

CAN ADAPTATION TO CLIMATE VARIABILITY AND CHANGE BE COMBINED WITH MITIGATION OF EMISSIONS AT THE LOCAL LEVEL?

A COMPARATIVE STUDY OF TWO COMMUNITY FOREST USERS GROUPS IN NEPAL

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Declaration

I, Bijaya Neupane, declare that this thesis is a result of my research investigations and findings. Sources of information other than my own have been acknowledged and a reference list has been appended. This work has not been previously submitted to any other university for award of any type of academic degree.

Signature.....

Date.....

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Abstract

This research investigated how community forest user groups at two sites in Nepal adapt with local weather events and climate variability, and the major factors that affected adaptive capacity of local people. Besides, this research identified to what extent the community forests could help in managing climate variability that impact on sustainable livelihood by improving the adaptive capacity of local people. This study also quantified the total above ground carbon sequestered by two community forests (CFs) situated in different altitudes. On the basis of this analysis, the implications were drawn out how carbon sequestration and adaptation to climate variability and change could be best combined at local level.

The main weather events and climatic variability found in the study sites were increase in dry periods, changes in rainfall pattern and increase in temperature. It was found many households in the study area were engaged in several adaptation activities, such as changing in cropping patterns, choice of crop species, local trade like selling of fishes, alcohol, vegetables, wooden and bamboo products, livestock farming, adding chemical fertilizers in farm land to increase productivity, collection of community welfare funds, involvement in seasonal jobs and out-migration.

The CF situated at lower altitude (Jalbire Mahila CF) sequestered 131.54 t ha^{-1} above ground carbon pool and the CF situated at higher altitude (Laxmi Mahila CF) sequestered 52.90 t ha^{-1} above ground carbon pool even though both CFs were in the same ecological zone (mid-hill) of Nepal. The species *Shorea robusta* was found sequestering more carbon pool on both CFs and the larger amount of carbon pool was found in stem of all the species.

There were some minor conflicts and quarrels between higher castes people and lower castes people regarding CF boundary encroachment, illegal collection of CF products, forest products distribution, loan distribution and fund transparency in the study area. The establishment of CF was not the major solution for managing climate variability and improving the livelihoods of poor and marginalised people in the study area. The main constraint of CF establishment was that the local people could not access to the forest products at any time on their own will.

KEY WORDS: Adaptation, carbon sequestration, climatic stress, empowerment, encroachment, fund transparency and vulnerable.

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Chapter 1: Introduction

Climate change is any change in the climate over time that continues for about few decades, due to natural variability or result of human activity. Though climate change is a major global issue, it has also been a great environmental and social challenge for Nepal. The emission of carbon dioxide and other green house gases from energy and industrial sources is also low in Nepal, but the country is ranked as one of the top ten countries which is most likely to be impacted by global climate change (WFP, 2009a). By some studies, it is recognised as the fourth most vulnerable country by the international community (Gautam, 2012; Maplecroft, 2011; Shrestha, 2012).

Weather events and climatic changes that have been reported (MFD, 2011) include late monsoon, irregular rainfall, flash floods, hotter summer and less cold winter. Some of these changes could be attributed at least in part to anthropogenic climate change (Gerrard and Gardner, 2000; Sidle et al., 2006). Various ecological zones of Nepal namely plains, hills and mountains (UNNIP, 2000; Malla, 2008) have faced climate change effects differently. For example, mountain communities receive less snowfall and experience increasing melting. Similarly, water sources are drying in the mid-hills and on the plains people receive greater flooding and unexpected cold waves. All these changes tend to contribute to reduced crop production or even shortage of food (Malla, 2008). This has negative impact on the rural economy. Majority of the people (about 80%) rely on agriculture for their livelihood and follow old cultivation practices in Nepal (Regmi et al., 2009a). Socio-economic and environmental factors are severely affecting Nepalese agriculture sector along with climate change (Bartlett et al., 2011). Various effects are observed on agriculture land such as soil erosion, landslides, drought and flood which ultimately reduces the productivity and yield. Due to low adaptive capacity in rural agriculture in Nepal, people are forced to migrate to cities or abroad for seeking employment. Increase of forest fires in dry periods, pests and diseases in crops, livestock and human population are frequent in Nepal due to climate variability (Bhatta, 2011).

It is indicated that different local communities of developing countries have developed their own adaptation and coping strategies. Some rural communities of Nepal have developed several adaptation measures based on their local knowledge and experience such as changing the crop species, cropping pattern and farming techniques in managing the climate variability

and change (Malla, 2008; Bhatta, 2011; Tiwari et al., 2010). The poor and marginalised in Nepal have access to fewer adaptation options. So, there is need for local level studies on adaptation processes in order to develop policies that can help those communities (ISET, 2008).

Gilmour and Fisher (1991) define Community Forest as the control and management of forests by the rural people for their domestic purposes which also became the entire part of their farming systems. From a climatic point of view, CF is significant; since they contribute in increasing the capacity of natural carbon sink (Karky and Skutsch, 2010). In Nepal, many rural communities fulfil their basic requirements such as fuel wood, fodder, timber, etc. from the CF. Some studies have reported that CF in Nepal has played dual role: enhancing the livelihood of the poor people and mitigating the greenhouse effect (Adhikari, 2011). In this regard, the community forest (CF) in Nepal might be the solution to manage the impact of climate variability at local levels (Bishokarma, 2010a).

Despite the significant of CF, women, poor and marginalised or socially excluded people called “dalits” are excluded in CF program of Nepal mainly in terms of decision-making and benefit sharing (Thoms, 2008; Uprety et al., 2012). These groups of people depend more on forest resources for their livelihood. The main causes for their exclusion are socio-cultural, economic and institutional factors. So, the livelihoods of such forest dependent people are not improved. Since many users groups of CF in Nepal are dominated by elite capture (high caste and wealthier people), they develop the rules in favour of them ignoring the problems of dalits (untouchable castes), women and poor people in the community. These groups of people are even unaware of the total income and expenditures of CF. In rural areas of Nepal, poor, marginalised people and women are more affected by climate change. These people have less capacity to cope and adapt with climate variability and change due to lack of knowledge and resources (Gum et al., 2009).

At the same time, productive and well-managed CF has the potential to sequester good quantity of carbon which can contribute mitigating the greenhouse effect. A programme to mitigate the impacts of climate change through reducing of carbon emissions from deforestation and forest degradation (REDD) in developing countries has been launched under the United Nation’s Framework Convention on Climate Change (UNFCCC). Nepal signed as commitment to contribute reducing global warming on 2007. The World Bank has assisted the developing countries in building capacities for REDD. Nepal submitted letter of

intent to the World Bank. Along with this, the final draft of readiness plan for REDD was prepared and submitted to the World Bank on 15th April 2008 after several meetings and working sessions of forum consisting of representatives of government, non-government, civil society, private institutions and donor organisations. After being approved in July 2008, Nepal formally became a participating country on REDD (RFCCC, 2010). The future will show whether the financial aid provided by REDD program can really help the poor and marginalised groups or not.

The following objectives were developed in order to explore the information in answering the main research question “Can adaptation to climate variability and change be combined with mitigation of emissions at the local level?”

Objectives

- to identify the adaptive measures being used by local populations to manage climate variability, and the factors affecting these measures,
- to quantify total above ground carbon sequestered by community forests and how measures promoting the forest conservation impact positively or negatively on sustainable livelihoods,
- to conclude how carbon sequestration and adaptation be best combined at local level.

Chapter 2: Literature review

2.1 Local climatic hazards and their effects

There is the clear distinction between climate variability and climate change. Weather changes daily but climate conditions vary between seasons and years. This variation in climate can be noticed by evidences like short winter, early snow fall in winter and heavy rainfall in summer. So, climate variability is the way by which climate changes yearly above or below the average long term value whereas climate change is the long-term change in average weather conditions (temperature, precipitation, wind), typically measured over 30 years (Dinse, 2011). According to IPCC's Fourth Assessment Report on Climate Change 2007, Climate change refers to any changes in the climate due to natural variability or human activity that persists for long period, usually decades or longer and can be recognized by means of statistical tests. Anthropogenic climate change in the context of the UNFCCC refers to warming of mean global temperature due to increased concentrations of green house gases in the atmosphere. This change in average temperatures manifests itself in changing climatic variability, such as seasonality, timing of rains, maximum and minimum temperatures, heat spells, intensity and frequency of extremes.

In Nepal, local people have been experiencing a shift in climate conditions, including increasing climate variability in the recent years, such as prolonged droughts, irregular rainfall which has negative pressures on forests and agriculture lands on Nepal (Bartlett et al., 2011). Some of the local climate change indicators in the mid-hills of Nepal include: early sprouting of grasses in pasture, incidences of flies and mosquitoes for long period of time, disappearance of local bird species, shifting of fog line in valleys towards higher elevations, increase in intensity of monsoon rain, longer dry season, and irregular rainfall (Local people, Jalbire Mahila CF).

Changes in climatic conditions such as an increase in dry periods affect rain-fed agriculture system in hilly regions of Nepal, in particular the crop productivity. Due to delayed rainfall, farmers had to face severe problem for planting rice seedling (Bartlett et al., 2010). Many rice seedlings were lost and many were not viable for producing good yield. Similarly, the people of western regions in Nepal are vulnerable and affected due to heavier winter rains. In 1999, there were large landslides in Laprak (Gorkha district) due to intensive rainfall, steep

topography, deforestation and heavy cultivation which destroyed huge lives and properties (Khanal, 2007).

The mid-hills of Nepal consist of complex topography and the output of global climate scenario modelling suggests that the impact of climate change is more intense in high elevations and in regions with complex topography that affects livelihood of rural people (Dixit, 2010). Shifts in local climate conditions have adverse impacts at a local level, such as reduced water flow in local rivers, lack of irrigation due to drying of local water sources, and the appearance of new crops and livestock diseases. Some local people who were dependent on herbs and fruit trees for their livelihood support are seriously impacted due to disappearance of such species.

The seasonal or long-term domestic and international out-migration among the adult of rural community is common in Nepal. Since the agriculture type is labour intensive, the agriculture sector is seriously affected by the out-migration of adult people in the community (Massey et al., 2007). On the other hand, about 64% of the cultivated area fully depends on monsoon rainfall (Chaudhary and Aryal, 2009). Poor and marginalised people called “ dalits” are more vulnerable to climate variability and change. Within these groups, women are mostly affected by the impact of climate variability and change (Sagun, 2009) because women spend most of their time in agricultural activities and caring their children in Nepal. As for example, due to high frequency of out-migration among adults especially male in Nepal, the women have to manage everything even when the family members become ill and so on. Local people might be aware about the local climatic hazards and their impacts but they are seldom familiar with global climate scenario and adaptation techniques (Regmi and Adhikari, 2007). Therefore, there is a need for designing community level or local level adaptation practices such as diversification of crop species that can survive in extreme climatic condition.

2.2 Adaptation to climate variability at local level

According to (Ravindranath, 2007), mitigation and adaptation are the two main strategies to address climate change. IPCC report 2007 defined mitigation as an anthropogenic intrusion to reduce the emissions and concentrations of greenhouse gases from the sources and in the atmosphere whereas adaptation as the ability of a system that can moderate possible damage , can take benefit of opportunities and manage with the effect by adjusting to climate

variability and change. Because of its low emissions combined with high vulnerability, adaptation may be a higher priority than mitigation in Nepal, despite of the fact that the international community have focused more on mitigation.

