important role in determining livelihood opportunities and strategies. It is the biding factor that pulls the other capital assets together in creating livelihoods.

3.2.1 Agriculture: Agriculture is the backbone of the economy of Nepal. It plays a vital role in livelihoods, employment, industrial development and international trade. More than 80 percent of the population depends directly on agriculture. Traditional and subsistence farming are predominant. Unfortunately about 60% of farmers cannot meet their food needs; an average household's production may suffice for only 3 to 8 months of the year. The agricultural sector has many challenges. First, over half of all households work less than 0.5 hectares of land to support each family of an average six members. Second, agriculture largely is practiced at the subsistence level. Third, limited crops are the source of food security. Cereal crops paddy (*Oryza sativa*), wheat (*Triticum aestivum*), maize (*Zea mays*), millet (*Eleusine coracana*), and to a lesser extent buckwheat species (*Hordeum vulgare, Fagopyrum esculentum*) are the mainstay of Nepal's agriculture. Millet is a relatively minor cereal. Maize is planted in April and harvested in August whereas Millet is planted as a rotational crop with maize. Rice is planted with the onset of the monsoon in mid-June.

Agriculture is very sensitive to climate fluctuations (FAO, 2008). Temperature, humidity, solar radiation and rainfall are important climatic factors for crops. The sowing time of crops usually coincides with the advent of rainfall. Delayed or below–average rainfall, extended droughts, and the shortening of the maturation period can adversely impact production. Permanent changes in these factors can cause crops to fail and agricultural production to fall. Crop failures also bring famine. Whether it brings increasing floods and storms or drought, climate change wreaks havoc for poor farmers, jeopardizing their livelihoods and threatening their food security. With increases in population and food demand, even a slight decline in annual food production is a matter of great concern in Nepal. The agricultural sector is adversely affected as well by the loss of fertile topsoil on account of soil erosion, landslides and floods. Soil loss is a major cause of decline in agricultural production. Climate change may exacerbate this situation.

3.2.2 Community forest: In rural areas, community forests are the major source of fire wood, fodder, timber and non-timber forest products (NTFPs) in the community. Two categories of forests exist, which are based on ownership: private forests and national forests. National forests have five categories: government managed forests, protected forests, community forests, religious forests and leasehold forests. Community forests allow for the "control, protection and management of local forest by local communities known as user groups" (Bhattarai and Khanal, 2005). The community forest programe is identified for its active role in raising awareness on issued of forest conservation (Yates, 2012).The main objective of the community forestry is to achieve sustainable use of forest resources by converting accessible national forests into community forests in stages.

Community forests aim to ensure equitable access to forest products without over-exploiting the forest resources. A community forest is a portion of national forest that is handed over to a group of user households for control, proper management and sustainable use for the group benefit. Local villagers can either use the products of community forests or sell them without damaging the forests. Community forests succeed because it is recognized that poverty and environmental issues must be addressed simultaneously to achieve progress in the community. Community forests provide sources for subsistence and economic products but also are important for the protection of watersheds, the control of erosion, the conservation of wildlife habitat and biodiversity and the uptake of carbon dioxide. Community forests devolve forest management and the allocation of use rights to local populations.

Access to forests is important because they are central to farming systems, as more than 83 percent of Nepal's population of 26.4 million is dependent on agriculture (CBS, 2012). Fuel wood supplies over 75 percent of the country's energy requirements. Moreover, forests play a critical role in the ecological cycle of cropping patterns, animal husbandry, and forest products that sustain agricultural production. That is why the forest is decreasing at alarming rates. Considering the rapid rate of deforestation, the government of Nepal has implemented many forest programs since 1978. The Community Forestry and Afforestation Division (CFAD) was created in 1979. Now named the Community Forest Program, it has received the highest priority in the forestry sector. Community forests have evolved as one of the major components of Nepal's forest development strategy during the past 25 years. At the

same time, many forest conditions have improved and previously degraded forest near villages and settlements have been restored. The Community Forest Program in Nepal is often cited as a successful model for promoting the environmental well being and livelihoods of local populations in South Asia.

Community forests comprise the most focused area of forest management in Nepal, especially in the hill districts. These management brought positive changes in the local environment and forest production (Pandit and Bevilacqua, 2011). The Community Forest User Group (CFUG) is entitled to develop, conserve, use, and manage the forest, sell and distribute NTFPs and even independently fix product prices. The NTFPs are the medicinal and aromatic plants, lokta paper, resins, seeds and bamboos that are high value products in the market. The income derived from the sale of NTFPs goes to the Forest User Group's fund. Nepal's master plan for the forestry sector was adopted in 1988. The revised forestry sector policy of 2000 has attempted to define accessibility to forests and their products based on collectively recognized traditional user rights. But this has excluded some traditional uses, especially by distant and seasonal users. Overall, the sustainable use of forest resources has become a great concern for socio-economic development as well as the ecological balance of the region (Bk, n.d)

3.2.3 Economy/ Migration: According to a 2008 World Bank study (World Bank, 2008), the share of remittances from abroad was 16% of Nepal's GDP; this soared to 28.8% in 2013. Nepal was also the 5th highest recipient of remittances globally, as a percentage of its GDP, at 23% in 2011 (CBS, 2012) and had the highest in South Asia. These figures illustrate the important contribution that migrant workers make to the economy of Nepal, at a level much higher than foreign aid, which is estimated to amount to less than a quarter of remittances. An average Nepali household receives almost twice as much income from remittances as from agriculture. A high level of unemployment, in combination with the decade-long Maoist insurgency, has caused widespread migration of mainly Nepalese youth to labor markets in the Gulf States, Malaysia and South Korea, in addition to the traditional destinations of Indian cities (NCVST, 2009). Some studies suggest that 1.3 million Nepalese are registered as migrant workers, while another 1 million may be unregistered. The flow of remittances has been a driver for service demand (Sharma, 2008). Migration is a major

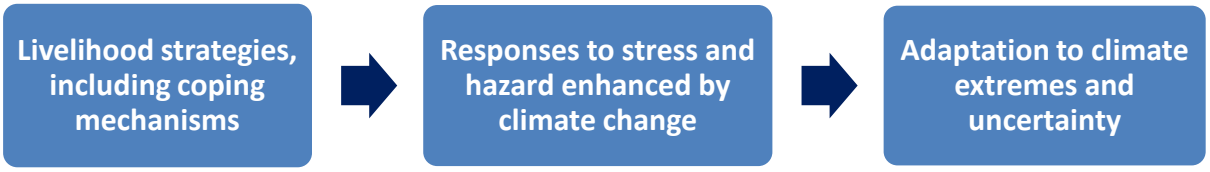
source of access to jobs with remittances forming a substantial part of an economic base. This transformation has in turn affected the farming system and reduced its resilience to climate change. The migration abroad of much of the youth has principally left the elderly and children to populate villages. A less robust population has left villages more vulnerable to climate change. On the other hand, migration, whether seasonal or long-term, is a key strategy of adaptation for many households. Out-migration can reduce the risk and in the short term can contribute to financial resilience through remittances. It also alters community relationships and local resource management dynamics. However, long-term such a strategy can debilitate the social and economic health of the country as domestic skill and expertise declines. While increased income from remittances can fuel an increase in consumer spending, such contributions also make the national economy more dependent on a fragile and consumerist remittance economy.

Migration can be a coping mechanism and survival strategy among poor communities. Migrant workers help the development and adaptation of their families and communities in face of climate and environment changes. Such migration can have positive effects on both the local coping capacity and the environment in areas from which these migrants originate, as well as in their temporary or permanent destinations. It can also be an adaptation strategy to climate and environmental change and is an essential component of the socio-environmental interactions that needs to be managed.

3.3 Adaptation: Adaptation to climate change is a complex, multidimensional, and multi–scale process (Bryant *et al.,* 2000; Bryan and Behrman, 2013: Tiwari *et al.,* 2014). According to IPCC (IPCC, 2007), the term "adaptation" refers to "the adjustments in natural and anthropogenic systems in response to actual and expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities." The concept of adaptive management recognizes that humans are not passive recipients of adverse environmental changes, but can exercise ingenuity and creativity in minimizing the negative impacts of climate change and can exploit them to their own benefit. Building adaptive capacity means incorporating climate change into community development, improving the availability of appropriate information and skills, and building effective institutions to access technology and to develop opportunities to raise incomes. Adaptation is about the capacity to shift

strategies and develop resilient systems that are sufficiently flexible to enable vulnerable communities to respond to change. It is thus not merely about coping or surviving, but about doing well in a specific context. Coping is reactive in nature and is about acting in response to observed climate impacts. Traditional coping systems are backward looking and based on historical experience and observation (Sperling *et al.*, 2003).

Moving from coping to adapting requires the right enabling conditions to foster responses that can take root and develop sustainably and constructively (Figure 4: Klatzel *et al.*, 2009). As for an example a stress can trigger adaptation or represent a window of opportunity to implement new strategies.



Source: Klatzel *et al.* (2009)

Figure 4: The shift from coping to the adaptation

Adaptation responses have been classified by various means: the spatial scale at which they occur (such as from top–down, state–led investments in infrastructure to community investments in food storage facilities to changes in individual farming practices); intent (either reactive or proactive); timing with respect to the climate stress; duration (short– or long–term); form/type (for example, technological developments, government programs, behavior change, and insurance); and effect (enhanced stability or resilience) (Bryant *et al.*, 2000; Heltberg *et al.*, 2009; Tiwari *et al.*, 2014). Furthermore, according to Agrawal and Perrin (2008), group adaptation strategies may be analyzed based upon their form or type, including mobility, storage, diversification, communal pooling, and exchange and function with respect to risk. Examples of adaptation decisions that are likely to have positive outcomes include changes in farming practices, livelihood diversification, asset accumulation and diversification, and investments in human and social capital (Parry *et al.*, 2008).

4. METHODS

4.1 Study area

4.1.1 Mid hills: The mid hills are located in an altitude of 200m to 3000m, between the Terai and the high mountains. The population of this region is almost 10 million or 38% of Nepal's populations. The mid hills generally have few roads and poor access to urban centers and their markets. Agriculture remains the primary source of livelihood for more than 90% of mid hill people, mostly on a subsistence basis. Livestock rearing is an integral part of the hill farming system (Winrock, 2002). Communities in the mid hills generally tend to be well established with little in-migration but noticeable out-migration, mostly for job opportunities abroad. Most mid hill forests tend to be managed for fuel wood and fodder. According to the master plan for the forestry sector, about 65% of the mid hill forests have predominantly small-sized timber and only about 30% percent have large-sized timber. They are the major source of fuel wood, fodder, animal bedding, fertilizer, timber, fruits, nuts, mushrooms, honey, vegetables, a wide variety of medicinal and aromatic plants and many more products. Fuel wood from forests remains the major source of household energy (66%) followed by kerosene (13.5%), cow dung cakes (10%) and Liquid Propane Gas (LPG) (7.6%).

The forests in the mid hills are in fair condition. The community forests near the national forest are largely protected, but the national forests are degraded. The community forest operational plans tend to be conservative, but inequitable. This forces people from both user groups and non-user groups to harvest their basic needs from national forest. As a result, national forests continue to degrade while community forests are protected. Despite the restoration of forests through the community forest program, the rate of forest loss outside the community forest in the mid hills is high. In other words, without community forest most of the forest in the regions would likely be similarly degraded (Duwal, 2011). There is a need of urgent forest management practices in order to conserve forest in the mid hill (Rijal and Meilby, 2012)

4.1.2 Parsa Wildlife Reserve: Parsa Wildlife Reserve is a protected area in the inner Terai lowlands of southern central Nepal. According to the Master Plan of Forestry Sector (HMG/N 1998a), the buffer zone forest of Padampokhari VDC and Parsa Wildlife Reserve

(PWR) are classified into Sal (*Shorea robusta*) Forest and Terai mixed hardwood forest, where Sal forest constitutes about 90% of the vegetation. A Sal tree is used for timber, fuel wood, fodder (Gautam, 1990; Sapkota *et al.*, 2009), leaves for plates (Rajan, 1995), seed for oil (Sharma, 1981) and resin or latex from heartwood (FRIB, 1947). Sal is also known to produce edible fruits, compost, fibers, leaves for umbrellas, medicinal plants, thatch, grass

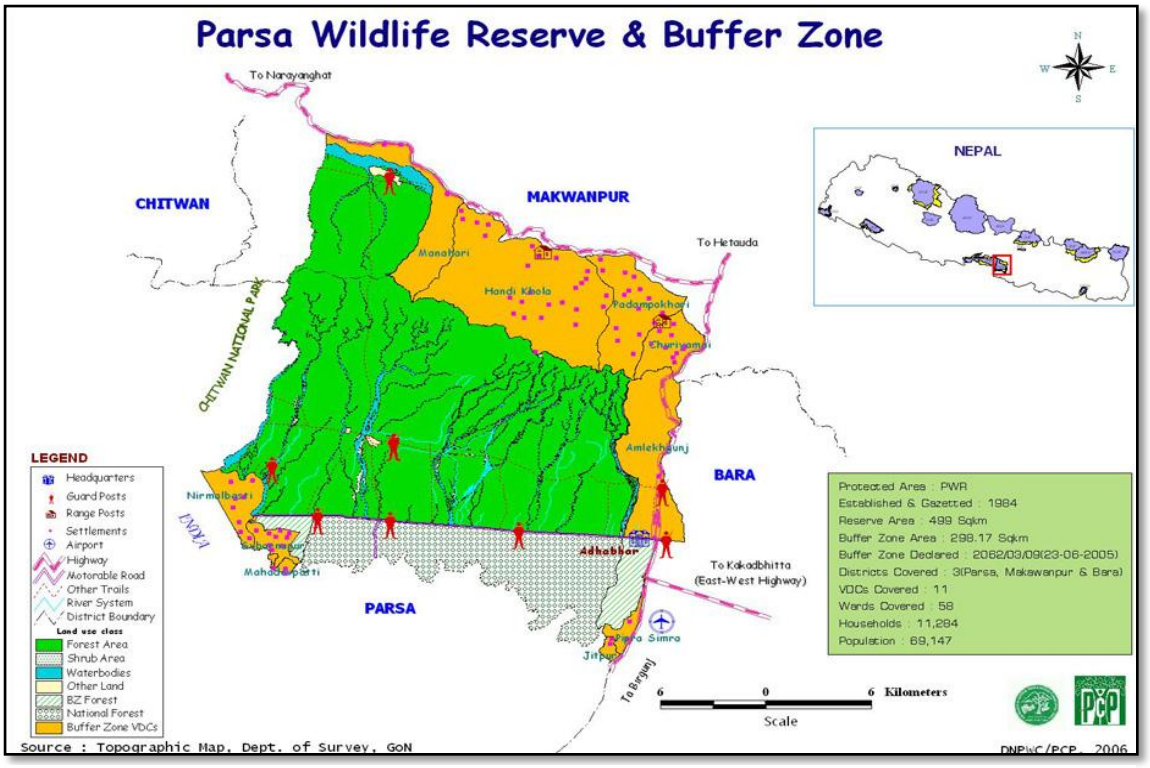


Figure 5: PWR and Buffer Zone

and broom and many other products depending on the species composition (Stainton, 1972).

The reserve is home to a healthy population of resident wild elephant (*Elephas maximus*). It also harbors the tiger (*Panthera tigris*), leopard (*Panthera pardus*), and sloth bear (*M*elursus ursinus) etc. There are nearly 500 species of bird recorded in the reserve. The Giant horn bill, an endangered species, is found here (DNPWC/PCP, 2006).

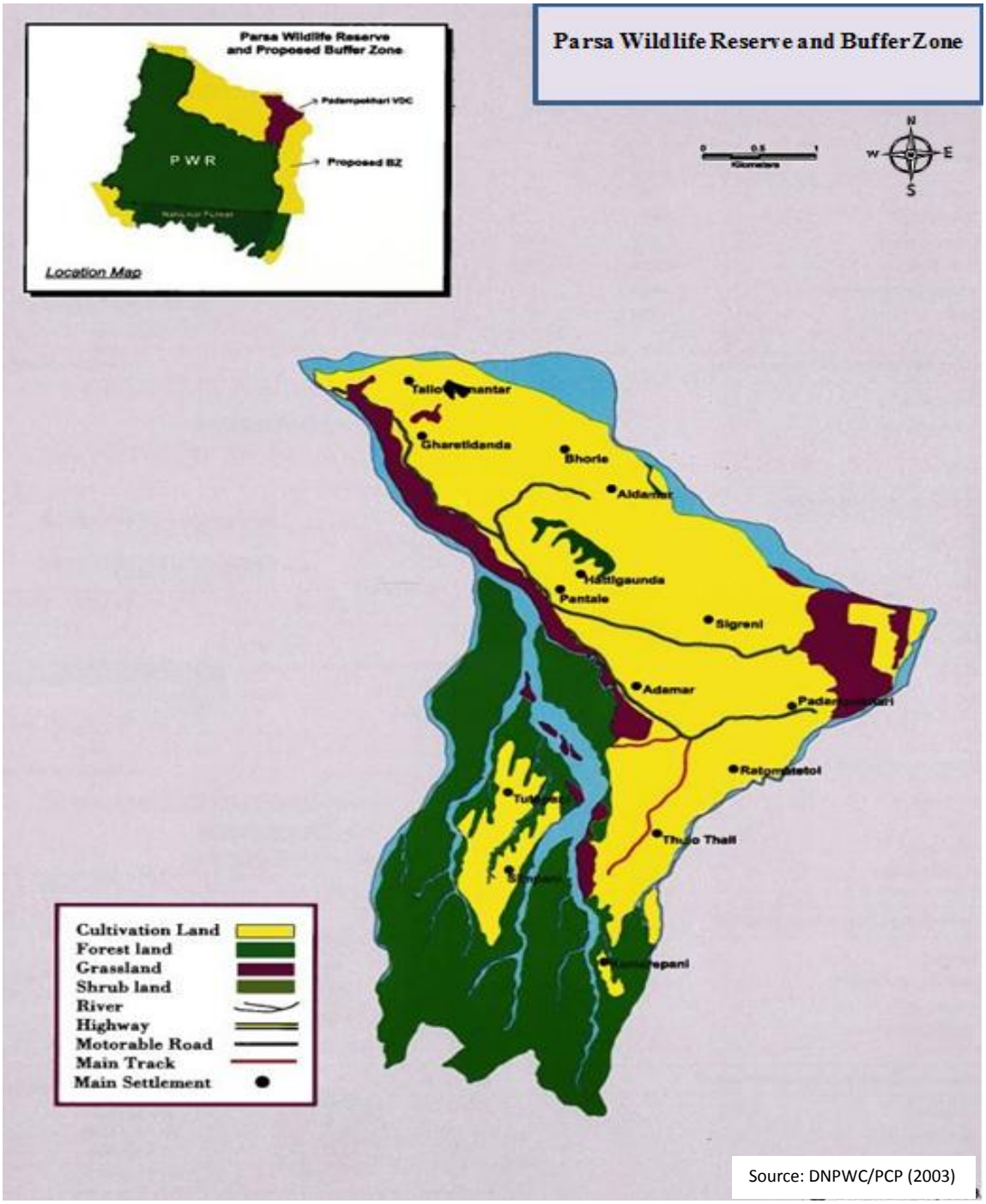


Figure 6: Padampokhari VDC and community's distribution

4.1.3 Padampokhari Buffer Zone VDC: A village development committee (VDC) in Nepal is the lower administrative part of its local development ministry. Each district has several VDC. A VDC is further divided into wards; the number depends on the population of the district: the average is nine wards. The division of the wards can be seen in Figure 6. Padampokhari VDC of

Parsa Wildlife Reserve lies in the northern part of the reserve in Bara district of Central Development region, Nepal. As per the demographic setting, it is bordered by PWR in the South, Churiyamai and Hadikhola VDC in the East and West respectively (Duwal, 2011). The climate is basically the sub-tropical monsoon type. Mostly the area is dominated by the Churia hills, which have an altitude range from 250m to 950m average above sea level. These rugged hills are crisscrossed by numerous gullies and dry stream beds. The soils are primarily composed of gravel and conglomerate and are very susceptible to erosion, resulting in a very fragile ecosystem (DNPWC/ PCP, 2003). Most of the Padampokhari VDC is covered by cultivated land (49.34%), followed by forest land (29.22%), shrub land (12.64%), river flood plains and wetlands (7.78%) and grasslands (1.02%) (DNPWC/PCP, 2006). The community forests are dominated by sal and mixed hardwoods. Sal (*Shorea robusta*) is the dominant species followed by Asna (*Terminalia alata*), Botdheyaro (*Lagerstroemia parviflora*), Chilaune (*Schima wallichii*) and Barro (*Terminalia bellerica*) etc. as the common species (DNPWC/ PCP, 2003).

4.2 Research Approach: The main approach used for data collection for this study was exploratory, where the data was gathered through observing people, actions and situations and exploring individuals' attitudes, preferences or behaviors in relation to the information issues of this research. The research follows both the qualitative and quantitative methods of information collection and analysis.

4.2.1 Site Selection: The study was carried out in the Padampokhari Buffer Zone VDC of PWR Nepal. The site was selected according to the following criteria:

- Transition between Terai and Himalayan regions
- Weather station available for the measurement for rainfall and temperature
- A region very susceptible to climatic disturbance which can be observed
- Previous study on the community forest and people had been conducted

4.2.2 Reconnaissance survey: A week-long initial field trip was carried out. The main objective of that visit was to become familiar with study area specifics such as geographical situation, community dynamics, social structure and other different characteristics of the community. This helped to identify socio-economic and bio-physical conditions of the community. The qualitative

information collected by employing initial participatory tools served as the initial step in identifying the relevant issues, which in turn helped to devise the preliminary questionnaire. This questionnaire was then pre-tested in the study area in a reconnaissance survey; a final questionnaire was then adopted after incorporating the necessary modifications. Similarly, frequent visits to the study area helped to create a comfortable environment with the community members so that they could express their feelings, making it easier to work with local people.

4.2.3 Sampling method: Respondents selected with "ad hoc" and "snowball" sampling techniques were first examined according to caste/ethnicity, economic class, gender, education and social position based on the local document called the "village development profile."

a. Snowball sampling: Snowball sampling technique was used to follow the pattern of phenomena and to understand the relationship of social processes, communal adaptations and information exchange about climate change. This snowballing is appropriate for determining the actor who becomes the source of information if the situation is dependent on other social factors. The selection of respondents with specific or unique characteristics (for example, some specific forest users, some people holding some position in CBOs, NGOs or a person from some specific location or ethnic community) was made by asking previous respondents or by asking population members about people (Bhusal, 2009).

b. Ad hoc sampling: Initial interviewees were selected on an ad hoc basis without considering other criteria. The researcher selected interviewees at random, provided he or she would agree to be interviewed and provide the time for it. Resting places (*Chautaris*), meetings of water user groups, corners of main meeting places, teashops, and fields were used to select people from different backgrounds for interviewing. Most of the respondents were selected in these ways (Bhusal, 2009).

4.2.4 Data collection methods:

a. Transect walk and direct observation: A small number of community members were asked to guide the researcher through the surrounding community, to record important natural features of the study area and the changes observed in their community. Special emphasis was placed on those that represented the livelihood strategies in the community. Photos were taken of all these areas to facilitate in reporting.

b. Focus group interviews: There were 9 focus groups interviews conducted to assess perceptions of climate change and its impacts on livelihoods and the local adaptation strategies, which were based on the 9 different wards in VDC. In the focus groups we hosted discussions about climate change and its consequences in the community. Each focus group consists of an elderly person, a youth, women and a knowledgeable person. A total of 10-25 people participated in each focus group. All responses of community members were recorded in writing and tape recorded. These groups are important in functioning as a platform for the implementation of different participatory research tools. The details questionnaires are attached in Annex III.

- ***Community characteristics:*** A first request in each focus group was to briefly address the communal context. The following statistics were requested: the present population and households, the 5 most cultivated crops, the 5 most widely owned types of livestock, the 5 most important income sources (both agriculture and non-agricultural), and the 5 most popular migration areas.

- ***Historical changes in seasonal calendar:*** This tool was used to show differences in the start and end of the monsoon seasons between two periods. This was asked for the present as well as for the time that community members considered rainfall patterns to be normal. This allowed a more concrete insight into the environmental change processes that have occurred. Subsequently, the timing of livelihood-centered activities was asked, such as planting and harvesting time. This was equally done for the past and present to show possible shift in these activities.

- ***Adaptation strategies:*** This tool aims to identify the coping and adaptation strategies that the community applies to the climate variability. These may include crop diversification, cultivation in different agro-ecological zones, responses to pests in agricultural fields and exchange of resources with other communities.

- ***Communal collective action:*** Community members were asked to identify the tasks they carry out collectively in their community. Moreover, they were asked about the traditional practices that have been used to work collectively. For example, participants were asked: "How can the present communal work be characterized compared to the

practices done in the past? Has it increased or decreased and why?" A copy of the questionnaire and data sheets are included in the Annex I, II and III.

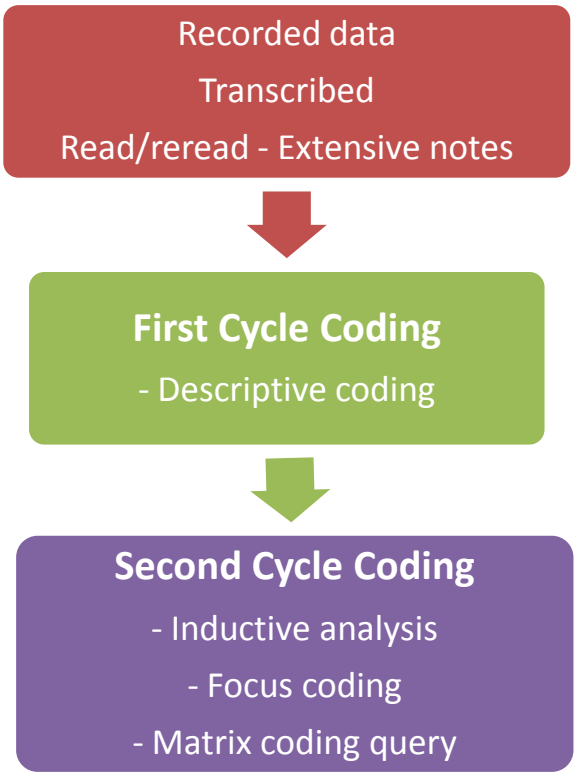
c. Key informant interview: There were 45 key informant interviews, i.e. 5 interviews in each ward were conducted. The respondents were asked open-ended questions about their experiences regarding climate variability, impacts and adapting activities (Annex II). The interviewers sought to encourage free and open responses, so that there may have been a trade-off between comprehensive coverage of topics and in-depth exploration of a more limited set of questions. The interviews also sought to capture respondents' perceptions in their own words, which is a desirable strategy in qualitative data collection (Frechtling *et al*., 1997). Those respondents were selected from each category of people including all gender, ethnicity, education, economic class and geographic location. The detailed characteristics of the VDC inhabitants were collected from the VDC office and Community Forest User Group office. The data was collected in local language (Nepali). Afterward, the data was transcribed to English. The information collected was supplemented by reviewing secondary literature and local published reports.

d. Climatic data: Rainfall and temperature data were collected from Department of Hydrology and Meteorology and analyzed to understand the long-term climate trends. The weather station was selected based on the proximity to the study area. The study site had 30 years of data, which satisfies the meteorological data analysis criteria as defined by the World Meteorological Organization (WMO, 1996). The review of articles and the local papers were also reviewed to supplement and validate the finding.

e. Linear regression analysis: In this study, the linear trend in a variable was investigated at annual and seasonal time scales. IPCC (2007) used this technique for investigating the long-term and short-term trends in observed climatic and hydrological variable. The method is based on fitting a straight line to a set of data.

f. Data management and analysis NVivo 10: The qualitative data was analyzed using NVivo 10, qualitative data analysis software developed by QSR International. It helps to manage data (organizing, keeping track of many records and creating conceptual maps), manage ideas (organizing and providing rapid access to conceptual and theoretical knowledge generated in the course of analysis), query data (asking simple or complex questions on enquiring process),

visualize data (showing the content, cases, ideas, concepts, timeline etc. at the various stages of interpretive process) and report data (knowledge developed from the data).



Source: Nvivo10

Figure 7: Conceptual flow chart on analysis of qualitative data

Audio recordings were collected in the field for both the focus groups and the key informant interviews; these were then translated into English and the transcripts were reaffirmed. Extensive analytical notes were written. The data were read and re-read prior to first cycle coding. Coding is a qualitative enquiry that builds knowledge about data with annotating and memoing (Saldana, 2009; Bazeley and Jackson, 2013). In the first cycle of coding, descriptive coding was done on the entire texts (Saldana, 2009). Descriptive coding was chosen to acquire detailed inventory of the data (Asah, 2010). These codes were prepared for the thematic analysis, which helped to categorize and analyze the data based on inventory. Then the process moved to the second cycle of coding. An inductive analytic technique was used. This approach was used because I wanted to import concepts during analysis rather than predefined hypothesis (Saldana, 2009). This will help to prioritize and classify the data, and integrate, synthesize and abstract from the data. In

order to stay consistent, an extensive memo was written in every theme. In the second cycle of coding, focused coding was used (Saldana, 2009). It helps to segregate group, regroup and relink texts to the first cycle. Then matrix coding query was done. Matrix coding query is a type of coding in Nvivo10 that assists the search for data meeting the criteria in the rows and columns of the query as needed. This helped to link the coded data with the demographic data. It also helped to filter the queries, a model which will be explored further. A thematic analysis of the data supported by the framework approach was used for the analysis. The framework was then applied to the transcripts which were indexed by theme and sub-theme using NVivo10. Matrix coding is the theory of building queries, where pairs of nodes are cross-tabulated and displayed as a matrix. It is often used to compare subgroups in a database. After that, a node that frequently appeared which is relevant to the research question might be selected, or it could be a focal point in the research. The whole process is shown in the flow chart in figure 7.