Nepal has high temporal and geographic climatic variability with climate zones ranging from sub-tropical to alpine due to large variation in altitude and precipitation. Even in short distance of 200 km from North to South, Nepal covers six geological and climatic belts ranging altitude 95 metres to 8000 metres above mean sea level. Agriculture is the main source of economy of Nepalese though only 27 % of country's land is cultivated and 1/3th of that land is irrigated (Dixit, 2010). Around 70% of Nepalese population rely on subsistence agriculture for living (NCVST, 2009). The rural people have to rely on climate sensitive sectors such as forestry, agriculture and fisheries. Some studies show that climate variability and change is mostly affecting agriculture sector in Nepal (Regmi and Adhikari, 2007; WFP, 2009; Bhatta, 2011). In Nepal, more than 86% of people live in rural areas and 89% of total energy is fulfilled by fuel wood (Koirala, 2007).

Many communities of developing countries are adapting with climatic variability and extreme weather events at local level (Adger et al., 2003). Some previous studies tells that local farmers of Nepal have also developed adaptation measures such as less water use, greater cropping intensity, changing in crop species, crop cultivation time, harvesting time, crop diversification, micro-irrigation and small-scale storage to adjust during climate variability (Gauchan, 2009; Baral et al., 2010; Tiwari et al., 2010). Several other adaptation options can be developed through knowledge and experiences of community based adaptation. However, every response to climate change may not be a good one in terms of being viable from social and environmental point of view (Eriksen et al., 2011). In particular, if adaptation is to contribute to sustainability, strategies have to address social equity and environmental integrity.

In Nepal, there are various examples of informal community based adaptation practices. For example, subsistence farmers have started to adjust their cropping seasonal calendar and have coped with drought through increased collection of local medicinal herb (WFP, 2009b). Another example is storing water in ponds for irrigating in the rural areas of the country. However, some significant traditional and local knowledge of Nepalese farmers such as selection of fodder trees on private lands, crop diversification, shifting natural resource based livelihood to livestock, seasonal migration, adopting agro forestry practices, following

rotational grazing, planting live fences, constructing brushwood check dams on landslide or erosion prone areas, storing grain seeds and fodder etc. have contributed a lot in adapting to climate variability and change (Chapagain et al., 2009). Local, traditional and indigenous knowledge of the local community need to be integrated into any formal adaptation responses in order to contribute to more sustainable development pathways, including social equity and environmental integrity (Eriksen et al., 2011).

One type of adaptation commonly practised in Nepal is agricultural: Some farmers in mid-hills of Nepal have changed the crops types due to prolonged dry months. They have planted banana species as being perennial crops more resilient to erratic precipitation (Gurung, 2007). Some farmers have started to grow maize and millet instead of rice in mid-hills of Nepal. They are also planting fruit species on slope land instead of agriculture crops. Besides, they are also conducting some income generating activities like vegetable production, goat keeping, milk production, small scale cottage industry and so on.

In addition, adaptation also means diversifying into other non-agricultural activities such as trade, which has been important in managing climatic variability that can support rural livelihoods. As for example, in the high altitude of Nepal, the communities earn money by collecting and selling valuable NTFP “Yarshagumba” (*Cordyceps sinensis*). Also, in the hilly regions, the sources of income are production and selling of vegetables, dairy products, chicken and eggs (Macchi et al., 2011). However, the productions of these commodities are reduced due to lack of enough water and local resources. Soil and water conservation activities such as terrace farming, slope land agriculture techniques, planting multipurpose trees have been conducted by the rural people with their own knowledge and ideas.

There are various limitations for mitigation and adaptation in context of Nepal such as lack of institutional and legal coherence, policy, awareness, and access to information in rural communities of Nepal. The adaptive capacity of rural community especially the poor people is low and they seldom receive emergency aid (support from local organisation, government, neighbours that includes food, clothes, and housing) even after climatic shocks or stresses (Regmi et al., 2009b). Poor people who depend on natural resources and who have few capital assets and livelihood options have low adaptive capacity and become more vulnerable to climate variability and change (Dulal et al., 2010).

Many rural areas in Nepal are not easily accessible, have very few resources and facilities. In hilly areas of Nepal, the poor people have limited livelihood options (Charmakar and Mijar,

2009). These people have few assets to recover and built livelihood after climatic stresses so they are vulnerable to adverse weather conditions that affect crops, animals, water sources and other natural resources. They have inadequate access to even basic infrastructures such as drinking water, health services, education and electricity. Due to land fragmentation among sons/male members in Nepalese family, there is insufficient land for future land security. The poor people having low land holding size and less productive land are becoming poorer and poorer due to land fragmentation in Nepal (Adhikari, 2008).

2.3 CF development and carbon sequestration

In developing countries like Nepal, there are several examples of successful communities who have converted degraded lands into well developed forests through sustainable management practices such as CFs in Nepal (Adhikari, 2011). The concept of CF was developed during late 1970's in Nepal when the state could not manage the deteriorating condition of the forests. Before the establishment of CF program in Nepal, the forests were under the private property which later nationalised under Private Forest Nationalization Act 1957. After that, the trees were chopped carelessly and forests were degraded severely because of state's control over and lack of people's ownership on it. The large forest areas were converted into barren land and realizing the importance of people's participation in forest management, the government of Nepal provisioned the system of handling portion of government forest to local political unit called "Panchayat", mentioned in National Forest Plan, 1976. After this too, there was continued deforestation and forest degradation during the period 1979-1994 (Ojha et al., 2008). Finally, Forest Act 1993 gave sole rights to the local people for the management of government owned forests as CF.

In CF, the local users develop the work plan to conserve, use and manage the forest as well as sell and distribute the forests products independently by fixing their prices. Some CFs became able to control the deforestation and maintain the forest in good condition fulfilling the basic requirements of people in mid-hills of Nepal (Acharya and Sharma, 2004). During the last 3 decades period, about 25% of the total forests cover around 1.219 million hectare being managed by 14, 337 Community Forest User Groups (CFUGs) distributed across 1, 647, 700 households i.e., about 35% of total population (Acharya et al., 2009). The forest act 1993 formally recognised CFUG as autonomous bodies which mean self-planning, self-

managing and self-implementing body. Every CFUG develop their own rules and regulations in protecting and managing their forest.

With comparison to atmosphere CO₂ (3000 Gt CO₂), forests accumulate more carbon dioxide (4500 Gt CO₂) and contributes significantly in global carbon cycle (Prentice, 2001). During the vegetation and plants growing season, the large quantity of CO₂ is taken up from the atmosphere and converted into plant biomass (Losi et al., 2003; Samalca, 2007; Deo, 2008; Adhikari, 2011). The forests have been declared for carbon sequestration by UNFCCC with its Kyoto Protocol and REDD (Reducing emissions from deforestation and forest degradation). In Nepal, CF has been recognised as major source of carbon sink. It is reported that about 20% of the total carbon stock is found in CF (Pokharel and Byrne, 2009). Carbon sequestration can be understood as the capturing of atmospheric CO₂ into green plants through which it can be stored for long time (Watson et al., 2000). This storage can be both above ground biomass (trees), under storey vegetation and below ground parts (roots and micro-organisms). This natural process of removing atmospheric CO₂ from the atmosphere is one of the effective techniques of mitigating the atmospheric CO₂ levels (Jina et al., 2008).

2.4 Positive and negative impacts of CF on rural livelihood

Chambers and Conway (1992) define livelihood as the people's capabilities and their means of living, which includes food, income and assets. The livelihood is said to be sustainable when it can cope with stress and shocks, maintain capabilities or resilience and provide opportunities for the next generation with long term and short term benefits at both local and global levels.

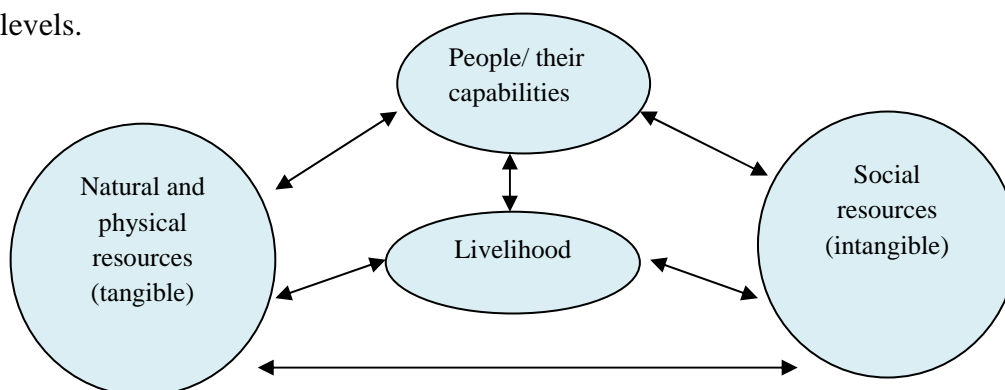


Figure 1. Livelihood components and relationship (adapted from Chambers and Conway, 1992)

Sustainable livelihood is closely related with availability of capitals (natural, human, social, physical and financial) and judgement of vulnerability such as trends, shocks and stresses within these capitals (Scoones, 1998 and Morse et al., 2009). These five capitals are suggested as essential elements for livelihood which are briefly described below:

a. Natural capital means natural resources such as air, water, soil, genetic resources and environmental services like hydrological cycles and pollution sinks.

b. Social capital means social resources such as social relations, networks and associations.

c. Human capital means human knowledge, skills, good health and physical ability.

d. Physical capital means physical infrastructures such as buildings, roads, production equipments and technologies.

e. Economic or financial capital means capital base such as cash, credit/debit, savings and other economic assets.

Some capitals are corporeal such as buildings, land, and cash and so on while some are incorporeal such as social networks, knowledge and good health. The balance in these capitals changes from household to household and over time depending on locations and vulnerability. Irregular rainfall for example will impact on natural capital and as a result reduce crop productivity, but may have less impact on other capitals. However, in long run this continuous irregular rainfall might reduce adaptive capacity on agriculture which impact on wide range of capitals, including social and human as people emigrate. In the context of my case studies, the capitals for household levels in the locality are:

a. Natural: Agriculture, farmland and forest resources.

b. Social: Access to social networks, decisions and social relations

c. Human: Skill development, awareness, knowledge and maintenance of good health

d. Physical: Community development works such as trails, water tank, shade and shelter

e. Financial/economic: Saving funds, providing loans and income generations

These capitals and resources are related to the tangible and intangible resources and ability to secure livelihoods and adaptive capacity as shown in fig. 1. The table 1 below is showing

how the community forest could contribute to strengthening the five capitals and related adaptive capacity at the community level.

The following criteria were developed in order to identify the differences between two study sites regarding 5 livelihood assets/ capitals.