5. RESULTS

5.1 Demographic composition of the study area:

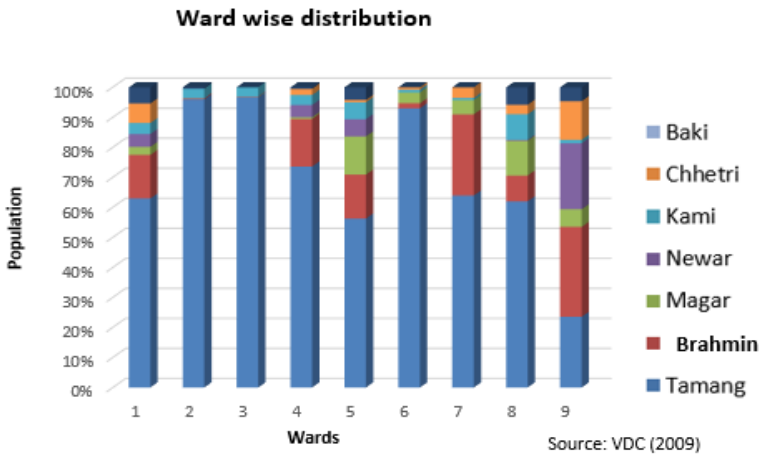


Figure 8: Ethnic composition in the communities

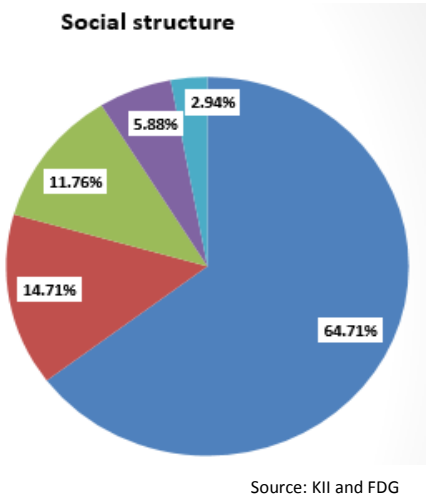


Figure 9: Ethnic compositions among the interviewees

Different ethnic groups of people reside in the study site; Brahmin, Tamang, Newar, Ghale, Chhetri, Gurung and Magar. Six communities are multi-caste while others are dominated with single caste, predominantly Tamangs. However, in ward 9 the community is more diverse than other communities as in Figure 8. In Figure 9, the pie chart describes the ethnic composition of those interviewed through this study. Most of them are Tamang, Rai, Brahmin and Baki in the

whole community as in the ward-wise composition in the community (Figure 8), where I conducted this study.

There are ten different community forests in the study area upon which people are dependent for their livelihood. About 66.9% of the populations are members of the community forest user groups, while the others are non-members, as described in Table 1. About 70.6% of people have access to drinking water while others collect their water supplies from the river, traditional stone spouts, or wells. Even though the male-female composition in the study is around 50% each, most families have males as the heads of the family as in Figure 10.

Table1. Community characteristics

Characteristics	**Ward 1**	**Ward 2**	**Ward 3**	**Ward 4**	**Ward 5**	**Ward 6**	**Ward 7**	**Ward 8**	**Ward 9**	**Total**
Household	1003	158	229	460	519	269	289	394	205	**3526**
Total Population	5350	862	1258	2551	2903	1403	1698	2297	1248	19570
Male	2673	466	663	1274	1452	712	847	1150	644	9881
Female	2677	396	595	1277	1451	691	851	1147	604	9689
CF* Dependency	3	1	1	1	2	1	1	2	2	
Caste Diversity	Multi-caste	single-caste	single-caste	Multi-caste	Multi-caste	single-caste	Multi-caste	Multi-caste	Multi-caste	
Social cohesion	strong	strong	strong	weak	weak	weak	strong	strong	strong	
Access to water sources Household	868	100	108	445	497	250	200	322	102	

*Community Forest

Source: VDC (2009)

Table 2. Community forests in the communities

	Community Forest	Area of CF (hectare)	Nature of Household
1	Situ	428.04	557
2	Gupteswori	209.5	468
3	Paribartan	206.5	301
4	Pragatishil	185	375
5	Bhorle	136.4	125
6	Janapriya	125.17	218
7	Kamleswori	106.2	144
8	Rapti	59.7	65
9	Amar	55	72
10	Janakalyan	10	34
	Total	1521.51	**2359**

Source: VDC (2009)

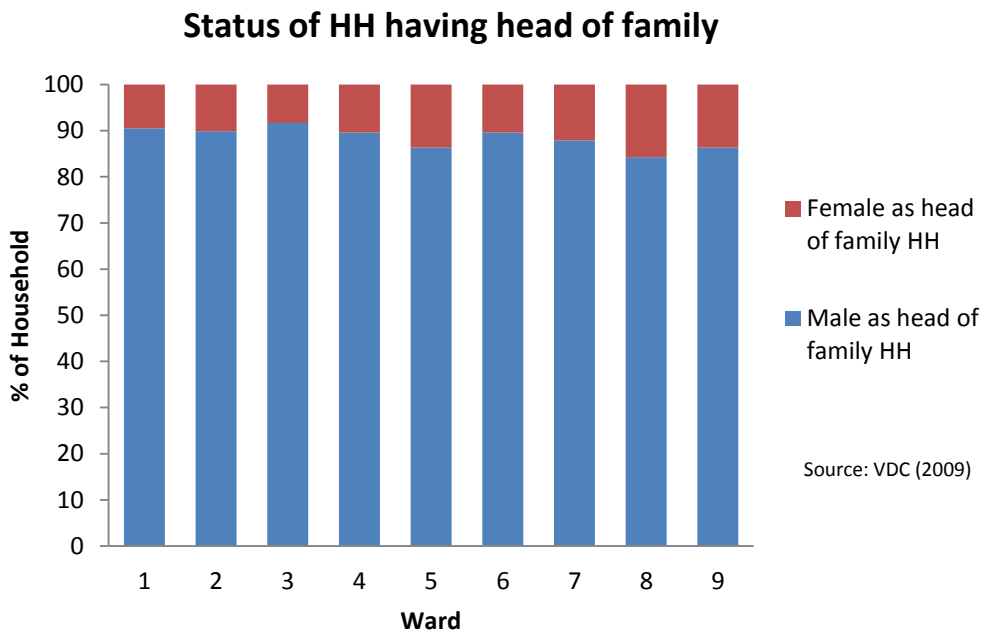


Figure 10: Gender of Household heads

5.2 Trends and variability in important climatic variables:

5.2.1 Temperature: Temperature is one of the most important variables of the climate. The annual mean temperature of Padampokhari VDC shows an increasing trend as seen in Figure 11. The annual mean temperature for this period was found 23.74°C. However, the highest and lowest of annual mean temperature in the study area were respectively 24°C in 1996 and 2010, and 21.8°C in 1984. The trend of mean temperature rise was positive and slow up to the year 1996. After that, it started fluctuating up to 2002. There was a sharp increase of temperature up to 2010. The annual temperature rise was 0.033°C/year and correlated with r square value of 0.2624.

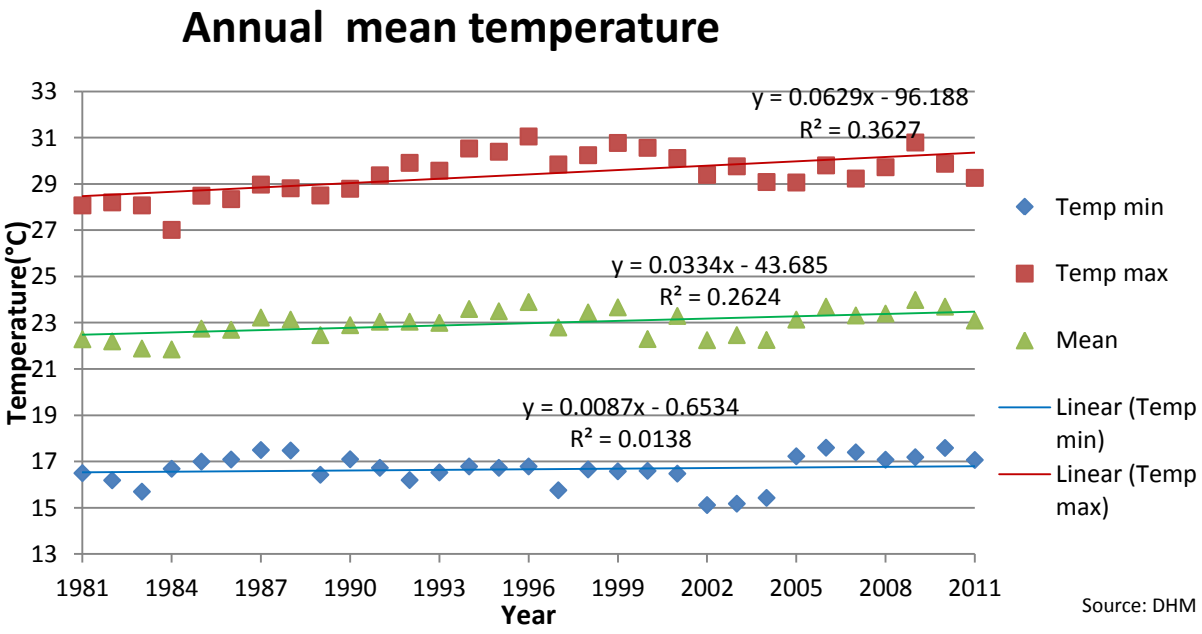


Figure 11: Annual mean temperature from 1981 to 2011

Figure 11 also shows the trends of maximum and minimum temperature of the study area. It shows that the maximum temperature rose slowly until 1990. After 1990, most temperatures were in the range of 29ºC -30ºC. It is noted that the mean maximum temperature was 30.8 ºC for the period from 1981 to 2011, with the highest value of 31 ºC in the year 1996 and 2010 and the lowest value of 27.8 ºC in the year 1984. The annual mean maximum and minimum temperature rises were 0.006ºC/year and 0.008ºC/year in between 1981 and 2011 as in Figure 11. The trend of mean minimum temperature rise is slow compared to the

maximum temperature rise. The maximum temperature rise is more correlated to annual mean temperature and minimum temperature with r square value of 0.36.

5.2.2 Rainfall: Rainfall records for the area showed no significant trends with low R value as in Figure 12. The mean annual rainfall was erratic but did not decrease during the overall annual rainfall from 1981 to 2011. The rainfall in Nepal is dominated by monsoon rainfall that extends from June to September. The general trend of the rainfall data showed that there is increase in annual rate by 0.9 mm/year (Figure 12). The pre-monsoon (March-May) trend also shows in the fluctuating pattern, although there was an increasing trend by 0.72mm annually from 1981 to 2011 (Figure 13).

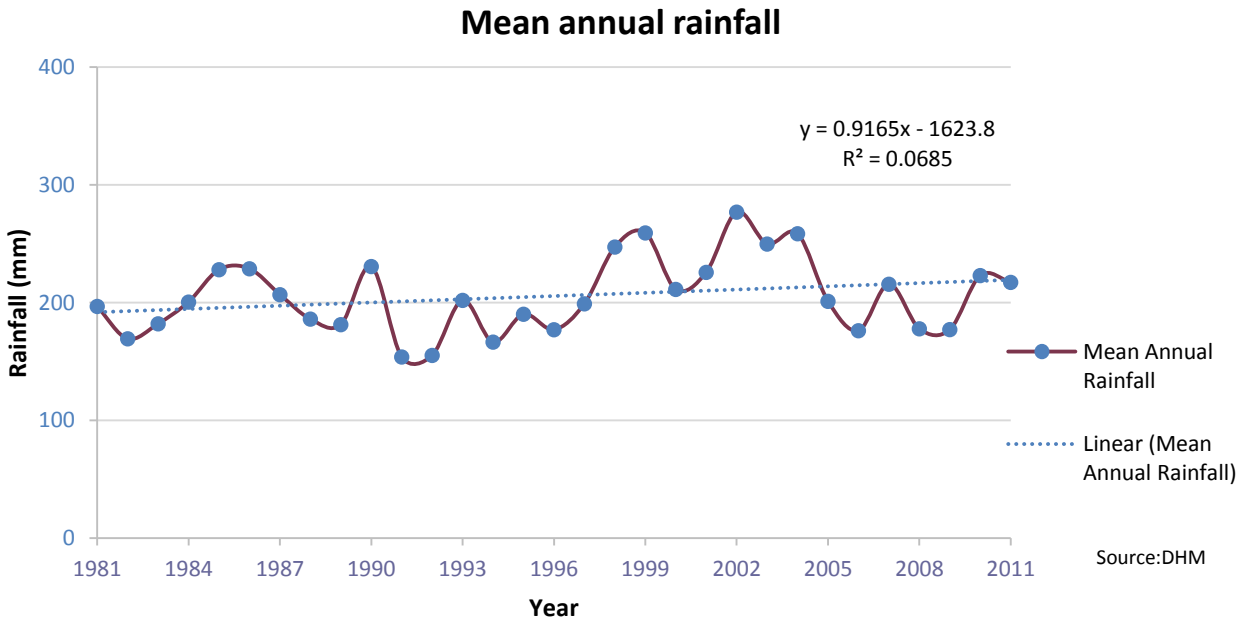


Figure 12: Annual rainfall trends from 1981 to 2011

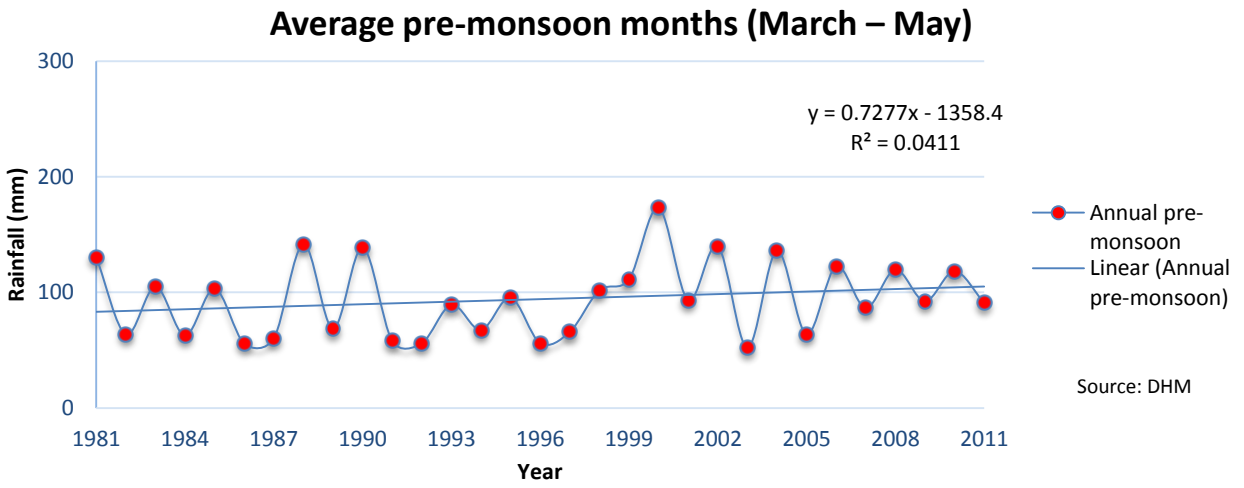


Figure 13: Annual pre-monsoon rainfall from 1981 to 2011

The monsoon rainfall is very important for agriculture. The cropping time depends on the date of onset and cessation of monsoon, because the maximum rainfall occurs in the monsoon season and this amount supposedly represents the major portion of annual mean rainfall. Although the general trend of monsoon rainfall is increasing by 2.4mm/year, it is not correlated as in Figure 14 with the r square value of 0.0741.

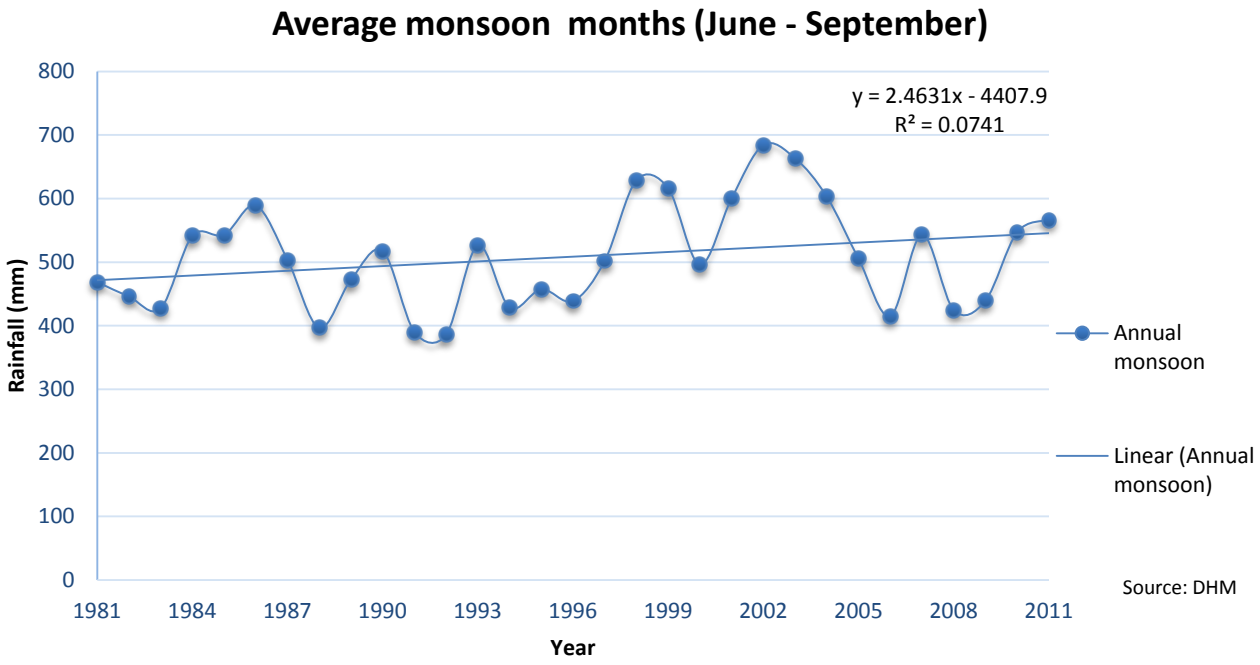


Figure 14: Monsoon trends from 1981 to 2011

There is a clear decreasing trend of post-monsoon (October – February) rainfall with an annual decrease by 0.2 mm from 1981 to 2011 (Figure15). This is also not correlated with R value of 0.0013. This is a major change in the rainfall pattern, which impacts the cropping time of several crops.

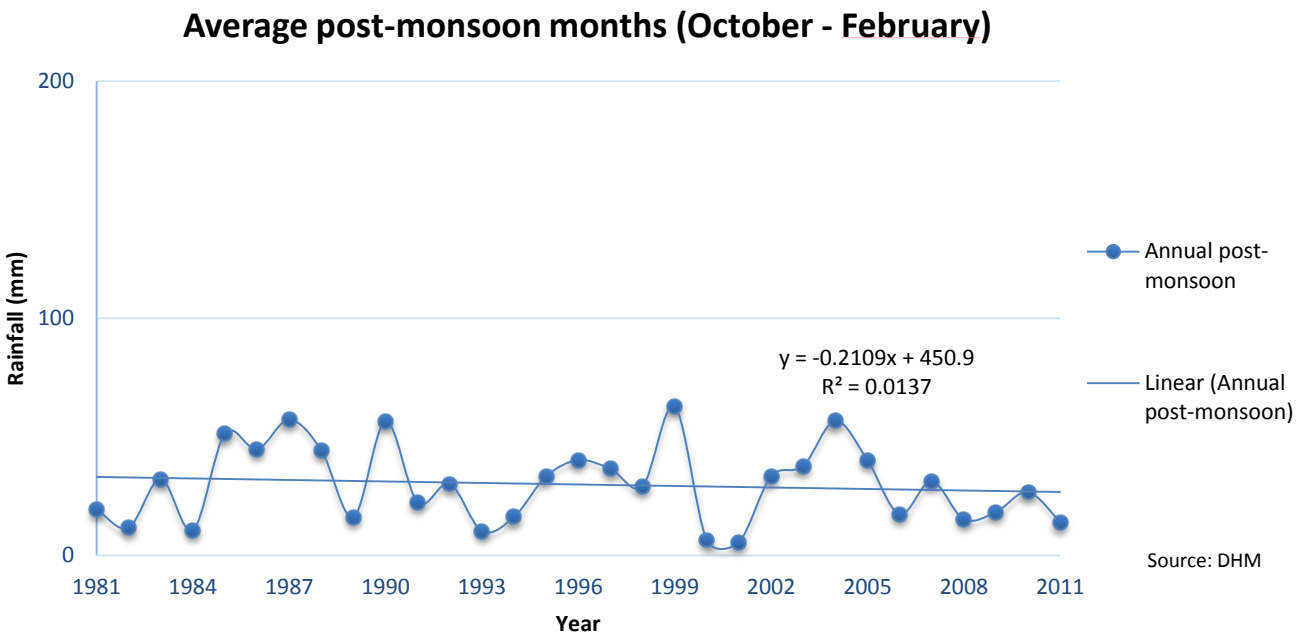


Figure 15: Post-monsoon trends from 1980 to 2011

Table 3. Climate parameters with r square and P value

	Climate Parameters	r square	p value
1	Annual Mean Temperature	0.2624	0.0032*
2	Annual Maximum Temperature	0.3627	0.000338**
3	Annual Minimum Temperature	0.0138	0.5294
4	Annual Mean Rainfall	0.0685	0.5294
5	Annual Pre-monsoon Rainfall	0.0411	0.2739
6	Annual Monsoon Rainfall	0.0741	0.1384
7	Annual Post-monsoon Rainfall	0.0137	0.5302

p value < *0.05**

Table 3 shows the climate parameters that are significant. According to the p value < 0.05, the annual mean temperature and annual maximum temperature are significant with the p value 0.0032 and 0.0003 respectively. The rainfall parameters are not significant as they have very high p value.

5.3 People's awareness of climate change:

The respondents were first asked if they have ever heard anything about "climate change". Only 19% of the respondent replied affirmatively. Although about 81% of respondents of interviewees didn't know the term "climate change", they are experiencing changes in rainfall and temperature and its impacts on their livelihood. Among the 19% of the respondents, about 21% had heard about it from the Buffer zone program, 3% of respondents heard about it in the media, and 76% of respondents were unclear about climate change (Figure 16).

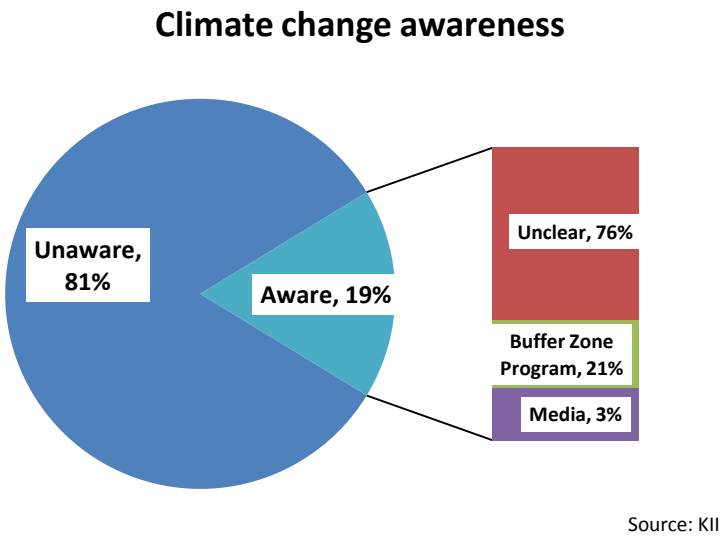


Figure 16: Climate change awareness in the community

5.4 Local perception about change in weather:

We examined local perception of climate change in the weather parameters. Then we focused on the respondent perceptions of the changes in the temperature and rainfalls. Generally, most of responses were on rainfall and temperature. As shown in Figure 17, most of respondents mentioned changes in rainfall and temperature rather than storms, thunderstorms or lightning, and male respondents perceived more changes in rainfall pattern than female respondents. On the other hand female respondents perceived more changes in

temperature than males. This may be due to most of the women working outside such as in the agricultural fields and in the forest for collection of firewood. Also, most male respondents work in the nearby town and are not involved in household works.

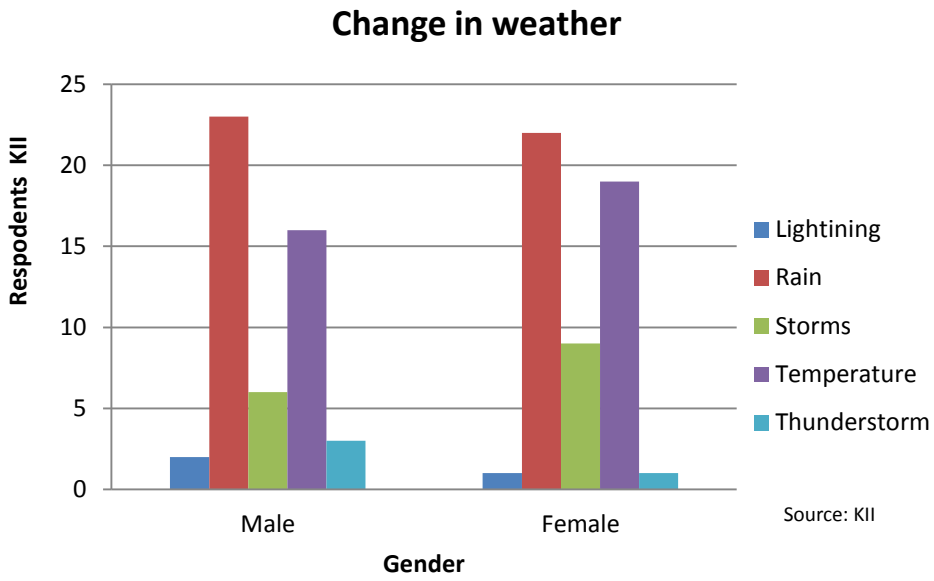


Figure 17: Gender perception of changes in the weather

Figure 18 shows people's perceptions of climate change across the nine different wards. In every ward people mentioned the changes in temperature and rainfall, but mostly in ward 2 and ward 9. This may be because these areas were seriously affected by water scarcity. In general, those interviewed who were aware of the term "climate change" but they did not know exactly what it was. Nonetheless, people within the study area have perceived changes that could be attributed to climate change.

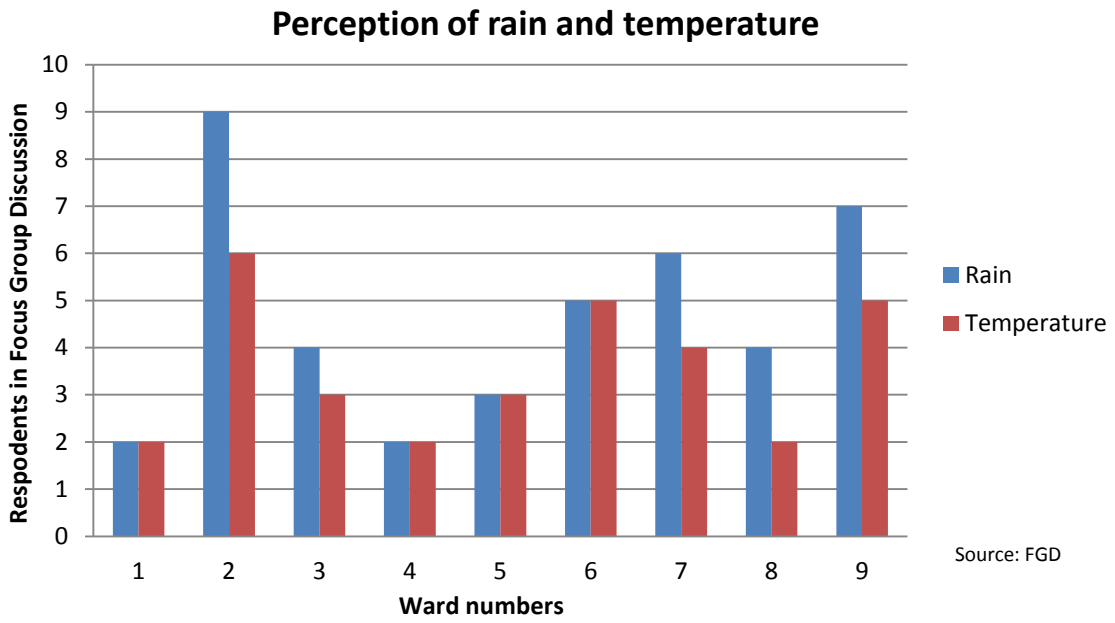


Figure 18: Ward perception of climate change in 9 different communities

5.4.1 Changes in temperature: The pre-monsoon extends from March to May, monsoon from June to September and post-monsoon falls in October to February. Besides that, there are four seasons, namely spring (March to May), summer (June to August), autumn (September to November), and winter (December to February). The changes in temperature perceived by the people were based on the indicators related to temperature change, such as changes in the duration of summer and winter season and extreme hot and cold days, and the changes in the occurrence of fog and frost. Traditionally, the respondents related the seasonal cycle of summer and winter to various seasonal religious festivals. Shree Panchammi is celebrated during the month of February/March and symbolizes the day of the onset of summer; winter is believed to start with Naag Panchami; and Gaijatra is celebrated in the months of July/August. The majority of respondents perceived a trend of increasing temperatures. They experienced longer summers and shorter winters. But some believed there to be less frost and that winter was becoming warmer than what it used be as recently as 10 years ago. Several people also stated that "the weather in the hills is becoming like the weather in the Terai" (Focus Group Discussion). In general, respondents across the nine communities believed that the extremely hot days were getting more frequent and that cold days were gradually declining.