Table 1. Criteria for evaluating 5 livelihood capitals in the study area:

Capitals	Indicators/ Criteria
Natural	Improvement in forest condition; availability of forest products like fuel wood, timber, fodder in adapting with extreme weather events and climatic variability which supports livelihood; reduction in time for collection of forest products
Social	Capacity building of users; participation of poor, women and marginalised people including lower castes “dalits”; maintenance of social harmony or no conflicts
Human	Access to skill development trainings; gain knowledge and experiences which help to adapt with extreme weather events and climate variability; leadership development of users, maintenance of good health of people
Financial	Development of community saving fund that can support poor and marginalised households during problems caused by natural disasters and climate variability; collection of good income from selling forest products from CF
Physical	Carrying out the community development works such as construction of trail, community building for providing shade and shelter to visitors and pedestrian, school repair, water tank, water taps, etc for the benefit of community.

Sources: (Carney, 1998; Scoones, 1998; Solesbury, 2003; Morse et al., 2009)

There are both opportunities and limitations to achieve sustainable livelihoods. In this study, sustainable livelihoods is evaluated by accessing the CF contribution in meeting the local needs for important forest products and enhance the physical, financial and social capitals of the communities (see Fig. 1 for conceptual framework). A major obstacle for sustainable forest management in Nepal is the lack of institutional capacity and proper arrangements (Pokharel et al., 2007). Institutional capacity here refers to capacity building, awareness, adaptive capacity and participation of poor and marginalised people. In some studies, it is reported that the rural people conduct climate change adaptation activities like plantation activities, community development works, and income generating activities such as goat rearing which directly and indirectly contributed their livelihoods (Dhakal and Masuda, 2008).

Some previous studies have suggested that the CF program in Nepal represents a successful example for enhancing biophysical environment and improving livelihood of some rural people (Subedi, 2006; Pokharel et al., 2007; Dhakal and Masuda, 2008; Ojha et al., 2009). As such, Nepal is renowned for its forest management approach in terms of Community Based Natural Resource Management (CBNRM). The fund established by CFUGs or local people at local level have proved to be fruitful in supporting people suffering from climate change incidences such as forest fire, landslides, drought, etc. The sources of fund are grants received from Village Development Committee VDC or municipality, CFUGs, NGOs and INGOs. Thus, CF have been successful in protecting people and the resources from harmful effects of climate change and providing opportunities for sustainable rural development and poverty alleviation through income generation activities (Bishokarma, 2010b).

At past, CF was intended just to fulfil the needs of forests products of local people, but now it is able to conserve the environment as well. It has helped the local communities to generate some income generating activities. The CF of Nepal helped in livelihood improvement of some rural people providing forest products such as timber, fuel wood and non-wood products (Ojha et al., 2009). For example, the Chepang tribal communities of Nepal have good knowledge on forest products and highly depend on those resources for food and medicine (Khatiwada et al., 2012). Some people collect fruits and medicinal herbs (e.g. mushroom, fern) from forest for selling in order to run their livelihood. So, rural livelihoods, mainly of the poor, are likely to be closely related with benefits provided by the forests.

At the same time, others have also argued that livelihood of several social groups is affected due to CF establishment because they are deprived of forest resources to conduct their traditional occupations. For example, livelihood of transhumance livestock grazers (Gautam, 2009) have been severely affected due to establishment CF. The common problems of CF reported by many studies are exclusion of poor, women and marginalised groups from gaining access to, social inequity during benefit sharing and decision making and control over CF resources (Adhikari et al., 2004; Gautam, 2009; Gentle et al., 2007; Pokharel and Nurse, 2004; Richards et al., 2003). Some CFUGs or local people have also faced problems regarding transparency of CF funds. Decision-making and benefit sharing are often captured by the local elites, wealthier and upper caste groups like Brahmin and Chhetri (Iversen et al., 2006). They dominate in decision-making position in the executive committees of CFUG.

Hence, the socially marginalised people such as poor, women and dalits often lose several opportunities of CF programs (Gautam, 2006; Uprety, 2006). For example, the women's representation in the apex body and in the REDD + working group is less than 10% (WOCAN, 2012). There is also negligible representative of marginalised people in the committee of many CFUGs. Even the marginalised people are participating in several CF programs; their physical presence does not guarantee their influence (Lama and Buchy, 2002; Nightingale, 2002; Timsina, 2002). The factors that bring social exclusion in CF programs are caste culture, social hierarchy, economic status and education of the people.

Though several community developments works such as construction of trails, water tank, repair and maintenance of schools, shade and shelter are built through the income of CF, some of the pressing problems of marginalised people are not really addressed (Kanel, 2004; Uprety et al., 2012). The policy of CF of Nepal has also emphasised in setting formal rules rather than focusing on the instant needs of poor, dalit and women (Bista et al., 2012). As for example, many CFs have developed the rules that the poor users pay lower or no fees for access to timber; however, this does not actually provide benefit to them because they are neither allowed to sell timber nor that timber can fulfil their subsistence needs. The rich people can also collect forest products from their private lands but the poor people have no other options than to rely on the resources of CF (Thoms, 2008; Adhikari et al., 2004; Malla et al., 2003).

Besides, the establishment of CF has led to the loss of traditional users in all ecological regions of Nepal. For instance, the hill migrants who live in terai are more active and tried to monopolize the use of CFs which is critically distressing the traditional users. Similarly, raising and herding of livestock is the main source of economy of high mountain farmers. Those livestock herders used to herd their livestock from high hills to mid-hill regions during every winter. But the establishment of CF in mid-hills have excluded those seasonal users which have seriously affected their livelihoods. In many hilly regions of Nepal, the socially marginalised people like blacksmiths have left their occupation after the establishment of CF (Dhakal, 2006). In many CF, those groups of people are excluded from charcoal collection.

The CF program of Nepal has given less attention to the social heterogeneity and resource diversity. The poor users are very weak that they cannot even generate better livelihoods options through the use of their available forest resources (Bishokarma, 2010a). Often, only the economically better off and high caste women have benefited even in case of female

managed CF (Buchy and Paudyal, 2008). Many CFs have paid less attention to the poor and to lower caste women. Thus, unless the socio-economic exclusion at community level is properly addressed, the participation woman in the CF program is meaningless.

2.5 REDD approach in Nepalese context

The carbon sequestered by the government managed forests in Nepal is 596.03 million tons and CF is 183.40 million tons (Pokharel and Byrne, 2009). The CFUG income will be supported if they will be able to get reward for carbon which can be helpful for sustainability of CF (Staddon, 2009). (Ojha et al., 2008) said that REDD will take few years to come into effect since voluntary carbon markets are already existing and compliance market for REDD is in process. Accordingly, the REDD which was later expanded to REDD+ was implemented in three watersheds areas of three districts of Nepal in the year 2011 (Adhikari, 2012). The summary information is given in the table below:

Table 2. CFs in several districts of Nepal rewarded by REDD+

Watershed	Total area (ha)	District	Carbon Pool (million ton)	Number of CFUGs benefited	Amount received through REDD (\$)
Charnawati	5996	Dolakha	4.6	58	45,535
Kayarkhola	2383	Chitwan	2.5	31	21,905
Ludikhola	1888	Gorkha	1.5	16	27,560

Source: Adhikari (2012)

Project on Reducing Emissions from Deforestation and Degradation Plus (REDD+) has been working with International Centre for Integrated Mountain Development (ICIMOD) which has collaboration with the Federation of Community Forest Users, Nepal (FECOFUN) and the Asia Network for Sustainable Agriculture and Bio resources (ANSAB) since 2009 and has established First Carbon Trust Fund (FCTF) and implemented in three watershed areas of Nepal in 2011 (Table 2). To include the role of conservation, sustainable management of forests and enhancement of forest carbon stocks in reducing emissions, the project REDD was expanded to REDD+. “The Norwegian Agency for Development Cooperation (Norad) has helped with the money of \$100,000 for the fund in this project. For the sustainability of this project, REDD payment are being allocated to the communities mainly being based on four criteria — quantity of forest carbon saved above the baseline, number of households of indigenous and marginalised people, the ratio of men and women and number of poor

households within the project area (focal person of REDD Programme at FECOFUN, Gorkha, Nepal). Rural communities can be trained for monitoring carbon stock in their forests which helps to reduce high transaction costs of REDD+ scheme in rural community of Nepal (Banskota et al., 2007). Due to the technological and financial constraints, REDD+ market could not expand in several other districts of Nepal. Moreover, due to lack of tenure rights to communities, high rate of deforestation in CF of plain areas in Nepal, the CF are excluded under CDM.

Chapter 3: The case studies

Study area

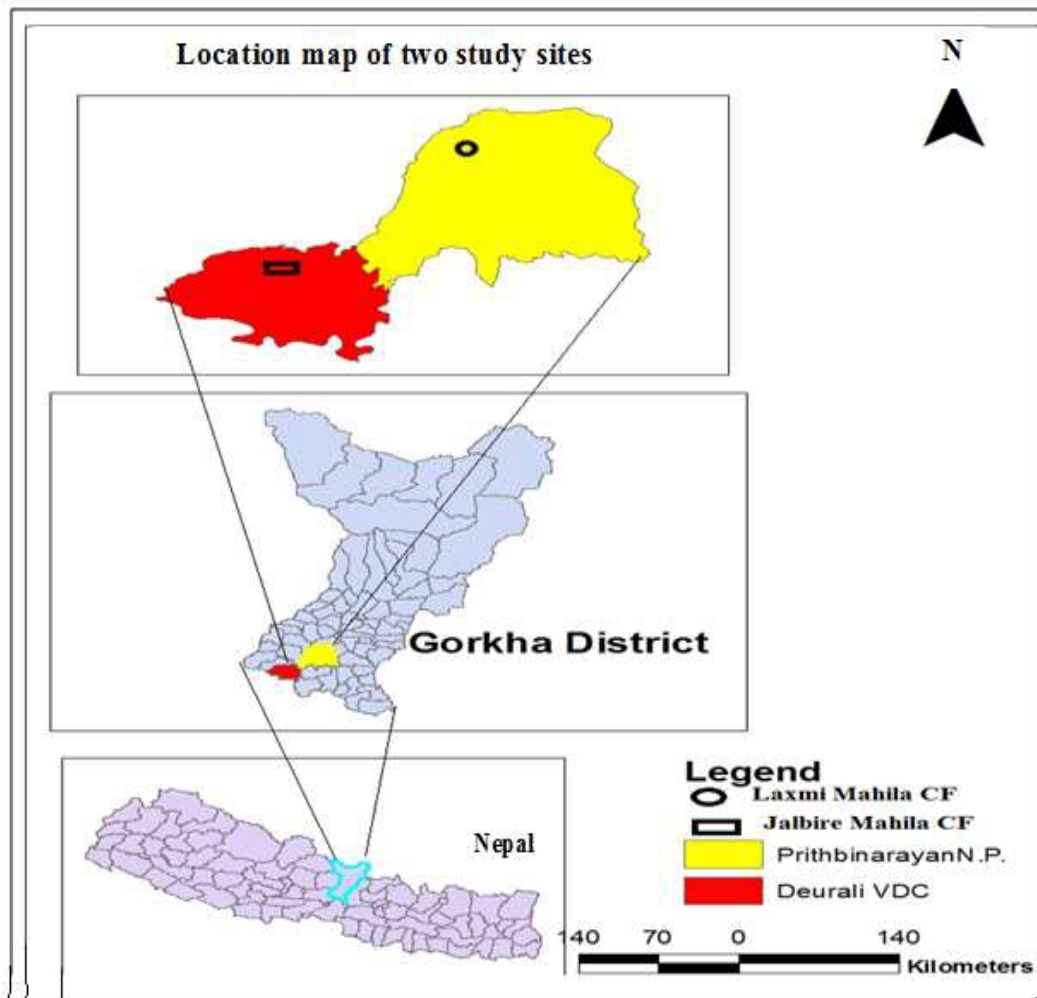


Figure 2. Location of study area

The two case study sites are located in mid-hills of Nepal, both affected by climatic variability and drought, where agriculture and animal husbandry are dominant economic activities. These sites were selected after a field visit identifying these features. Jalbire Mahila CF is situated in Deurali VDC in Gorkha district and Laxmi Mahila CF is situated in Prithvi Narayan Municipality in same district of Nepal. The characteristics of the study area are summarized in Table 3.

Both sites show signs of irregular rainfall that varies year to year, long drought, soil erosion, invasion of unwanted weeds, and diseases in agriculture crops, hail storms (Jalbire Mahila CFOP, 2011 and Laxmi Mahila CFOP, 2009). Rice is the main food crop there which

requires sufficient water. Some lands had to be irrigated with rain water and when the rain could not occur in time, the farmers had to wait for rain for rice cultivation. The rainfall occurs mainly from June to mid of September. But, due to climate variability there was irregular pattern of rainfall, sometimes occurring in other months too. This was the new climatic variability observed in the study areas since past few years. July to end of august rains is heavier in Gorkha district of Nepal.

Table 3. Characteristics of study area

Characteristics	Jalbire Mahila CF	Laxmi Mahila CF
Area (ha)	6.5	8.1
Households	40	84
Population	217	458
Caste or ethnic groups	Chhetri, Magar, Gurung and Sarki	Brahimin, Chhetri, Newar, Magar, Gurung, Damai and Sarki.
Rainy periods	June, July, August	June, July, August
Altitude (m)	600 m above mean sea level	900 m above mean sea level
Slope (degree)	10-20	20-40
Major tree species	<i>Shorea robusta</i> , <i>Schima wallichii</i> , <i>Dalbergia sissoo</i> , <i>Acacia catechu</i> .	<i>Shorea robusta</i> , <i>Schima wallichii</i> , <i>Castanopsis tribuloides</i> .
Major wild animals	Monkey, Jackal, leopard	Monkey, Jackal, leopard
Major food crops	Rice, maize, pulses	Rice, maize, millet, pulses
Species dominancy	Pole size (dbh 10-30 cm)	Pole size (dbh 10-30 cm)
Major occupation	animal husbandry, small business, carpentry, working in rubber factory	small business, abroad income, teaching profession
Income generation activities	Making leaf plates from leaves of sal, plantation of amriso, bamboo and produce brooms, baskets, and several other products of bamboo species. The plantation of medicinal species like harro, barro, amala, kurilo.	Making leaf plates from leaves of sal, plantation of amriso, bamboo and nigalo to produce brooms, baskets, several other products of bamboo species. The plantation of medicinal species like harro, barro, amala, kurilo.

Chapter 4: Data collection and analysis

Data were collected in December 2011 and January 2012. Various methods were used for collecting both qualitative and quantitative information which are briefly discussed below:

4.1 Socio-economic data

Structured, semi-structured and unstructured questionnaires (Bryman, 2008; Kothari, 2009) were used to collect information regarding impacts of climate variability on farming practices and socio-economic conditions of local people. Though there were total 40 households in Jalbire Mahila CF and 84 households in Laxmi Mahila CF, from statistical analysis point of view, 25 households were selected from each study sites using purposive random sampling technique (using records of households provided by president of CF) so as to represent each class of people with their wealth rank rich, medium and poor.

During this method, at first the wealth ranking of households was done purposively with the help of existing wealth ranking records of CF which was further revised from discussions of CFUG committee members, key persons and local leaders. Then the stratification of households was done into three categories- wealth class “Rich”, “Medium” and “Poor”. The selection of adequate representative sample or households was done randomly from each stratum. The wealth ranking of households was done on the basis of food sufficiency, income sources, house structure and land holding size in the study area (Table 4).

Table 4. Wealth ranking/ well being ranking criteria of households in the study area

Rank A “Rich”	Rank B “Medium”	Rank C “Poor”
<ul style="list-style-type: none"> • Land sufficient for surplus food production. The food can be sold after consumption for a year. • Sources of income from government or non-government offices, pension, etc.; savings in bank • Employ labours for crop production and harvesting • Having big house even sufficient for renting some rooms for others. 	<ul style="list-style-type: none"> • Land just sufficient for food production enough for consumption for a year but not for selling. • No any external sources of income; no savings in banks • Do no usually employ labours to work on their farm • Having small house, tightly arrangement just for family members. 	<ul style="list-style-type: none"> • Landless or less land insufficient for food production. The food produced is not enough for consumption for a year • Work as a labour in other’s farm land and local construction works • Having small house usually made up of local resources such as mud, bricks, hay, bamboo, etc.

In order to complement the information obtained from questionnaire survey, I and my data collection group members conducted four group discussions in the study area covering mainly three themes that are related to adaptation measures against climate variability and change. They are:

1. Socio-economic condition of people that affects adaptation activities
2. Major risks/shocks due to climate variability
3. Benefits of the CFs (both environmental and socio-economic)

Each of the group discussions were conducted representing different categories of people:

1. Women
2. Male elders
3. Marginalized people/disadvantaged group
4. Representative of project/government offices working in local forestry and environment sector

This helped a lot in collecting perceptions of different people in different themes. There are normally several interests and values represented by different groups of people within a community which affects the adaptation outcomes (Eriksen and Marin, 2011). So, these group discussions were intended to assemble detail information regarding various matters on the study sites.

We also conducted 10 key informant interviews in each site. Since we did not have detail information of respondents for key informant interviews, so the respondents were purposefully selected with the help of local key informants (president and elite person holding vital position in the committee of forest users groups in the study area) to represent all categories of people with wide range of socio-economic characteristics.

During selection of key informants, it was ensured that the interviews could cover vulnerable and more forest dependent people. These interviews were intended to accumulate in-depth information, each covering one of the themes 1 to 3. They were asked to provide depth information on any of those 3 themes on which they have more knowledge and were more familiar.

In my study areas, every household were the member of CFUG. It is mandatory that everyone living in the community should be the member of CFUG. In case, if any household is not the member of CFUG, then they cannot share the benefits provided by the community forest. Regarding the membership fee, every CFUG or local people decide the membership fee on their own way.

Apart from group discussions and key informant interviews, another method used for socio-economic data collection was trend analysis. Similar to English calendar, there are 12 Nepali months consisting of four main seasons. Seasonal calendars were formed and analysed to gather information on rainfall pattern and distribution throughout the year, how local people manage their time for different activities during different seasons. The seasonal trend analysis was done for each category of people in the study area: marginalized people, women and the people having small shops and local employment for developing one common seasonal trend analysis table of the study area. Simultaneously, daily time use analysis during busy season (during agriculture work load time) was also carried in the study area. This daily time use analysis helped to know what activities are carried out by different people during a day.

4.2 Meteorological data

In this study, annual rainfall and temperature data (1982-2011) recorded by the Lumle Meteorological Station, Department of Meteorology and Hydrology, the Government of Nepal, were used. Annual rainfall and temperature data of past 30 years were used to examine whether crop productivity and the livelihood of local people in the study area were affected. This meteorological station is approximately 51 km and 62 km far from Jalbire Mahila CF and Laxmi Mahila CF respectively. Since there was no meteorological station in Gorkha district, the climatic data was collected from the nearest meteorological station from the study area which is located in neighbouring district Kaski. As both districts lie in same ecological region of Nepal, i.e., hilly region, so it was assumed that there might be similarities in climatic data between the study area and chosen meteorological station.

4.3 Bio-physical data

4.3.1 Sample plot selection and sampling design

Two CFs (Laxmi Mahila CF and Jalbire Mahila CF) were chosen for sampling and measurement (Table 5). More than 50% crown coverage by pole size tree (dbh 10 to 29.9 cm) has been reported in CFOPs for these forests (Laxmi Mahila CFOP, 2009; Jalbire Mahila CFOP, 2011). Based on the crown coverage and size of the trees, 10 m x 10 m sample plot (DoF, 2010) size was used in this study. Generally, larger size of sample plot (e.g. 25m x 20m) was used in previous studies (e.g., Khanal et al., 2010). But 10m x 10m sample plot size was used by Shrestha and Singh (2008). Areas of both CFs were small (Table 3) and therefore smaller sample plot size were used in this study. Species distribution in both forest areas was more or less homogeneous, 5% sampling intensity was used (DoF, 2010). The calculated plot to plot distance is 43 m. The summary statistics of data are presented in Table 5.

Table 5. Summary statistics of inventory data

Characters	Laxmi Mahila CF			Jalbire Mahila CF		
Total area, ha	8.10			6.49		
Total area sampled, m ²	4050			3245		
No. of sample plots	44			33		
Plot wise	Mean ± sd	Min.	Max.	Mean ± sd	Min.	Max.
Dbh (tree), cm	43.45+-12.35	30.2	50.6	40.53+-8.70	31.1	64.7
Height (tree), m	19.57+-4.98	16.4	27	24.85+-2.95	22	33.9
Dbh (pole), cm	13.24+-3.10	10	29.9	15.74+-4.20	10	29.6
Height (pole), m	11.18+-2.68	2.8	19.6	15.55+-3.12	8.7	21.9
Dbh (sapling), cm	7.45+-1.30	5.1	9.9	8.38+-1.32	5.5	9.9
Height (sapling), m	6.91+-1.88	2.6	12.6	6.73+-1.57	3.1	8.7
Mean no. of trees/plot	0.09			0.75		
Mean no. of poles/plot	9.02			10.54		
Mean no. of saplings/plot	3.48			0.88		
CF wise (whole forest)*						
Dbh (tree), cm	800	556	1042	797	612	1273
Height (tree), m	360	302	497	489	433	667
Dbh (pole), cm	244	184	550	310	197	582
Height (pole), m	206	52	361	306	171	431
Dbh (sapling), cm	137	94	182	165	108	195
Height (sapling), m	127	48	232	133	61	171
Total trees	74			453		
Total poles	7305			6845		
Total saplings	2815			571		

* No standard deviation (sd) is calculable

4.3.2 Sampling and measurement

During measurement works in both CFs, first one sample plot was selected randomly and with reference to that first plot, other plots were fixed with the help of GPS (Global positioning system) instrument. Silva compass was used for locating directions and measuring tape was used for measuring size of plots. Similarly, Vertex was used to measure

height of the tree, diameter tape for measuring dbh of the pole and tree species. Ranging poles were used to locate boundaries of main plots (10 m x 10 m) and nested plots (5 m x 5 m and 1 m x 1 m). Digital weighing machine was used to measure weight of leaf litter, grasses, herbs, seedlings and other dry matter of each sample plots which were collected and tied together in a polythene bags.

In the main plot size 10 m x 10 m, trees (dbh>30 cm) and poles (dbh=10-30 cm) were measured. Similarly, within this main plot size, nested plot of size 5m x 5m were laid out for measuring saplings (dbh=5-10 cm) and another nested plot of size 1 m x 1 m was laid out within 5 m x 5 m plot for measuring weight of regeneration (dbh<5 cm), grasses, herbs and leaf litters (Khanal et al., 2010). All the herbaceous and woody vegetations (dbh<5 cm) inside 1 m x 1 m plot were clipped and collected and the representative sub-samples were taken to the Soil laboratory of Institute of Forestry, Pokhara, Nepal for oven drying. The samples were oven dried at constant temperature (80⁰C) until the weights of sample became constant (e.g., Petsri et al., 2007). Those weights were recorded for further calculation of carbon pool.