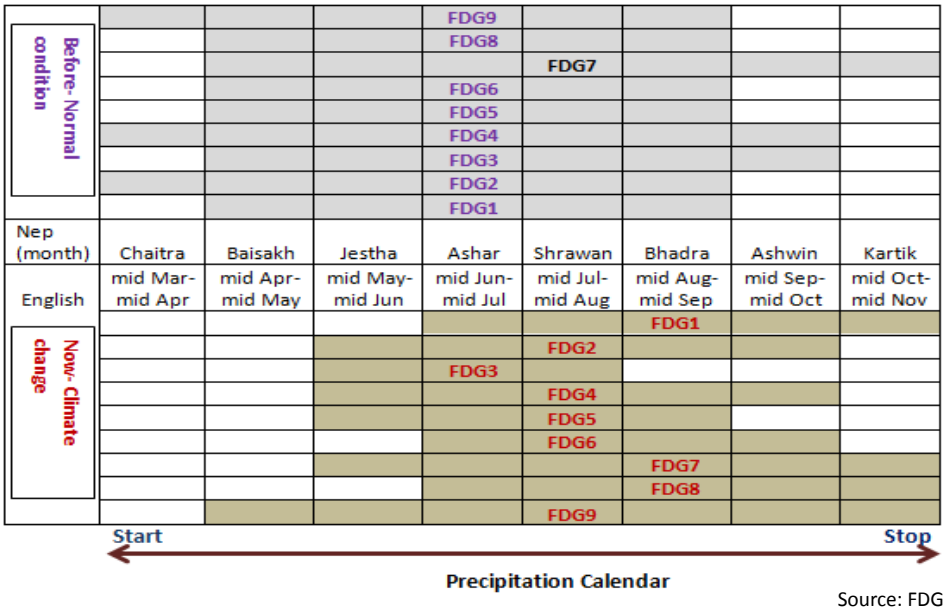
Some respondents remembered that the practice of setting a fire called "Maghe Mudo" during the month of February used to be common up until 1980. However, this practice has almost disappeared across all those communities, apparently as a result of increasing temperature. The respondents also perceive that the small decline in the number of frost days started in the 1990s and became more intense after 2000.

5.4.2 Changes in rainfall: The modest changes in average rainfall do not fully account for all rainfall changes. The monthly average rainfall can provide a picture of the total amount of rainfall in the month, but it does not show rainfall timing. The changes in the rainfall pattern perceived by the local people across the study sites were documented based on the perceived changes in the total amount of rainfall, number of rainy days, onset and cessation of the monsoon, and the amount of rainfall. These variables are important as they influence decisions made by the local people for selecting the cropping patterns. Respondents were also asked to base their perceptions of change in rainfall over a period of 30 years.

a. Shifting monsoon and effects on monsoon crops:

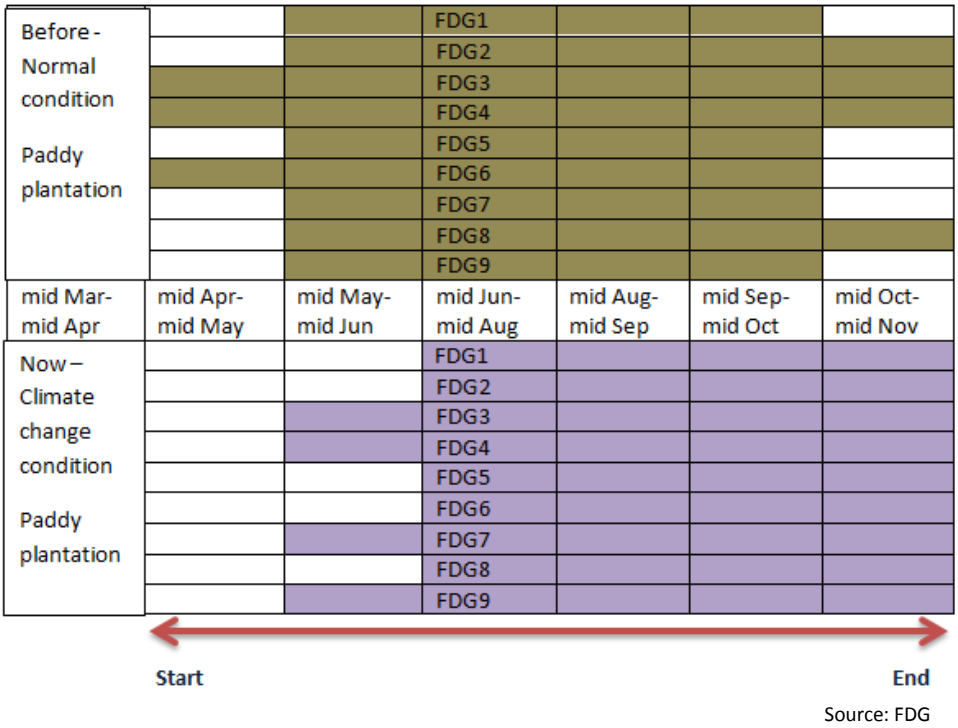
Prior to the 1980s, the pre-monsoon rainfall used to be from mid-April to mid-May. Late May was regarded as the end of the pre-monsoon season. Pre-monsoon is the time for the farmers to prepare the nursery bed for paddy, which will be transplanted during the monsoon months. According to focus group discussions, pre-monsoon rainfall is decreasing. Due to inadequate rainfall, paddy seedlings in a nursery are deprived of sufficient water required for their development. This can impact paddy transplantation time in monsoon season.

June used to be the first month of monsoon, and paddy transplantation used to be accomplished by this month prior to the 1980s. The rainfall in June has declined too, which in turn has delayed the paddy transplantation time. The delaying of transplantation until August has become common and indicates a delay in monsoon rain. The monsoon rain is delayed by a month according to the precipitation calendar prepared by focus groups (Figure 19). Over the years, July has become the peak season for paddy transplantation. Obviously, this delay in the transplantation process affects the ripening and harvesting of rice as well as the sowing of winter crops. In addition to paddy, maize is also affected by the delay in monsoon.



Source: FDG

Figure 19: Seasonal calendar prepared by focus groups



Source: FDG

Figure 20: Seasonal paddy plantation calendar prepared by focus groups

Delays in the monsoon set back paddy transplantation as shown in Figure 20. Rice is a staple food in the country, and the delay in the monsoon has huge impacts in paddy plantation. Most of the focus groups said that they used to plant rice in mid-May to mid-June but this has now

changed to mid-June to mid-August. The most interesting part is that the harvest time is same whenever they plant; i.e. mid October to mid December as in Figure 20. A decline in paddy and other crops can thus have significant impacts on food problems. As an example, during the winter of 2008-2009 the drought was prolonged and food scarcity was severe. During this period most monitoring stations received less than 50% of normal rainfall (Dixit, 2010). Although a single drought does not indicate climate change, the frequency of these kinds of extreme droughts have increased in last 20 years.

A key informant interview revealed that the nature and intensity of rainfall have become more erratic and unpredictable than before and that heavy but short duration downpours have become more prevalent. Respondents recalled that in the past, there used to be periods of Shrawan Pani, during which there was continuous rainfall for 7-10 days. This formed the only water source for Bhadra (mid-August to mid-September) and Ashoj (mid-September to mid-October). Relating the rainfall events to traditional rituals such as Krishna Astami celebrated during August/September, Shiva Ratri falls in the month of February-March. In terms of annual rainfall trends, the focus group discussion elaborated on the perceived decline in the total rainfall – monsoon as well as winter rainfall amounts – and the perception that they can no longer depend on their traditional practices of livelihood activities (mainly agriculture). The annual rituals such as Nag Panchammi Jhari, Shaune Jhari (rainfall during July/August), Shora Sharadda Jhari, Naurat Jhari and Maghe Jhari were associated with persistent rainfall (Jhari – rainfall for more than a day). Respondents recall this kind of persistent rainfall prior to 1980 when they had to carry the traditional folding umbrella called “Ghum”.

Triangulating the rainfall perception with actual trends was difficult. Monthly averages can give a picture of total amounts but do not show rainfall timing. A linear trend line for monthly rainfall amounts also did not demonstrate a clear pattern.

5.5 Climate change attributing factors:

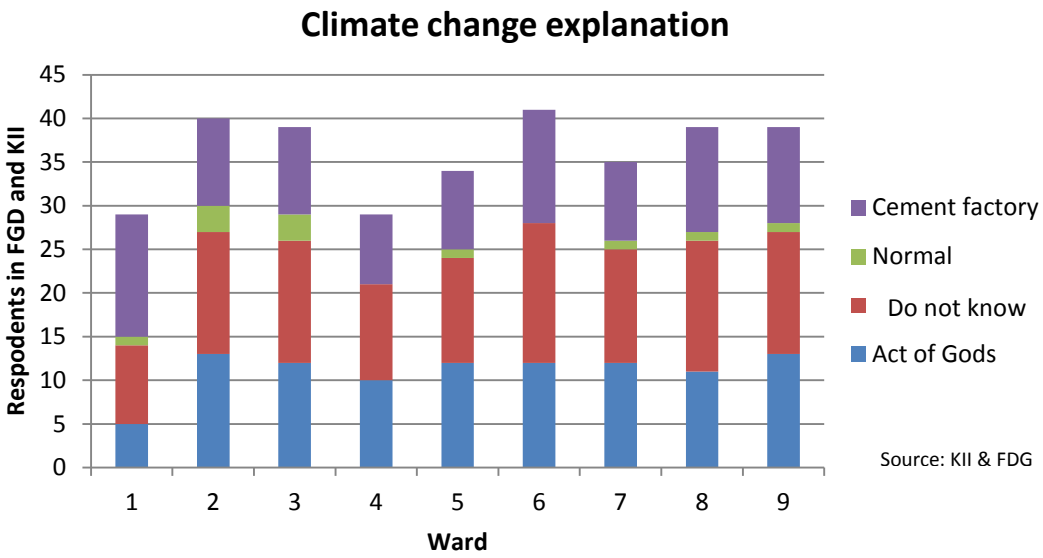


Figure 21: Climate change explanation in the community

According to key informant interview and focus group discussions, people believe that the changes were due to the cement factories and act of Gods. This may be because people feel negatively about the cement factory, and it is easy to blame environmental changes on something they perceive as harmful. In addition, it is easy to blame a supernatural power like "God". Most of the respondents are unaware of the changes in the community as presented in the Figure 21. A small number of the respondents think that the changes are normal.

5.5.1 Cement factories:

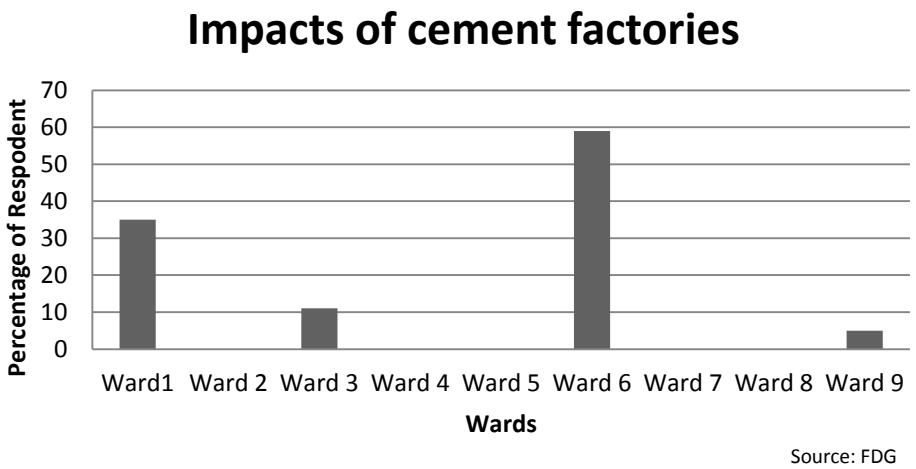


Figure 22: Cement factories impacts in the community

There are two cement factories associated to the community. Based on the Focus Group Discussion, we found that wards 1, 3, 6 and 9 consider that the cement factories have a serious effect as shown in Figure 22. The responses from key informants revealed that the environmental changes are blamed on the cement factories. The major impact is on crop yield. Research has shown that the production of crops decreases within a 3-4 km perimeter of the cement factory (Chapagain and Dhakal, 2011). People also perceive that more hazy, foggy and poor sunlight during the winter are the most prominent problems and directly impact farmers in their common practice of sun-drying. This may be due to creation of an inversion layer, which retards the air mixing. As rainfall is poor in these conditions and during the winter season and not available to wash the dust from the grains, the dust from the cement factory remains deposited for a longer period in the foliage of plants. People around the cement factories perceive that due to heavy deposition of dust, no vegetable cultivation can be carried out in the severely affected area and the straw of rice and wheat is not palatable to livestock. The following is a sample of responses in the community.

> *"In the past there used to be dense forest and the population was also less. We can easily predict the weather, like the time when rains started. Now, almost half the forests are destroyed. The rapid increase of the population had led to more pressure on forest and water resources. The major cause of change is the road construction. This had increased the pollution in the community by establishment of cement factories and burning of plastics"*
> -- Ward 2 FGD

5.5.2 Act of Gods: Some respondents believed that most of the unpredictable events happening in the weather were due to the increase in the angriness of the Gods. They also believed that this has become worse. Some believed that these changes were happening as a result of sinful activities of humans, such as cutting of trees and modern activity. People believe that changes result from people forgetting to worship the Gods, to pray for blessings from the Gods and to engage in traditional ritual activities. The following are some of the quotes from key informant interviews mentioning about the disfavor of the Gods.

> *"People are involved in agriculture. If the climate is favorable, we benefit otherwise we do not. It depends upon the luck, that's something should be written by God." --KII Ward -3*

"It is said that 'Bharne pani uni lagne pani uni' which literally means in English God is responsible for giving and taking from us." --KII Ward -2

"I don't know what is happening!!! I think the sun is getting closer, that's why we are feeling hotter every year. These intense temperature increase and decrease in rainy days are making our life harder to sustain in the community." -- KII Elder

"People are more focused on learning new things but they are forgetting their traditional beliefs in the community. The traditional ritual like "Hom yagya" for the Gods is what makes them happy. This ritual brings the purity of the weather and all other parameters in the environment. If we have do these rituals every year there will be rain in time and fresh air. Today's generations are not following this kind of ritual they just want to be modern." --KII Ward-8

Table 4: Direct and indirect changes due to climate change

Direct changes due to climate change	**Indirect changes due to climate change**
Temperature increase	Changes in the crops species
Change in rainfall	Emissions from cement factories
Change in monsoon patterns	Excessive use of chemical fertilizers
Decline in post monsoon rainfall	Decrease in crop production
Drying out of water sources	Increase in crop weeds and pest
Massive widening of riverbeds in forest due to flashfloods	Reduction in forest resources
	Migration
	Changes in cultural practices
	Increase in population

Source: Field Observation

According to my observations in the study area, the direct and indirect changes due to climate change are displayed in Table 4. The temperature has increasing trend which was has high p value. Though the rainfall doesn't show a clear pattern, there is a decreasing trend in the post monsoon rainfall. Also, there is a huge widening of riverbeds in the forest. Table 4 also lists some of the indirect changes attributed to climate change such as changes in the crops species, decrease in crop production, loss of cultural practices, etc.

5.6. Impacts due to climate change:

5.6.1 Impacts on agriculture:

Paddy and wheat rotation are the most important crops in the Khet (low land irrigated farmland) and maize and beans in rotation with mustard are important winter crops in Bari (rain fed terrace land). Potato has been cultivated as a winter crop by farmers with dependable irrigation services. Farmers also used to plant paddy twice in a year in Khet where there are good facilities for irrigation. Respondents also have observed changes in agricultural production, in crop patterns, excessive use of chemical fertilizer, increase in pests and production as shown in Figure 23.