4.3.3 Estimating Biomass and Carbon

Species-specific stem volume was calculated using volume equation, Eq. (1) (Sharma and Pukkala, 1990) with data of total height and dbh measured for each individual (tree, pole and sapling), and volume obtained for Eq. (1) should be multiplied by 1000 as per its application guideline.

$$\ln (V) = a + b * \ln (dbh) + c * \ln (ht) \dots \dots \dots (1)$$

Where V= total stem volume with bark (m³), dbh= diameter at the breast height (cm), ht=total height (m), and a, b and c are species-specific parameters, and their estimated values are reported in Sharma and Pukkala (1990). Even though this model does not cover some species of my study area such as *Castanopsis tribuloides*, *Mangifera indica*, *Engelhardia spicata*, *Mallotus phillippinensis*, *Ficus nerrifolia*, *Trichilia connaroides* and *Jacaranda mimosifolia*, models (Sharma and Pukkala, 1990) for miscellaneous hill species or Terai species were applied. This model was also used by other researchers in similar studies (e.g., Adhikari, 2011; Karna, 2012; Khanal et al., 2010; Shrestha and Singh, 2008; Shrestha, 2008).

The total species-specific stem volume obtained from Eq. (1) was multiplied with specific-specific dry wood density (Brown, 1997; Chaturvedi and Khanna, 2000) to get the oven dry

weight of stem. The fractions of biomass of branches (0.45) and leaves (0.11) to total tree biomass of *Alnus nepalensis* (Sharma, 2003) was used to estimate branch and leaf biomass for all species in the study area. Because of lack of species-specific conversion factors, this information was used in this study. Other researchers (e.g., Adhikari, 2011; Khanal et al., 2010; Shrestha and Singh, 2008; Shrestha, 2008) have also followed Sharma (2003). The samples of undergrowth vegetation (species with dbh < 5 cm, grasses, herbs, leaf litter) were green with higher moisture content. So, they all were oven dried at a constant temperature of 80°C for about 48 hours (e.g., Petsri et al., 2007) until the weights of the samples became constant. Oven drying was carried out at Soil Science Laboratory of Institute of Forestry, Pokhara in Nepal. However, some studies have used 70°C temperatures for oven drying (e.g., Jacobs et al., 2009; MacDicken, 1997).

Total above ground dry weights for each sample plot were obtained by summing up of dry weights of trees, plots and sapling and undergrowth (grass, herbs, leaf litter). Total biomass of each CF was calculated (Table 13). The total carbon content was assumed to be 43% of the total dry biomass (Negi et al., 2003). I chose this factor because this is the typical value of carbon content in forest species which has also been used by many researchers in other studies (e.g., Shrestha and Singh, 2008; Shrestha, 2008; Shrestha, 2009; Khanal et al., 2010). But carbon content was calculated as 50% of the total dry biomass in some other studies (e.g., Petsri et al., 2007; Terakunpisut et al., 2007; Adhikari, 2011).

4.4 Data analysis

Both socio-economic and bio-physical data were analysed using statistical softwares MS excel, SAS (SAS Institute Inc, 2008) and Sigma plots with versions 2007, 2008 and 2011 respectively. Sigma plot was used mainly for analysis of both socio-economic and bio-physical data whereas MS excel and SAS were used for biomass estimation and carbon content calculation.

Chapter 5: Results and discussion

5.1 Climatic events and shifts

There are several factors that affect adaptation to climate variability and change. One of the important factors affecting the adaptive capacity of local people in the study area was the type of climatic risks and shocks. There were different perceptions of local people regarding the frequency of occurrence of climatic hazards on both study sites. The results obtained from questionnaire survey are illustrated below (Fig. 3).

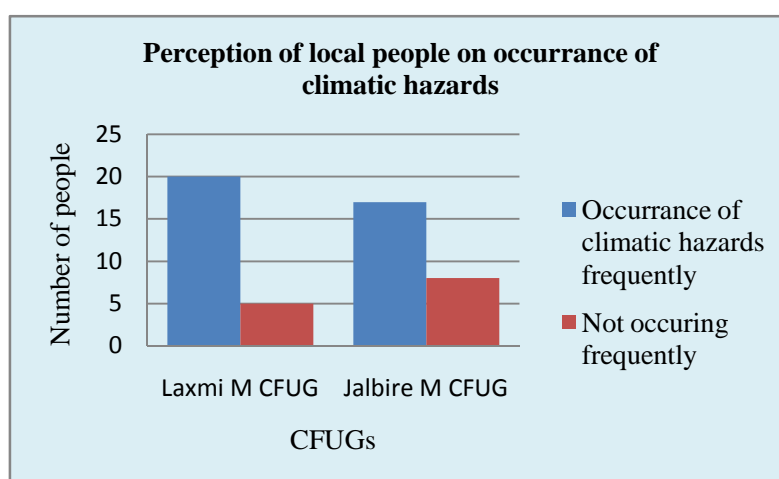


Figure 3. Perception of local people on occurrence of climatic hazards

The various climatic shocks and stresses on both study sites were occurrence of irregular rainfall, increase in dry periods, loss in productivity and quality of crops (e.g., Box 1) and increase in number of disease affected crops and livestock. The information obtained from the key informants' survey suggests that among the different climatic risks and shocks, there was a trend of more irregular rainfall and long dry periods becoming common and frequent in the recent years in the study area (Table 6), though most predominantly in Laxmi Mahila CF. People were experiencing hailstorm and thunderstorm even in winter season, in the past normally expected to occur only in the autumn period. According to the information provided to me, the climatic events experienced by the local people just few months before my field visit were heavy winds and storms in Laxmi Mahila CF which destroyed huge quantity of

crops and vegetables. Similarly, there were few small landslides in the road cutting areas of Jalbire Mahila CF. Due to those climatic events especially irregular rainfall and long dry periods, the agriculture crops and vegetable plants were severely damaged which lost the labour and capital of people. Almost all the

Box 1. Effects of climate variability and change

*“Since the past two decades, the productivity of agriculture crops is diminishing due to loss in soil fertility. The soil fertility is lost due to soil erosion, landslides, less microbial activities in soil, less input of organic manure in the soil and so on. In order to maintain the crop productivity, we are obliged to use chemical fertilizers because we do not have sufficient organic fertilizers. Though, the use of chemical fertilizers increase the yield of crops at the present moment, but it severely affects the properties of soil. The **quality of crop is reduced** that are produced through the input of chemical fertilizers which is directly and indirectly affecting our health.”*

(“Female teacher Bishnu Maya of age 20 in Laxmi Mahila CF”).

key informants agreed that weather events were frequently occurring in the study area. Only a few informants said that such weather events were not occurring frequently. The types of weather events and climate variability found in the study sites are described in table 6 below.

Table 6. Type of weather events and climate variability in the study area

CF	Most frequent weather events	Mostly occurring time/season	Duration of occurrence
Jalbire Mahila and Laxmi Mahila	Intense/heavy rainfall with hail storms/thunderstorms	July, august, September	2-3 months
Jalbire Mahila and Laxmi Mahila	Long dry periods	February, March, April, May	4 months
Laxmi Mahila	High wind velocity/storms	March, April	2 months
Jalbire Mahila	Flood	July, August	2 months

5.2. Meteorological data

The local people’s perception of climate variability and change was studied with supplement information that was obtained from the data collected from the meteorological station. Some perceptions were in accordance with the climatic data whereas some were contrary with respect to the climatic data.

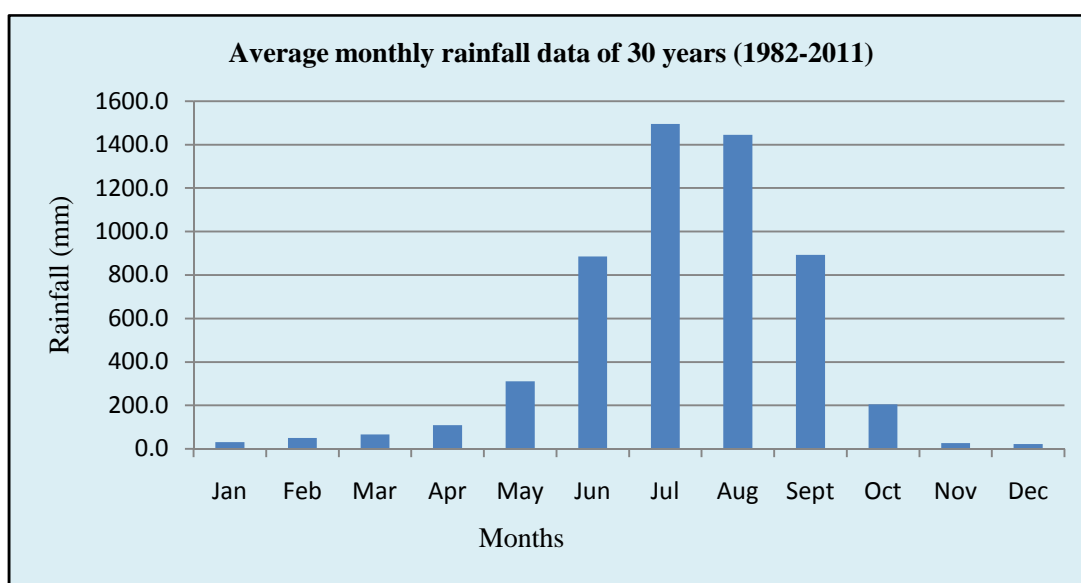


Figure 4. Average monthly rainfall data of 30 years

The above bar graph (Fig. 4) shows the distribution of average monthly rainfall of 30 years (1982-2011). The amount of rainfall is highest in July and lowest in December. Since the rainfall is mostly occurring during June to September, this period is called monsoon period. Two crops rice and soya bean are grown during this monsoon period whereas other crops such as millet, wheat, potato and ginger are grown during other than monsoon period (Table 11). The months November to April received little rainfall. So, the crops grown in these months do not get sufficient water which results in low productivity (Source: key informant survey). The agricultural lands of many households in the study area were not access to irrigated water (Source: field visit). Due to the variation in seasonal precipitation in the locality of Nepal with frequent and intense floods and droughts, the situation of uncertainty was developed mainly with respect to rain-fed agriculture (Karkee, 2008).

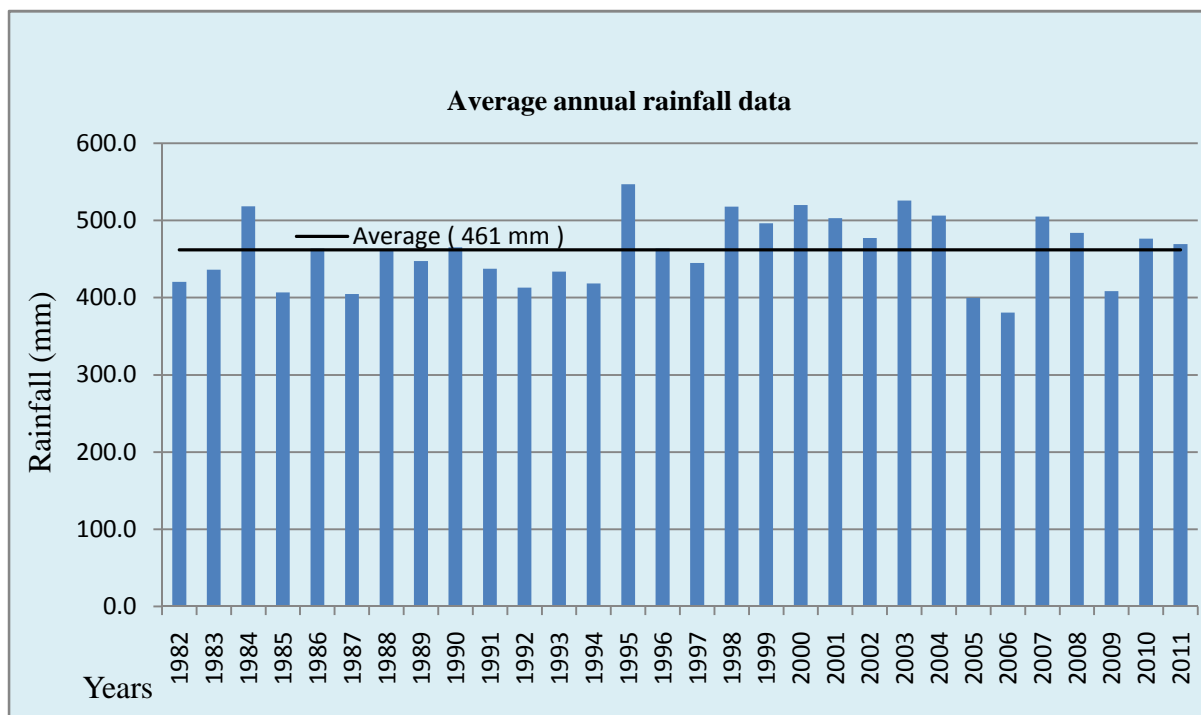


Figure 5. Average annual rainfall data over 30 years

The figure (Fig. 5) shows the average annual rainfall data of 30 years. There is no evident trend in rainfall from 1982 to 2011. However, it is observed that the years 2005 (399 mm) and 2006 (380 mm) had received less rainfall in comparison to average value which is 461 mm.

Again, by analysing average monthly rainfall data of monsoon period (June to September), there is no such significant shift in rainy season in this meteorological station (Fig. 6), contrasting with key informant interviews observations that people have experienced shift in rainy season in the study area. So, there is no apparent trend in the average monthly monsoon rainfall from 1982 to 2011 (Fig. 6). Yet, it is observed that the years 2005 (978 mm) and 2006 (950 mm) had received less rainfall during this monsoon period in comparison to average value which is 1179 mm. The local people have experienced that rainfall occurs mostly from July to September. But, they further told that rainfall used to occur mostly from months June to August about 20 years ago.

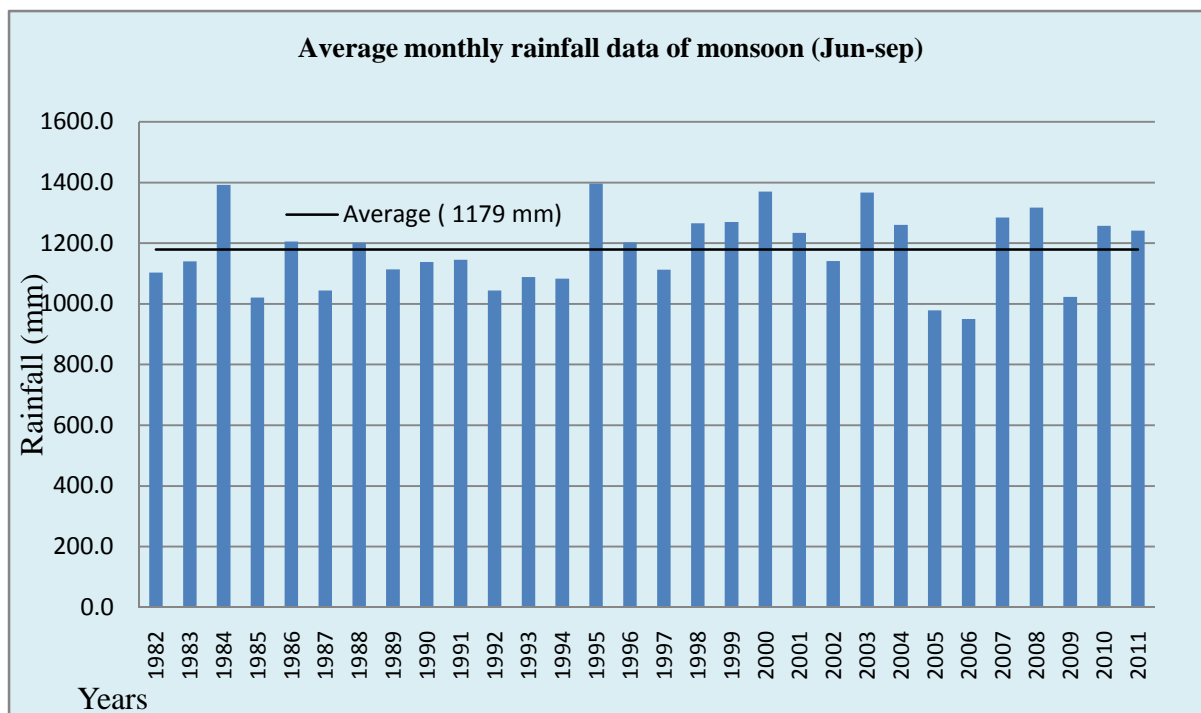


Figure 6. Average monthly rainfall data of monsoon over 30 years

In addition to this, local people have experienced irregular distribution of rainfall during the monsoon period. With reference to the information provided by them, some days during monsoon receives heavy rainfall with hailstorm while some days receive gentle drizzle. They also added that the heavy unexpected rainfall with hailstorm has been destroying fruits and vegetable crops of many households in the study area.

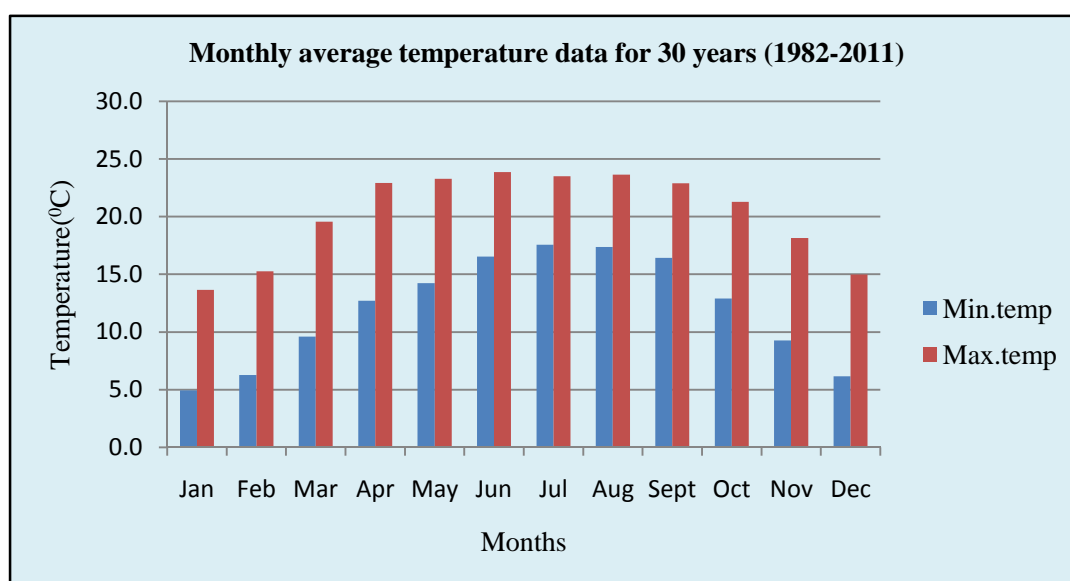


Figure 7. Monthly average temperature data of 30 years

Some of the observations from interviews regarding climatic variability and changes described in previous section are also captured in meteorological data. The figure below (Fig. 7) shows the monthly average minimum and maximum temperature data of 30 years from 1982 to 2011. The temperature varies during the year with highest value in June and lowest value in January. The months March, April and October receives less rainfall (Fig. 4) but the temperature is still high during these months (Fig.7). So, according to key informants survey and focus group discussions, the local people were experiencing drought during these months and some other months with less rainfall.

5.3 Different forms of capitals affecting livelihoods and adaptive capacity

5.2.1 Physical, natural and financial capital

Different forms of capital affect the general adaptive capacity in the study area. The household interviews showed slightly different dependency on agriculture in two areas, as shown in Fig. 8. This reflects difference in physical/natural capital and the availability of alternative livelihoods. There are close inter-linkages between different types of capital, especially social, human and natural, since education levels, socio-economic status and trade appear to be linked.

The results obtained from questionnaire survey are presented in the bar graph below (Fig. 8).

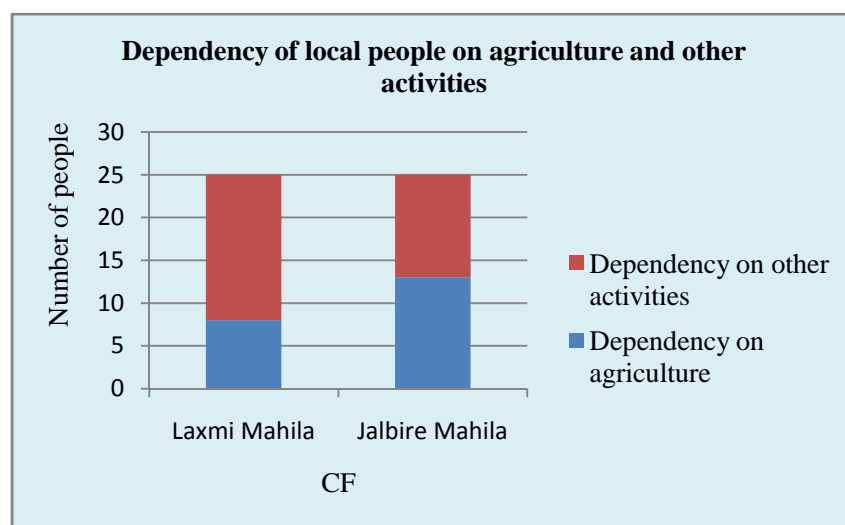


Figure 8. Dependency of local people on agriculture and other activities

The key informant survey confirmed that more local people were involved in agriculture in Jalbire CF than in Laxmi Mahila CF. Both male and female were involved in agriculture and animal husbandry for their income sources in Jalbire Mahila CF whereas more female were involved in these activities in Laxmi Mahila CF. The male were engaged in local business activities, government jobs, teaching and so on (other than agriculture related activities). There were mainly two reasons for these differences. Firstly, there were a higher proportion of higher caste people such as Brahmin and Chhetri in Laxmi Mahila CF than Jalbire Mahila CF.