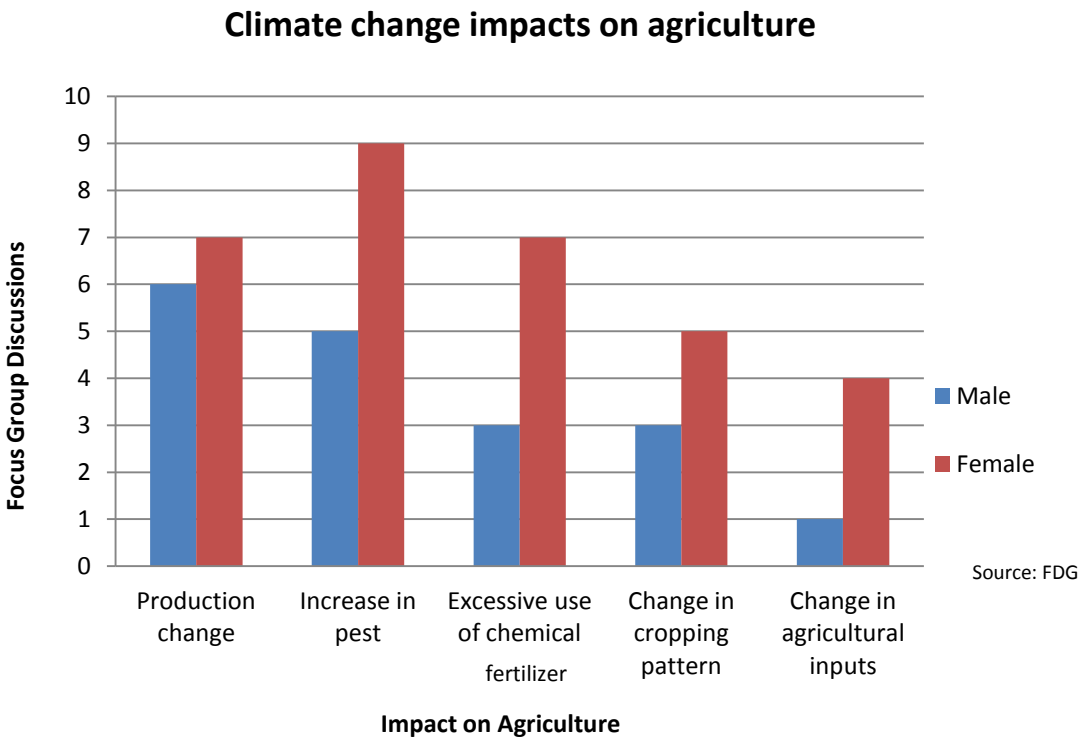


Figure 23: Climate change impacts in agriculture

a. Decline in winter rain/drought: The winter crops in the valley of the study area were primarily cultivated in rain-fed conditions, which are more prone to crop failure due to climatic variability. Farmers dependent on rain have remained helpless against dry winters, which result in decreases in crop yield. Consequently, many farmers have stopped growing wheat and instead keep their land fallow. The small number of farmers continuing wheat cultivation have seen their crops stressed by increasing temperature and unexpected pre-monsoon rainfall. This is because of hardship in wheat harvest time.

Delays in the wheat harvest have in turn affected monsoon crops like paddy transplantation due to delay in monsoon. Also, delay in paddy harvest has led to a delay in sowing of winter crops. These delays have in turn caused an additional problem for germination in winter. As a result, some farmers have been left with no option besides leasing out their lands or leaving their lands fallow.

b. Impacts on crops/decrease in crop production: Farmers noted both positive and negative impacts of increased temperatures. Within the past few decades, people perceive rainy days have decreased annually in the study area for a month, with delays in the monsoon breakout and early monsoon breakoff. Over these years, rainy days have decreased in winter as well, while the intensity of the rainfall period increased.

There has been a reduction in yield and production of the key maize and rice crops. Agricultural production of rice (*Triticium aestivum*) in that area has decreased on account of shorter winters and insufficient post-monsoon or winter rain. It has also led to a decrease in millet production (*Eleusine coracana*). Farmers have also ceased growing barley (*Hordeum vulgare.)* and Gaiyya (traditional rice species).

The most noticeable impacts are in paddy transplantation. In the recent decade, the paddy was transplanted after the second week of July and it ripened in the second or third week of November. The negative impacts of increasing temperature were also noted in the quantity of agricultural yield. The yields of rice and wheat have decreased with an increase in the variability of climate. Respondents perceive a decline in the frost during

the winter months, which coincides with a loss in a taste of the mustard leaf. They perceive that the taste is added by the frost.

Farmers perceive that increases in drought conditions result from increased temperatures and less certain rainfall, which have in turn caused crop disease and crop damage. The farmers believe several factors have caused decreases in the production, including increased rainfall uncertainty, low quality fertilizer, water scarcity, and increases in pests and crop disease.

c. Change in crop weeds and pests: Farmers perceive that an increase in the incidence of pest infestation and weeds started only after 2000's. A decade before, the major weeds were Dubo (*Cynodon dactylon*), Gande jhar (*Ageratum conyzooids*), and Kuro (*Bidense pilosa*) commonly present in the paddy field. Now there are more species like Pire ghas (*Polygonum barbatum*). Similarly, sterile spikelet and discoloration of paddy leaves are increasing day by day. The occurrence of pests was relatively low compared to summer, but the pest population is increasing every year. In the recent years, people have observed many unidentified diseases in agricultural crops. Some of the prevalent diseases in barley, millet, paddy, maize and wheat include barley stripe, leaf spot, blast, root rot and leaf blight. According to respondents, new insects have appeared and spread on crops as well as fodder and other vegetation. The most prevalent one is aphids, which affect a wide range of crops, including mustard, maize, broad bean, pulses and other vegetables. This causes crop losses. Potatoes are damaged by leaf blight, red ant and leaf spot, which have become more frequent in the last few decades. To cure these insects and diseases of key crops, farmers have increased the use of pesticides. The increases in temperature have created many adverse effects such as maturation of seeds and spread of pest and diseases. Farmers were also worried about reducing production of staple food crops and the cash crops such as ginger and mustard.

Farmers explained that the main reason behind these changes is the natural pest predator cycle as a result of unbalanced ecosystem, which is mainly initiated by the use of the chemical fertilizer. The farmers believed that increasing temperature, decline in frost, and rainfall variability were the major causes of increased pest infestation in crops. Following is the local statement of experience in the changes in the crop pattern.

"There was lack of food on one season; somehow we were able to produce offseason maize which was used for daily purposes. The other people went out searching for labor work in the same community, other towns, or the capital city, or even abroad. ."-- KII Ward-7

"The pests are different in different crop. We aren't able to do anything against pests except to increase more pesticide in the farm. When the pests attack the flowering bud then what can we expect for the fruits? Before this kind of pests used to be in maize and soybean but now we are seeing them in the paddy also. The severity of pest depends on the rainfall amount and timing. If it rains on time there is low pest infestation."--KII Ward -9

d. Excessive use of chemical fertilizer: Many people in the community perceived that there has been excessive use of fertilizer in the past few decades. They perceive that use of excessive fertilizer has adversely impacted soil fertility and crop production. Most people noted that an increase in pests has resulted from use of chemical fertilizers. From the decade of 2000, agricultural production has declined despite the cultivation of good varieties of crops and use of fertilizers. However, farmers complain about the low quality of fertilizer, which they believe to be responsible for soil degradation. They also perceive that the topsoil is so hard and infertile that they can no longer find earthworms in the soil.

"In those days we used to produce all organic but now we are using chemical fertilizer in each and every crop. The first fertilizer was introduced in 2050 BS which helped to increase the crop productivity. It helped for 2-3 years to produce more crops but after that the productivity was decreased. Now, we can't stop using it because everyone is using it. If I won't use it then my farm land won't have any yield at all. I am also seeing that there is more disease due to use of chemical fertilizer." –KII Ward-8

5.6.2 Impacts on water sources: In most of the wards, the primary sources of water are pipelines and traditional stone spouts as demonstrated in Figure 24. In some wards such as ward 2 and ward 6, they are entirely dependent on stone spouts. According to the focus group, the traditional stone spouts are drying up, and about half of them are not in use. This actually explains why the pipeline water system is spreading out in all wards of 9 communities.

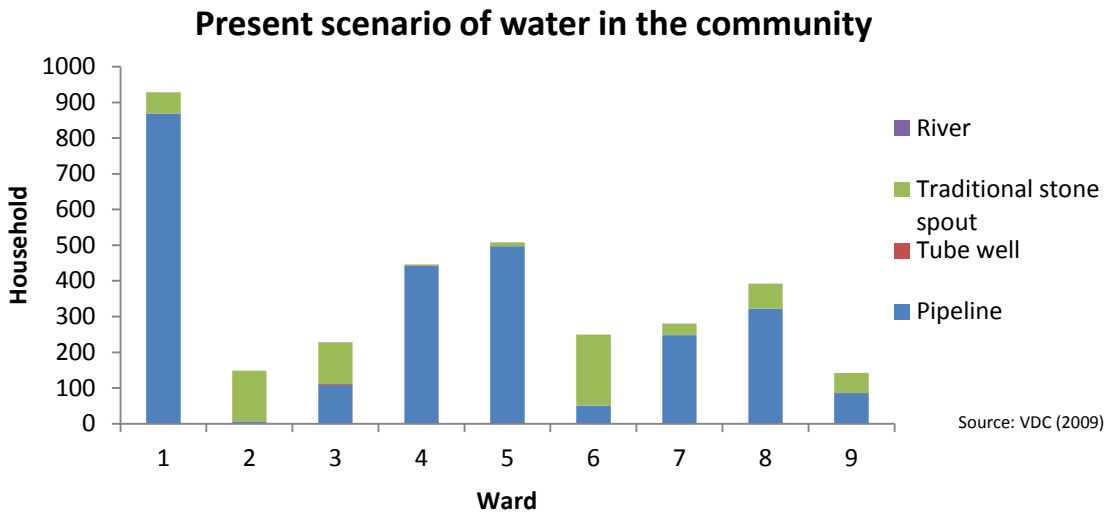


Figure 24: Water availability in the wards

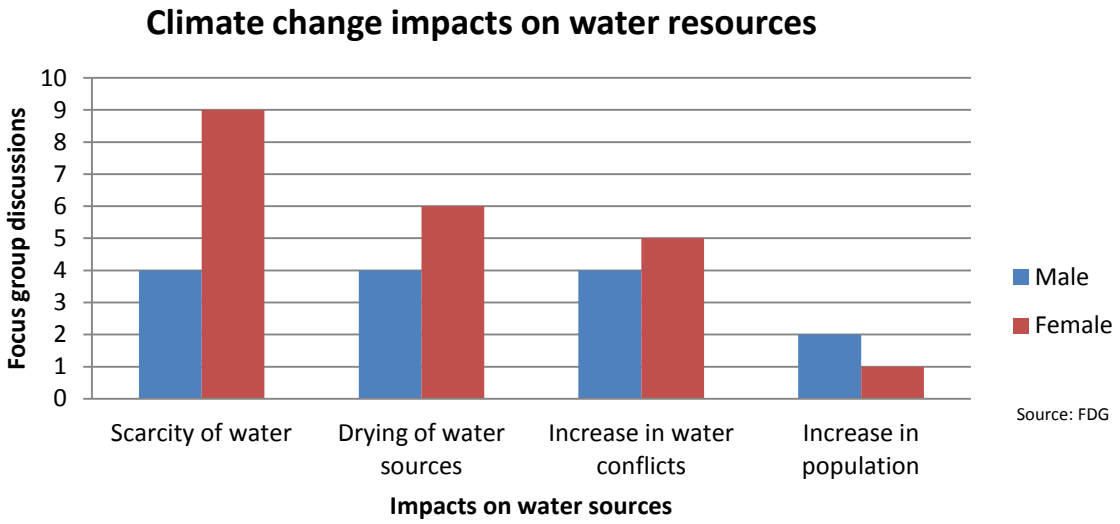


Figure 25: Climate change impacts on water

The scarcity of water sources is one of the major problems mentioned by local people. According to FGD in 9 wards, the major impacts are scarcity of water, drying up of water sources, water conflicts and increases in population, as shown in Figure 25. Moreover, female respondents have noticed more scarcity of water than male respondents. This may be due to most of the water-related activities such as the fetching and cleaning of water resources being done by women

rather than men. Nevertheless, it affects all the sectors such as agricultural production, drinking water supply, hydropower, and water-induced disasters as well as forest and biodiversity.

a. Increasing water scarcity: Water shortage has been identified as a key problem in recent years. Some respondents perceive that insufficient rain, unusual rainfall patterns and increased temperatures are responsible for water scarcity. Rivers and streams are drier and there is a notable decrease in drinking water. There is reduced river flow due to less rainfall, which makes it harder to irrigate the crops and provide water to the communities. Furthermore, in ward 2 the local people are buying water from tankers. On the other hands, some respondents mentioned that they fetch water from the river, which means they are spending most of their time bringing water to the house than their other works. This has also impacted children's study time at home.

b. Drying water sources: In the study area, drying up of the traditional water sources – wells, rivers, springs and ponds – was found to be severe during the dry and hot seasons. If this trend continues, many biological and human systems would face challenges in the future from drought and water shortage. According to the focus group discussions, farmers have to carry water for long distances to meet the daily water requirements for household and farming activities. Water scarcity has increased in the last 15 years. In all the communities, water scarcity is observed and mentioned as a growing concern of the local people.

5.6.3 Impacts on forests:

a. Pest infestation: The forest resources are continuously declining. Landless people in many areas are encroaching upon forests and illegal timber extraction is diminishing the resources. In recent years, an unidentified disease and thick fog from the cement factory has hampered forest growth. People gave examples of the forests in Sisau, Imli, and Kimbu, which have been badly affected by the disease. Changes in temperature and rainfall patterns have created favorable conditions for pests, diseases and invasive species to emerge and spread in agricultural and forest lands. Respondents have already experienced the emergence of species that they have never seen in their field area. Invasive species like Banmara (*Lantana camera*), Gande Jhar (*Ageratum conyzoides*), Aaloo Jhar, Badame Jhar, Kande Jhar and Titepati (a local weed) are more evident in the study area. Furthermore, respondents perceive that invasive species are spreading very fast and damaging agriculture, pasture and forest lands.

b. Increase in forest area, but decrease in water resources: The local people believe that an increase in forest area will increase the water resources. More than 90% of the respondents mentioned that forested area has increased. The respondents raised the issue of decrease in water sources. People appeared confused as to why the forest areas were increasing, but water source was becoming scarcer; they seem to be unaware of climate change, but they are observing changes in their forest. The presence of community forest was the great initiative that increased forest area, while at the same time the people suffered from severe scarcity of water sources. The main reason behind these issues may be the eucalyptus plantation near the water sources.

c. Massive widening of the river banks: The pattern of erratic rain in recent years has produced increased landslides and soil erosion in the study area. On one hand these natural disasters are depleting forest resources, whereas on the other hand there is illegal sand and stone mining. In addition to these factors, the illegal quarrying of stone and pebble collection from these banks are the major causes of the widening of the riverbanks in the forest. As an example, the digging for stones makes the area more vulnerable to soil erosion. People also perceive that the width of riverbanks has increased up to ten-fold compared to around 30 years ago. Here is the typical response from the key informant interview.