In Nepalese society, these higher caste people especially male are more educated and so more male people of Laxmi Mahila CF were found involving in educational institutions (schools, colleges), offices and small business. Secondly, since the distance from Gorkha districts headquarter to Laxmi Mahila CF was comparatively nearer than Jalbire Mahila CF, local people of Laxmi Mahila CF

Box 2. Short-term and long-term migration of adults

“15 to 20 years ago, there was enough manpower in our village for agricultural activities. But nowadays, many adult male and female have migrated towards towns and cities in search of good education and employment. These adult people have less interest on local agricultural and farming system. Many of them have even gone to foreign countries in education and working visa. This has resulted in expensive manpower for agricultural works because of lack of sufficient local manpower. People are even hired from another village for agricultural activities. In comparison to input, there is less output from the agricultural sector in our village. So, the new generation are now attracted towards job of cities and abroad.”

(A 60 years old poor woman named Sanu Gurung of Jalbire Mahila CF.)

had more access to employment opportunities in the district headquarter. This difference and shifts in climatic conditions are important because climate variability is likely to affect areas with the highest dependence on agriculture, such as Jalbire Mahila, more severely.

It is also essential to know about the income sources and employment of the community people in order to understand their capacity to adapt with climate variability and change. In addition to agriculture, the other livelihood sources were local business, income from urban and abroad jobs (after temporary migration), trade or selling of local fishes, local alcohol and locally made bamboo and wooden products, government and private jobs such as teaching, working in offices and local institutions in the study area. Local business here includes small food, clothes, electronic equipments, other household materials, and tea and alcohol shops.

According to the information obtained from household survey and key informants survey livelihood activities are strongly differentiated by social characteristics (castes, ethnic groups, marginalised groups) at both study area (Table 7 and 8).

Table 7. Livelihood sources and types of agricultural activities of different social groups

Serial number	Different social groups in both CFUGs	Livelihood sources (mostly involved)	Types of agricultural activities
1	Brahimin (caste)	Government jobs, teaching and local business	Growing paddy, lintels, soya bean, seasonal vegetables
2	Chhetri (caste)	Teaching, local business and abroad income	Growing lintels, millet, soya bean, seasonal vegetables
3	Newar (ethnic group)	Local business including selling local fruits and vegetables	Growing potato, millet, ginger, garlic, onion, seasonal vegetables
4	Gurung (ethnic group)	Military services, Abroad income	Growing maize, millet, soya bean, potatoes
5	Magar (ethnic group)	Abroad income, selling local fishes, local alcohol, local fruits and vegetables	Growing paddy, maize, millet, potato, ginger, garlic, onion, seasonal vegetables
6	Sarki (marginalised group or dalits)	Driver, carpenter, local level labour in house and other small construction works, selling locally made wooden and bamboo products	Growing potato and seasonal vegetables
7	Damai (marginalised group or dalits)	Small tailoring business, local level labour in house and other small construction works	Growing millet, maize, potato, seasonal vegetables

Among these social groups, the people who were having local fruits and vegetables business, doing daily-basis labour works and selling local fishes were mostly affected by climatic events and variability. The castes mainly affected by climate variability were Newar, Magar, Sarki and Damai. Due to the pattern of irregular rainfall and long dry period, these groups of people faced difficulties in performing their works, especially farming, trade and local labour.

Table 8. Non-agricultural activities (mostly trade) by caste in the study area

Castes	Non-agricultural activities
Brahimin	Selling vegetables such as cauliflower, cabbage, potato, tomato, sponge gourd, snake gourd, bitter gourd and leaf plates in small scale
Chhetri	Selling maize, soya bean, lintels, vegetables such as cauliflower, tomato, spinach, snake gourd, sponge gourd, pumpkin shoots
Damai	Selling locally made iron weapons, tailoring, weaving and knitting clothes, working as local level labour
Gurung	Selling millet, maize
Magar	Selling local alcohol, fishes, locally made wooden and bamboo products and vegetables like tomato, cauliflower, bitter gourd, ladies finger, sponge gourd
Newar	Selling local alcohol
Sarki	Selling locally made wooden and bamboo products and working as local level labour

Mainly medium class and financially poor categories of people belonging to all castes were engaged in local trade (Table 7) for their livelihoods support as well as in managing impact of climate variability and change. Among the above castes, the poor people were mostly “dalits” or marginalised/ socially excluded people (Damai and Sarki) in the study area (Table 3, 7 and 8) who were more affected by the impact of climate variability. These poor families did not have good sources of income. Very few adult male of these poor families were able to go abroad for earning money and most of those who did went gulf countries and were working in companies providing very low wages. Many families of these poor categories even could not afford for moving abroad. Due to less output from agriculture sector and lack of local employment opportunities, many adults and youths belonging to middle and even rich families in the study area had migrated towards urban areas and abroad in search of good income and employment activities (e.g., Box 2). So, the trend of migration was reflected by the low wages and income from local agriculture which reduced the adaptive capacity in agriculture because of loss of manpower for conducting agricultural activities. Also, it was found that almost all of the abroad migrants did not invest their remittances in agriculture activities. Rather, they invested their remittances for purchasing private assets such as houses, lands for building houses and local shops.

A similar social differentiation between social groups was found in the study area in terms of involvement in, and obtaining benefits from CFs. In addition to this, caste and social marginalisation had resulted in less capacity of poor people to adapt with climate variability

and extreme weather events in the study area. Most of the opportunities were captured by elite and higher caste people in the community. The socially excluded people “dalits” could not actively involved in decision-making and benefit-sharing. They were not even aware about the total income and expenditures of CF. Key informant interviews revealed that some poor people were not even financially supported by rich people during the time of climatic stress and hazards (Key informants survey during field visit). Food aid from governmental and non-governmental organisations might be solution for poor people who are more vulnerable to climate change impacts but it does not solve the problem of power differences among different social groups.

5.2.2 Human and social capital

The next important factor that affects adaptation measures is the awareness and education level of local people. Information obtained from questionnaire survey which is presented below (Fig. 9).

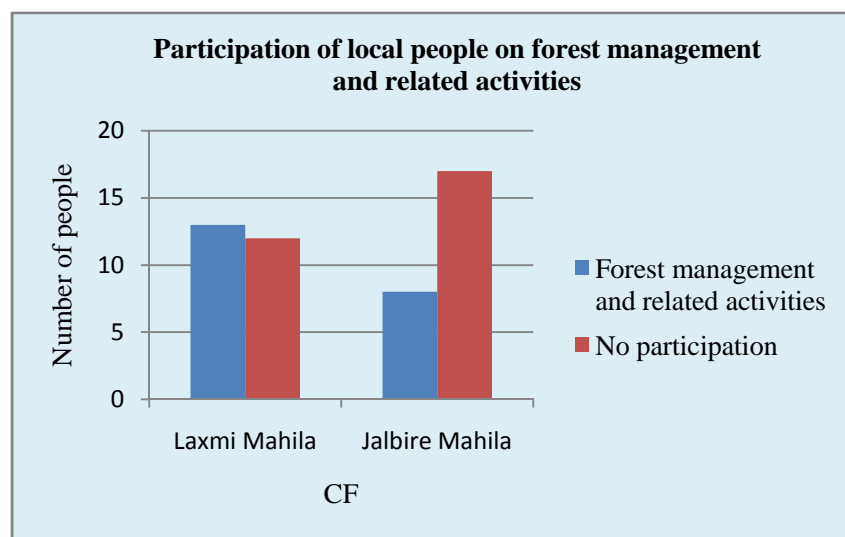


Figure 9. Participation of local people on forest management and related activities

Key informant survey provided the information that the study area had fairly similar physical, natural and financial capital, although some variation in species composition and income of

people (Table 4). But there was significant variation in human and social capital in the study area. Women were found to be more active and capable in managing forest and other social activities in Laxmi Mahila CF than in Jalbire Mahila CF. Participation of women was also found to be high in every activity in Laxmi Mahila CF.

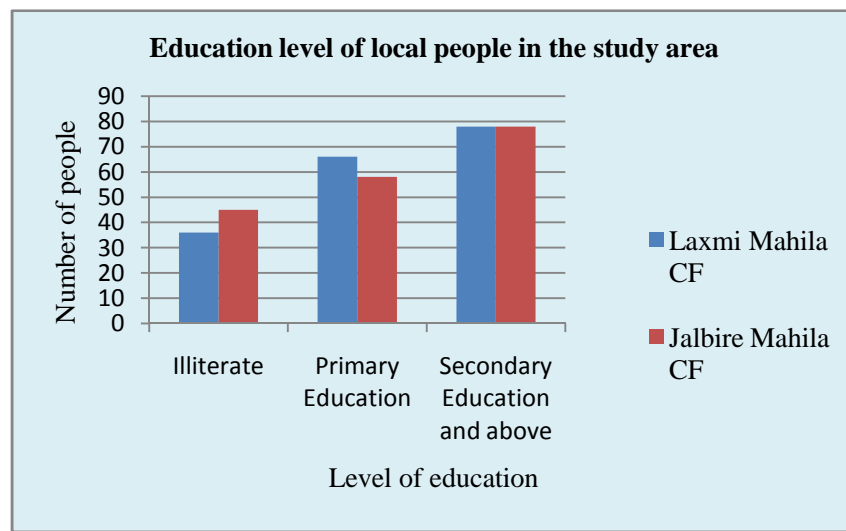


Figure 10. Level of education of local people

Those differences were mainly due to the level of education and caste composition of users in the study sites. There were higher proportion of higher caste people such as Brahmin and Chhetri in Laxmi Mahila CF than Jalbire Mahila CF and these higher caste people were found to be more educated (Fig. 10). The level of education had played vital role in capacity building of women in Laxmi Mahila CF. However, the gender-wise education level of the study area was not investigated specifically (Fig. 11).

In the figure (Fig. 9), the education level of Laxmi Mahila CF was found to be higher than that of Jalbire Mahila CF. Primary education was found to be higher in Laxmi Mahila than Jalbire Mahila CF, although the secondary education and above was found to be same in both CFUGs. Similarly, the illiteracy level was also higher in Jalbire Mahila CF. So; the overall result shows that more people were literate in Laxmi Mahila than Jalbire Mahila CF.

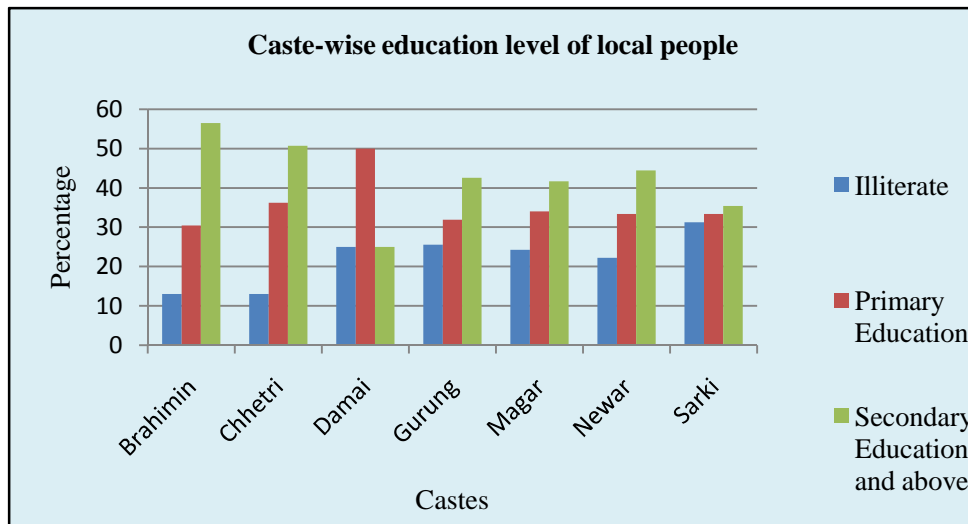


Figure 11. Level of education of local people

There were fewer differences in the education level among different social groups (Fig. 11). The education level of higher castes people (Brahimin and Chhetri) was greater than other castes people in the study area. Most of the users of the community expressed that education was important and even some parents of marginalised groups or lower castes attempted to send their children to the schools.