> *"The banks of the river in the forest used to be small like a small channel. This was around 30 years ago. But now, I feel like there is more channel than forested area and it is expanding in an alarming rate. In the past these lower lands used to be the farmland but now all of these lands are covered with pebbles and stones or simply the deposition of the river product." --KII Ward-2*

d. Reduction of forest resources: In the past, forests were very rich with varieties of non-timber forest products (NTFPs). Local treatment systems were very effective, which resulted in diversity of NTFPs such as the medicinal trees Harro, Barro, Kurilo, Chiraito etc. The local people believe that even cancer will treated through NTFPs. People in the study area opined that many NTFPs cannot survive in changing climatic conditions. With the increase of temperature and droughts as well as thick fog in the winter, many NTFPS have become extinct. Due to extreme drought, people perceive that there is a direct impact on the growth of palatable grass species. Regeneration of fodder species in pasture and forest fodder are also decreasing, because of less rainfall. As a result, there is a shortage in diversity and quality of livestock fodder. This has adversely affected livestock by reducing the production of milk, milk products and meat.

Livestock population is also decreasing. Drought has affected livestock by drying wetlands, pastures, water resources and streams and by decreasing the availability of drinking water. Increasing temperatures have also affected livestock by allowing the spread of new diseases. The scarcity of fodder and space for livestock rearing community is forcing the farmers to change their livestock pattern. Following is a typical response to the decrease in forest resources.

> *"In the past, the forest was dense. We used to collect wood, fodder and grasses whenever we could. We used to collect fire woods for different cooking purposes like for rice, vegetables and meat. Now, we get only the leaf litter for free and we have to buy firewood from the community forest."*
> *--KII Ward -7*

5.6.4 Impacts on health:

The resurgence of tropical disease is another important threat to Nepal. Global warming could contribute to outbreaks of malaria, kala-azar (Leishmaniasis), and Japanese encephalitis. The government is requesting more research on the efficient control of the potential outbreaks, knowing that chemical intervention could have controversial effects on both ecosystems and people's health. The impact of climate change on human health is widely felt. Respondents at study sites experienced various kinds of diseases, malnutrition in children, viral influenza, allergies and itching, menstruation problems experienced by girls, and skin diseases due to emissions from the cement factories. Many respondents pointed out the current need for using mosquito nets.

> *"I exactly don't know from which year we started having problems with mosquitoes. In the past, we used to sleep on the balcony during the summer season but it's not possible now. This is really serious in the evening; we can't stay longer outside of the house. The government of Nepal distributed mosquito nets which can only be used inside the homes." ----KII Farmer*

5.6.5 Impacts on the economy:

Livelihoods can be measured by the dependency of households on necessary resources. Economic status is also measured by dependency on natural resources and household occupation. As agriculture and livestock are the main sources of income, the loss or degradation of agriculture threatens the income level of the household. More than 82 percent of the households in the study area were dependent on agriculture and livestock. In other words, the impacts on agriculture and livestock have direct impacts on the livelihoods of local people. Thus, climate change impacts income and the overall economy of the community. Nowadays, to fulfill the

income gap from agriculture and livestock, youth members of the households are engaged in alternative professions like business, foreign employment, and wage labor.

5.7 Local adaptations

5.7.1 Adaptive strategies

a. Switching towards less water-demanding crops and changes in paddy species: Typically, people used to plant Taichin, Mansuli and Basmati varieties of paddy, which have higher water demand. More recently, they have started using the hybrid paddy varieties like Kumal. This hybrid paddy can grow in less water demanding conditions, does not need to be irrigated and is less affected by the variability of water supply. Farmers also have switched to maize and wheat that require less water. The traditional crops like kodo (local millet) and Gaiyya (local paddy species) are not used anymore. Moreover, farmers have moved to cash crops like ginger and mushroom farming. These crops are economically more productive, but not all the farmers can shift to these kinds of crops. These kinds of changes have occurred in very small groups of people, sometimes among 3-4 households, while most other farmers still depend upon the rain-fed traditional crops.

Because of delayed monsoon and untimely rainfall there are intensive downpours and reduction in yields. This results in dryness in some areas and excessive rain in other areas. Due to the reduction of the monsoon season/period by one month, the cultivation of the long period of monsoon crops is not feasible in many parts of the study area. As the rain starts later and stops earlier, people are unable to cultivate a large variety of paddies such as: Masino Dhan with the genotypes Sawamansuli, Mansuli, Basmati and Aanadi etc. Rainfall patterns have hindered the growing of local indigenous varieties of paddy crops. To tackle this, the farmers abandoned growing Masino Dhan and have been growing Moto Dhan with the genotypes Radha-4 (IR 8423) and Osan, which become ready within 125 days with a potential grain yield of 6.0 t/ha and average yield of 3.0 t/ha. These species have been shown to be field resistant to blast and bacterial blight. Crops can be harvested much earlier, preventing the crops from being washed away by the floods. The short duration Radish *(Raphanus sativus*) and Carrot *(Daucus carota*) are now more common. High yielding off-season varieties includes Mino early, Japanese white, Tokinashi and 40 days. Among them, 40 days is quite popular among farmers.

b. Leaving land fallow: Most commonly, people leave their land fallow particularly when there is crop failure and poor yield, which have occurred recently in the study area. According to several respondents, the winter crops are not getting a favorable environment because of temperature increases that affect the soil moisture and disturb the seasonal cropping cycle. Therefore, farmers have no option besides leaving the land fallow, which may continue for 6 month periods. As noted above, people within the study area also blame the cement factory for not being able to grow anything on their agricultural land. The area affected by the cement factory has a huge deposition of white airborne sediments, which damages crops and decreases crop yields.

c. Occupational diversification and forced migration: Somewhat paradoxically, the reduction in livelihood opportunities has been accompanied by trends towards diversification; that is, the adoption of multiple income-generating activities. People are shifting to off-farm occupations such as tailoring, jobs in government offices and private firms, and wage laborers. The main changes are because of the decline of economic returns from agriculture. The main reason for the losses may be due to changes in climate. Most of the people perceive that there is a high amount of youth migration to work as laborers in other countries like Malaysia, the Gulf States, and Saudi Arabia. Also, people are shifting to off-farm occupations such as textiles, jobs in government, industries etc. At first the migration was from the hills to the valley. The emergence of services and infrastructure in the valley has caused a considerable migration to valley communities and an abandonment of marginal rain fed lands that form a meager basis upon which the livelihoods could be sustained. At present, a common income strategy found in all communities is migration to nearby urban areas such as Heatuda, Kathmandu and Biratnagar to find work in predominantly in urban construction. It is almost exclusively men that conduct this work with the result that women often stay behind with the children. More than half of the household heads migrate temporarily to Heatuda or Kathmandu every year for several months at a time. This migrant work has made it easier to sustain a rural livelihood than before, as the risk of a downturn in agricultural production can be better spread. When a family has small children, the head of the family moves out in search for work as a laborer while in families with older parents the children are burdened with the task or migrating and sending remittances.

d. Improved varieties of plant and livestock species: With the changing pattern of climate, people prefer to raise improved varieties of livestock instead of strictly local varieties. Murrah buffaloes *(Bubalus bubalis*), indigenous to India, are well adapted from Terai to high hills and have been producing at a higher level than the indigenous breeds. Raising such buffalo species has also improved milk production. Farmers prefer to feed animals and grazing calves on nutritious and dry fodders. In the study area cow *(Bos primigenius*) and Murrah buffalo varieties of improved livestock are common. More milk-giving livestock are popular because selling milk has been facilitated by the development of the dairy industry. With fewer numbers of livestock, there is less need for grazing land. Stall-feeding is largely practiced. The local people provide local grasses to livestock to get more milk. There is an increasing trend of replacing low-productive or indigenous livestock with improved varieties of livestock. Similarly, cultivating new varieties of grass and fodder in private land is also popular.

e. Increasing use of pesticides: With an increasing occurrence of pests, farmers are applying pesticides more frequently and in larger amounts. The volumes of pesticides have doubled over the past decade. In addition to insect pests, diseases are also increasing. People also perceive that increases in pests are due to the increased use of chemical fertilizers, according to the focus group and key informant interviews in the community. Furthermore, the cash crops as an alternative to traditional crops have improved resistance to increasing pest and disease.

f. Afforestation: According to the focus group and key informant interview there was massive deforestation around the 1980's. After that the community forest program was established in the community for the conservation of forest through local people. Currently, every year CFUGs have a plantation program in the community forest where they plant approximately 100 trees in the fragile topography. People also perceive that due to increasing the forest growth the landslide and soil erosion have been decreased within the community forest. The following is a selected response taken from key informant interviews.

> *"In the land where landslides may occur, different species of grasses can be grown like Vetiver and bamboo species can be also grown, which not only control landslide but also helps in income generating activities. Epil Epil is the grass species that can be grown in these areas which grows well within 30-40 days and can be used as timber too."* --- *KII member of CFUG*

5.7.2 Community based adaptation:

Perma System: Social factors are also very important in causing changes in community-based practices. The system of labor exchange, which is called "Perma" in the local language, is commonly in the rural villages of Nepal. Labor is exchanged in the same unit with same gender by one household to another household in the village. People rely on the perma system, which means helping each other in the agriculture. This is actually a tight cohesion of the community. Approximately 5 years ago, changes occurred in collective action and perma system in the study area. In recent years there has been less willingness to contribute this kind of work, which had been particularly beneficial for marginal populations in the study area. Changes in weather patterns as well seem to have negatively influenced perma system. The changes in perma translate into changes in the cost of labor. As noted above, there used to be a month-long gap between the first rain and the planting of the crops. Because of the delay in the onset of the monsoon, however, planting now needs to occur as soon as possible after the first rain to minimize the decrease in yields. This has led to a situation in which the whole community needs to mobilize at the same time. The exchange of labor becomes less effective under these changes since everyone needs help all at once. This has increased the dependency on family members, including the children who are not able to attend school during the planting season.

In the past, the perma culture was purely based on labor exchange. But now, it is characterized by a monetary transaction. The diversification of income sources in the community has caused the cost of work labor to increase. The hike in labor costs in turn has caused much of rain-fed land to remain fallow. The solidarity among community members performing collective action has decreased since households have increased focus on non-agricultural income sources. Consequently, people in the study area have become more individualistic and social bonds have weakened. Respondents reported that development of their family was more important than the development of the community. Following is a quote taken from the key informant interview.

> *Perma culture usually occurs in plantation and harvest period. People are unable to participate in these kinds of communal work because they are increasingly involved in paid work labor for the family. Perma is becoming harder nowadays, as most of the youths are migrating and do not work in the agriculture. Even, it is so harder to get work in agriculture because most of them are involved in road building, house building in the urban areas. --- KII Ward-5*

6. DISCUSSION

Several climate change studies emphasize the importance of local perceptions of climate change and adaptation (Dahal, 2005; Thomas *et al.*, 2009; Piya *et al.*, 2012; Shrestha and Sada, 2014) but ignore climate change awareness at the local level. In this research about 81% of the respondents had never heard the phrase "climate change." A similar situation is reported by Bgy and Salick (2009) in Tibet, Piya *et al.* (2012) in mid hills of Nepal, where respondents had never heard the term climate change. Most people in the study area may not understand literally what climate change means, but many of them perceive environmental changes, especially related to climate variability. This finding was supported by Mertz *et al. (*2009) where local never heard about climate change.

The general trends that have been corroborated by ground level observations in nine communities of the study area do provide a basic framework of changes. It has been observed, for instance, that the rainfall patterns are changing, winter and post-winter rain are decreasing, and the monsoon is arriving late causing lots of damage when it does arrive, summer is getting hotter, hail frequency is increasing, and so on. In this case, adaptation should be based on the environmental changes rather than the term "climate change" so that the local people can understand more clearly.

The trend of increasing temperatures was perceived in every community, which coincides with the results obtained from the analysis of temperature data. This finding was also supported by earlier studies (Shrestha *et al.,* 2012; Baidhya *et al.*, 2008; Practical Action, 2009; Shrestha and Sada, 2013). The GoN (2010) also stated that people from mid hills of the central development region perceived an increase in temperature.

A linear trend line for monthly rainfall amounts did not demonstrate a clear, visible pattern. This finding confirms the conclusion of Shrestha *et al.* (2012) and Practical Action (2009) that there is

no detectable long-term change in annual rainfall amounts, although subjective perceptions of the changes in rainfall did not coincide with the analysis of rainfall data. A similar finding was made by Baul *et al.,* (2013) for the middle hills of Nepal. This variation in the perception and rainfall data could be due to decline in water availability caused by the compounded effects of increasing population. The unavailability of meterological stations to interpret the local climatic information in the study area could help explain why local perceptions do not exactly align with an analysis of recorded data. Furthermore, the amount of rainfall received in nine communities might be different but the local peoples have great knowledge about rainfall in their communities. Also, more detailed climatic data could show changing trends more distinctly.

Cultural practices are important for climate change adaptation. Cultures are not static; they change with environment and climatic variability (Strauss, 2012). As is shown in this research, there is a loss of cultural practices with changing climate. A similar finding was reported by Adger *et al.* (2012), where climate change has impacted negatively on the local culture.

A variety of different non-climatic factors that have varying effects on the region, including resources mismanagement and rapid population growth, also cloud the effects of climate change (Bartlett *et al.,* 2010). This is true in this study area where people confuse the changes with some of the non-climatic factors like the cement factory and population growth. In addition, some people perceive that changes are due to act of gods. This means they may not have the proper capacity to develop proper adaptation strategies in place to respond to climate change.

The shifting on seasonality and unpredictability of the rainy season adversely affects both planting and harvesting of crops; for example, rice production falls with a decrease in monsoon rains. In response, communities are altering cultivation schedules and types of crops grown, often to less water-dependent varieties. That means the local people are dependent on hybrid varieties of crops and spending more money on seeds. Consequently, local knowledge of planting and local seeds are disappearing. As income drops due to reduced crop yield, communities are moving from subsistence to cash crop production (RECOFT, 2012). Thomas *et al.* (2007) concluded that people recognize changes in experienced climate parameters and identified them as more important to their decision-making. As an example, farmers who live closer to natural resources often observe and feel the effect of climatic variability, they monitor the activities around them and they are the first to adapt to any changes (Idinoba *et al.,* 2009,

Gyampoh *et al.,* 2009). That is why traditional knowledge is one of the best options for coping with climate change.

Extreme temperatures can significantly reduce crop yields (Porter and Gawith, 1999; Rai *et al.*, 2011; Lal, 2011), especially during flowering periods when plants are sensitive to extreme temperatures (Wheeler *et al.,* 2000). The IPCC (2007) concurred that higher temperatures are also a reason for the reduction of cereal (e.g. wheat and rice) production in South Asian countries. Numerous studies have linked increases in temperature to enhanced risk of pest infestation and the invasion of new weeds and diseases (Malla, 2003; Chakraborty *et al.,* 2008; Dukes and Mooney, 2000; Ziska *et al.*, 2011; Bandari, 2013). Baul *et al.* (2013) found that the observed invasive plant species such as Nilgandhe (*Ageratum species*), Kalo banmara (*Ageratum adenophora*) and Gande jhar (*Ageratum conizooids*) were considered the cause of reduction of rice, maize and vegetable production, which agreed with people's perception in my research. Chakraborty and Newton (2011) pointed out the effect of drought stress on disease resistant crops, giving pests and pathogens more opportunity to succeed. Increased pest and crop disease were observed in the study area. A crop yield loss of 20-24% was reported by Upadhyaya (1998) in lowland areas. People in the study area have perceived this linkage.

The observed changes in seasonal rainfall patterns can have implications for existing water use in agriculture. The increase in pre-monsoon rainfall may allow for the possibility of additional crops during a growing season. Nayava *et al.* (2009) pointed out that changed rainfall distribution in February and March had a very good impact on yields. The decline in the wheat yield across the study area could therefore be linked to declines in winter rainfall. Analysis of the influence of pre-monsoon rainfall on maize yields and production by Nayava and Gurung (2010) recommends that maize planting times and varieties need to be adjusted according to the change in rainfall pattern in recent decades. The present study also emphasizes the need for readjustment of the cropping pattern according to the changing rainfall patterns. This also speaks to the need for joint action between scientific and local communities.

According to the SAGUN Program (SAGUN, 2009) water scarcity is experienced broadly, and the drying-up of springs and rivers is an identified risk in the entire Dhading district. Boisvenue and Running (2006) found that climate change has negative impacts on the forest when water was a limiting factor. In the study area the local people perceive an increase in forest area and a

decrease in water sources. Furthermore, people seem confused about apparent contradiction. According to my observation, there is a Eucalyptus plantation near water sources, which may be contributing to water decrease. This observation is supported by research done by Joshi and Palanisami (2011) in the South Karnataka, India, where they found that Eucalyptus roots can grow up to 20-30 feet for extraction of ground water, and the water uptake ranges from 50-90 (liters/day/plant).

The adaptive strategies adopted in this rural part have to a certain extent been helpful in overcoming the agricultural and water stress added by climatic variability. Nevertheless, it should not be ignored that there are needs for improving the adaptive capacity and empowering locals with better adaptive options other than leaving their land fallow and dependent on the increased use of chemical fertilizers. Sovacol *et al.* (2011) also pointed out that there is a need to promote community resilience by enhancing local ownership, building capacity and creating networks that help local to adapt to climate change. Osbahr *et al.* (2010) suggested that to assist adaptation there is a need for location-specific adaptation. Manandhar *et al.* (2010) and Rai *et al.* (2011) have stressed that climate change is not always the main driver behind the impacts on the different sectors, but in many cases it plays the catalytic role, so that changing climate may further aggravate the already-adverse conditions.

Osbahr *et al.* (2010) found that some of the collective adaptive actions enhanced livelihood resilience in the face of climate change and variability, but that others have negative spillover effects. In my research there was previously perma system which has now changed into monetary value. This system should be rejuvenated in every community so that they can better absorb the adverse impacts of climate change.

Migration is a response to climate change impacts in the community and a way of adapting to climate change. In this research, youths are migrating at a higher rate which means there is no proper environment in which to sustain livelihoods. Warner (2009) pointed out that climate-related changes motivate migration in order to "restore back" to the previous position, e.g. getting back the farmland which was washed away by floods.

Impacts of climate change are inevitable and rural communities are the most vulnerable due to their low adaptive capacity, but local people are rich with traditional knowledge. Climate change

cuts across all economic segments, but most seriously affects the rural economy (Bray and Storch, 1999). Since, climate change is largely attributed to complex anthropogenic activities, the solution to climate change does not lie solely in the scientific understanding of the natural world. A response to climate change should include observations, feelings and perceptions by affected of changes in the natural world. These factors can all be used to interpret the climate change in their language so as to develop climate resilient communities.

7. CONCLUSION

This study has analyzed the perception of climate change by local people living in the rural area of Padampokhari village, and their responses to its impacts. Local communities in the rural areas seem to have extensive knowledge of environmental changes, despite being unaware of the term "climate change." Most of the perceived knowledge about its impacts and their responses correspond to the trends observed in the data collected from DHM. The people's perception and data are consistence on temperature increase and decrease in post-monsoon rainfall. This research addresses different resources affected by climate change, including agriculture, forestry, water sources, and the economy in general, of the community.

Local populations experience a number of impacts to their livelihoods with changes in climate. The major impacts in agriculture include declines in crop production, decreases in winter rain, changes in cropping patterns, changes in crop weeds and pest infestation, and excessive use of chemical fertilizers. People have been responding to water scarcity and reduction of water sources in every community by leaving land fallow, shifting to agricultural crops, changing cropping patterns, and increasing the use of pesticides. Local knowledge of climate change can play a crucial role in developing local adaptation strategies. Farmers may not have a full explanation of what they are observing and experiencing, but they can nevertheless help in designing adaptive strategies for climate change and its diverse impacts. Furthermore, local knowledge can help to develop climate resilience at local scales. The development of resilient communities requires creative intervention to control poor practices and to strengthen the adaptive capacity at the local level.

This study found a growing perception among the local people of changes in climate, and therefore stresses the need to develop a mechanism for transferring knowledge of climate change

to the local level and simultaneously exploring local adaptation practices to identify strengths and weaknesses in order to foster climate resilient communities. Similarly, the study found the direct and indirect impacts of climate change are increasingly pronounced in different sectors. Awareness of these changes emphasizes the need to strengthen the adaptive capacities of local people. Local institutions need to communicate knowledge of climatic uncertainty and adaptive practices in order to replicate successful measures to enhance and expand climate resiliency.

Therefore, to minimize the impacts of climate change, the government of Nepal should concentrate on expanding the awareness of climate change impacts and the development of adaptive strategies. This will require further research on climate change mitigation and adaptation at the local, regional and national levels for the rural community so as to implement the adaptation strategies.

8. RECOMMENDATIONS

Awareness of climate change and its impact must be raised within rural communities. Local populations are experiencing changes in climate, but they do not know the cause and consequences of climate change. The capacity for coping with the impacts of climate change must be strengthened. Following are some of recommendations from this work.

- Meteorological data and the objectives of scientific analysis must be combined with the perceptions of local populations to advance understanding of climate change. Combining scientific data and analysis with local people's experience and perceptions will improve understanding of climate change at the local level.
- It is extremely important to include climate perception in a bottom-up approach so that effective climate change adaptation can build a climate resilient community.
- Local adaptation practices must be preserved and promoted so as to minimize climate change mitigation.
- Awareness and sensitization about climate change should be done in the community. Information regarding climate change should be delivered in a local way of understanding change, rather than by using the specific words "climate change."
- This kind of research should be replicated in more rural parts of Nepal for better understanding of climate change at the local level.

- To reduce uncertainty in the production of main crops and cash crops, crop insurance must be established at the local level.
- To preserve local seeds of main crops and endemic crops, seed banks should be established.
- Further study will be needed for climate change mitigation and implementing adaptation strategies in the future.

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Annex I: IRB Permit

UNIVERSITY of WASHINGTON
HUMAN SUBJECTS DIVISION

Date: 7/22/2013

PI: Dr. Stanley Asah
Assistant Professor
Environmental & Forest Resources

CC: Pratibha Duwal

RE: HSD study #45409
"Perceived Impacts of Climate Change on Livelihood: Exploring Opportunities for Adaptation in Padampokhari VDC, Nepal"

Dear Dr. Asah:

The University of Washington Human Subjects Division (HSD) has determined that your research qualifies for exempt status in accordance with the federal regulations under 45 CFR 46.101/ 21 CFR 56.104. Details of this determination are as follows:

Exempt category determination: **2**

Determination period: **7/22/2013 - 7/21/2018**.

Although research that qualifies for exempt status is not governed by federal requirements for research involving human subjects, investigators still have a responsibility to protect the rights and welfare of their subjects, and are expected to conduct their research in accordance with the ethical principles of *Justice, Beneficence* and *Respect for Persons, as* described in the Belmont Report, as well as with state and local institutional policy.

Determination Period: An exempt determination is valid for five years from the date of the determination, as long as the nature of the research activity remains the same. If there is any substantive change to the activity that has determined to be exempt, one that alters the overall design, procedures, or risk/benefit ratio to subjects, the exempt determination will no longer be valid. Exempt determinations expire automatically at the end of the five-year period. If you complete your project before the end of the determination period, it is not necessary to make a formal request that your study be closed. Should you need to continue your research activity beyond the five-year determination period, you will need to submit a new *Exempt Status Request* form for review and determination *prior to implementation*.

Revisions: Only modifications that are deemed "minor" are allowable, in other words, modifications that do not change the nature of the research and therefore do not affect the validity of the exempt determination. **Please refer to the Guidance document for more information about what are considered minor changes.** If changes that are considered to be "substantive" occur to the research, that is, changes that alter the nature of the research and therefore affect the validity of the exempt determination, a new *Exempt Status Request* must be submitted to HSD for review and determination *prior to implementation*.

Problems: If issues should arise during the conduct of the research, such as unanticipated problems, adverse events or any problem that may increase the risk to the human subjects and change the category of review, notify HSD promptly. Any complaints from subjects pertaining to the risk and benefits of the research must be reported to HSD.

Please use the HSD study number listed above on any forms submitted which relate to this research, or on any correspondence with the HSD office.

Good luck in your research. If we can be of further assistance, please contact us at (206) 543-0098 or via email at hsdinfo@uw.edu. Thank you for your cooperation.

Sincerely,

Bailey Bell
Human Subjects Administrator
(206) 221-7918
bbell3@uw.edu

Annex II: Key informant interview Script

Opening Question:

Tell me your name and how many years you have been living in the community?

What is your major occupation to sustain the livelihood?

- Can you please list the sources of income and whether that is sufficient or not? If it is insufficient how do you manage?

Introductory questions:

What are the resources that people depend upon in the community and the community forest?

- Are you a member of the CFUGs?
- What are the resources you depend on in the CF?

What are the resources utilization practices that have been adopted?

- What are the legal procedures to acquire the resources?
- What are the illegal procedures?
- Why does a person do that?

Key Questions:

What are the environmental changes that you have observed in the community?

Let's talk more specifically about the changes, especially drought and the forest changes.

- How often are the extreme events happening?
- How are you adapting to the extreme events?
- Was the adaptation successful in coping with the extreme events? If not why?
- How successful are you coping with climate change impacts? (different problems and the adapting procedures)
- What do you need to adapt to the changes that occur in the community?
- What are the traditional ways of coping with climate change?

Do you ever hear the term climate change in the community? (If yes where and how)

- What do you think about climate change?
- What should you should to cope with climate change?

Specific Questions

Climate change impacts on livelihoods

Block 1 :

What are the major impacts of change in climate variability on the community?

Can you please list the changes in the community due to major extreme events that have impacted in the community?

What sort of livelihood transformations have been observed in the last 20 years?

What are the new sources of the income have been developed in community? Where did the opportunities for new income come from?

Adaptation

Block2:

What are the major problems of climate change affecting in the community?

What are the indicators of climate change?

Do you think it is really happening in the community? Can you please give me an example?

What sort of adaptation techniques have been applied in the community to withstand the extreme events?

Can you please list the adaptation techniques applied in different fields in the community?

Are all these adaptation techniques locally developed or did some organization train you in the techniques?

How effective are the adaptation techniques in withstanding the impacts?

What are the changes needed for adaptation in the community so that the community will be happy?

Which part of livelihoods should be more focused on adaptation and why?

Annex III: Data sheet of focus group discussion

DATA SHEET OF FOCUS GROUP DISCUSSION

Community perceptions on ecosystem services and change over time

Ecosystem Provisions	**How do you benefit?**	**Benefit changed over time?**		**Why the change?**
		Before	**now**	
Agriculture Ecosystem				
Livestock				
Fruits				
Cereals				
Fowls				
Community Forest				
Timber				
Fuelwood				
Fodder/litter/leaves				
NTFP				
Salforest/regeneration				
Invasive species				
Water Resources				
sources				
Drying sources				
Accessibility				

Seasonal calendar

Livelihood	Monthly Calendar												
	English Month	Mid April-Mid May	Mid May-Mid June	Mid June-Mid July	Mid July-Mid August	Mid August-Mid Sept.	Mid Sept.-Mid Oct.	Mid Oct.-Mid Nov.	Mid Nov.-Mid-Dec.	Mid Dec.-Mid Jan.	Mid Jan-Mid Feb.	Mid Feb.-Mid March	Mid March-Mid April
	Nepali Month	Baishakh	Jestha	Aashadh	Shrawan	Bhadra	Ashwin	Kartik	Mansir	Paush	Magh	Falgun	Chaitra
Climate Pattern													
Rainfall	Before	← – →		←	—	—	→			← – →			← – →
	Now	← – →			←	—	→						
Hailstone	Before	↔										← – – →	
	Now	↔										← – →	
Warmer Days	Before	← — →		← – – –	– – →	— →					← – →	← — →	
	Now	← — →			← – –	– →						← – – →	← – →
Colder Days	Before						← – – –	– →	← — →			← – →	
	now						← – – –	– →	← — →			← – →	
Flood/ Landslide	Before				← — →								
	Now				← – – –	– →							
Drought	Before		← – →									← – – –	– →
	Now	← — →			← — →		← —	— — —	— — —	— — —	— — —	— — —	— →
Strom	Before	↔										← – – –	– – →
	Now	↔										← – – –	– – →
Forest Fire/Fire	Before	← — →											← — →
	Now	← ···· →											← ····· →

Livelihood calendar

Livelihood	Monthly Calendar												
	English Month	Mid April-Mid May	Mid May-Mid June	Mid June-Mid July	Mid July-Mid August	Mid August-Mid Sept.	Mid Sept.-Mid Oct.	Mid Oct.-Mid Nov.	Mid Nov.-Mid-Dec.	Mid Dec.-Mid Jan.	Mid Jan-Mid Feb.	Mid Feb.-Mid March	Mid March-Mid April
	Nepali Month	Baishakh	Jestha	Aashadh	Shrawan	Bhadra	Ashwin	Kartik	Mansir	Paush	Magh	Falgun	Chaitra
Agriculture Based													
Rice Production	Before			←	– – –	– – –	– – –	– – –	→				
	Now												
Maize Production	Before	—	—	—	—	—							←
	Now	←	—	—	—	—							
Millet Production	Before			←	—	—	—	—	→				
	Now				←	—	—	—	→				
Legumes (Rice Bean/ Horse Gram	Before				←	—	—	—	→				
	Now												
Animal Husbandry	Before	←	—	—	—	—	—	—	—	—	—	—	→
	Now	←	—	—	—	—	—	—	—	—	—	—	→
Labor													
Agriculture Based	Before	← — →		←	—	—		→	→				→
	Now	← – – →			←	– – →		←	– – →				← – →
Construction	Before								←	– – –	– – –	– – –	→
	Now	← — →					←	—	—	—	—	—	→
Others (Remittance)	Before												
	Now	←	—	—	—	—	—	—	—	—	—	—	→

Livelihood Productivity and Productivity Inputs

Productivity			Inputs		
	Before	**Now**		**Before**	**Now**
Agriculture			**Agriculture**		
Rice					
Maize					
Millet					
Traditional legumes					
Fruits/Cash Crops					
Animal Husbandry			**Animal Husbandry**		
Pig					
Buffalo					
Cow					
Goat					
Labor				**Labor**	
Agriculture based					
Construction					
Remittance					

"Climate change "------ word …. Heard …. Yes/No?

Where do you heard the Climate change?

How do you think about climate change?

Perception of CC	Perception of Vulnerability	Key Impacts	Local adaptation to reduce impact	Effectiveness	Remarks
Drought •					
Heat/Cold					
Diseases in livestock/Agriculture					
Forest • 1st • 2nd • 3rd					