5.3 Local adaptive mechanisms and the role of CF

5.3.1 The contribution of CF to the five capitals and adaptive capacity

The environmental and socio-economic benefit of CF also contributed local adaptation strategies in the face of climate variability and change. People who have access to more environmental and socio-economic benefits are likely to be less vulnerable to climate variability and change.

Table 9. Priority of forest products for different classes (caste) of people

Castes	Mostly used forest products	Ways how they are used
Laxmi Mahila CF		
Brahimin	Shorea leaves	Making leaf plates
Chhetri	Fuel wood	For cooking food in tea shops
Damai	Poles/ bamboo	For making charcoal/ local products like stools, chairs, baskets, racks, frames, etc.
Gurung	Not specified	Not specified
Magar	Fuel wood/ timber	As fuel for preparing local alcohol/ for making wooden products like chairs, tables, cupboard, benches, etc.
Newar	Fuel wood/ poles	As fuel for making local alcohol/ poles for religious activities
Sarki	Poles/ bamboo	For making charcoal/ local products like stools, chairs, baskets, racks, frames, etc.
Jalbire Mahila CF		
Chhetri	Fodder	For cattle
Gurung	Fuel wood	As fuel for making local alcohol
Magar	Fuel wood/ timber, bamboo	As fuel for making local alcohol/ local wooden and bamboo products
Sarki	Poles/ bamboo	For making charcoal/ local products like stools, chairs, baskets, racks, frames, etc.

In addition to direct benefits to household, income from CF also benefits adaptive capacity at the community level (Fig. 12). During household interviews, it was found that the poorer households were using more forest resources especially fuel wood and fodder than the richer and medium households. The main reason was the poorer households could not afford expensive LPG gas and kerosene oil from the market for cooking. Regarding fodder, the poor households had less land but were found keeping large number of cattle and had no other options such as collection of fodder and forage from their private lands or buying fodder from others. Due to this reason too, they had to highly depend on CF. There was no great differences in the use of timber by poor and rich households but the purpose was slightly different. Poor were mainly using the timber for making agricultural and local furniture tools for selling whereas rich were using timber for construction of big houses and interior furniture.

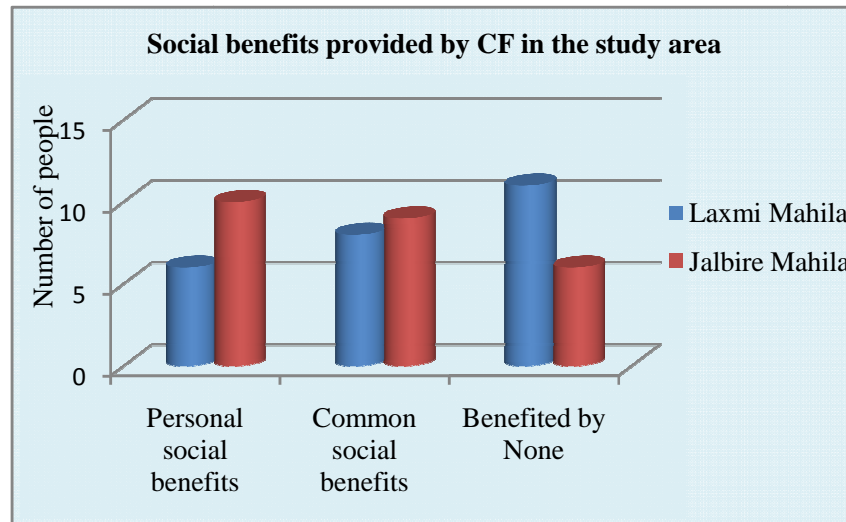


Figure 12. Social benefits provided by CF in the study area

CFs on the study area has contributed by providing both personal social benefits and common social benefits. Personal social benefits includes house construction, house maintenance, toilet maintenance, making furniture and making agriculture tools whereas common social benefits includes different activities such as school construction and maintenance, water tank construction, shade/ shelter construction and trails construction (e.g., Box 3).

Besides these social benefits, the CF has also contributed in various environmental benefits such as improvement in soil fertility and productivity, minimization of landslides/erosion, availability of drinking water, increase in floral and faunal diversity, increase in air quality, control of illegal felling and hunting. However, it

Box 3. Contribution of Jalbire Mahila CF

The income of Jalbire Mahila CF has been utilized for the welfare of the community. One of the great contributions of Jalbire Mahila CF is providing ambulance service in the community. “Before few years, the users of our CF had to face great challenges in emergency situation during sudden accidents and sickness. We were not able to get immediate access to medical treatment. Due to which many people of our community became handicapped and some even died due to lack of treatment in time. Especially the poor, old, pregnant women and children were victim of such bad situation. But after we have purchased one ambulance in 2010 and hired one driver from the income of our CF, many people of our community are benefited. They are able to get medical treatment access quickly.”

(Middle-aged man, key person of Jalbire Mahila CF users groups committee named Amar Gurung).

was argued that most of the activities regarding CF was captured by elites and relatively more educated users (mostly male) in Jalbire Mahila CF. Those elites and educated male were taking advantage over the less educated female of Jalbire Mahila CF. Due to this problem, the women could not raise their voice in CF programs.

5.3.2 Adaptation activities in the study area

People in the study area (Laxmi Mahila and Jalbire Mahila) have developed several adaptation activities. Most of the activities were found to be similar between two CF. However, there were some different adaptation activities on the study area. As both CF are situated in different altitudinal zone, there were differences found in the species composition. Plant species like *Dalbergia sissoo*, *Acacia catechu* were planted in the landslides prone areas of Jalbire Mahila CF whereas species like *Cinnamomom camphora*, *Fraxinus floribunda* and *Albizia procera* were planted in Laxmi Mahila CF.

Another main cause of differences between adaptation activities in two CF was distance from district headquarter (Gorkha Bazar) and availability of river. Laxmi Mahila CF was close to Gorkha Bazar (10 km) and Jalbire Mahila CF was comparatively far from Gorkha Bazar (35 km). The river named 'Daraudi' was found near Jalbire Mahila CF but there was no such rivers nearby Laxmi Mahila CF. Regarding the adaptation activities other than agriculture, the users of Laxmi Mahila CF were engaged in offices, schools and local business because it was near from the district headquarter whereas most of the users of Jalbire Mahila CF were engaged in seasonal works, fishing and rubber factory nearby (Gorakhkali Rubber Factory).

Some studies have reported that community forestry is one of the successful programs in mid-hills of Nepal for providing socio-economic and environmental benefits (Yadav et al., 2011). However, some have argued that CFs of Nepal has controversies and conflicts within local people such as exclusion of poor, women and marginalised people in decision-making, benefit-sharing and other forest management programs (Sunam and McCarthy, 2010). Only few adaptation activities practised by the local people were directly and indirectly linked with CF. Also, no any governmental and non-governmental organisations have worked in order to aware and minimize the impact of climate change in the field level (Tiwari et al., 2010). Providing loans to people from the saving fund of CF, collecting fodder from CF for cattle, collection of *Shorea robusta* leaves for making leaves plates and production and selling of

local wooden and bamboo products collected from CF are some of the examples of adaptation activities linked with CF in the study area.

Some of the main common and different adaptation activities practiced by local people on the study area are mentioned below:

Common adaptation activities in the study area

- Increase in migration rate of adults towards cities and abroad. So, this might be one of the reasons for decrease in population of Gorkha district since last 10 years period (CBS, 2011).
- Changing in cropping season/planting and harvesting time. For e.g. at past, rice was planted in June and harvested in November. But, now the rice is planted in July and harvested in October.
- Practice of agro forestry system and home garden by the community.
- Decrease in dependency on use of fuel woods through improved stoves, LPG or cylinder gas and bio-gas for cooking and heating.
- Establishing dykes and check dams across rivers and streams, maintaining vegetation cover on slope and barren land, planting trees on road and river banks are some other soil and water conservation techniques (key informant survey, 2012).
- Local people able to get loan for keeping cattle and vegetable farming from the local people or forest users' collective fund.
- Addition of chemical fertilizers in the agriculture land to increase productivity that can fulfil the demand of growing family size.
- Dependency of local people not only on prime or major crops (rice, maize) but also on alternative crops/vegetables (cauliflower, tomato, cabbage, spinach, ginger) that can be easily sold in the market in good price.

Table 10. Differences in adaptation activities in the study area

Management Mechanisms	Laxmi Mahila CF	Jalbire Mahila CF
<ul style="list-style-type: none"> Change in species composition 	<ul style="list-style-type: none"> Changes in species composition. For e.g. <i>Asparagus racemosus</i>, local cucumber, black basmati rice is not found in Laxmi Mahila CF site. Whereas the species like <i>Eucalyptus species</i>, <i>Cinnamomom camphora</i>, <i>Fraxinus floribunda</i>, <i>Albizia procera</i>, sabitri mansuli rice are found now in this area which was not found 20 years before. 	<ul style="list-style-type: none"> Changes in species composition. For e.g. mustard is not found in Jalbire Mahila CF site. Instead species like <i>Dalbergia sissoo</i>, <i>Acacia catechu</i> etc. are found in this area now which was not found 20 years before.
<ul style="list-style-type: none"> Selling of local resources 	<ul style="list-style-type: none"> Production and selling of bamboo products and leaf plates in a small scale. 	<ul style="list-style-type: none"> Selling of stones from a small stone mine which is located within Jalbire Mahila CF area.
<ul style="list-style-type: none"> Income generating activities 	<ul style="list-style-type: none"> Cultivation of vegetables by some CF users in commercial basis (more women and poor people involvement). 	<ul style="list-style-type: none"> Fishing within local rivers of Jalbire Mahila CF and selling them in the local shops by some CF users (more marginal people involvement).
<ul style="list-style-type: none"> Change in cattle composition and number 	<ul style="list-style-type: none"> Changes in cattle composition (from cow, buffalo to goat, pig) 	<ul style="list-style-type: none"> Keeping less number of cattle than past years.
<ul style="list-style-type: none"> Off-farm activities 	<ul style="list-style-type: none"> Search/involvement in jobs other than agriculture and farming. 	<ul style="list-style-type: none"> Seasonal employments (working in rubber factory nearby, carpentry, tailoring, collecting wood from flooded rivers, selling seasonal fruits and vegetables in local shops).

Geological and socio-economic factors were mainly responsible for differences in adaptation activities in two study areas. Although two study areas were located in same ecological regions (i.e., hilly region) of Nepal, but the slope and altitudes of two sites were fairly different (Table 3). Due to these variations in slope and altitude, the species composition was found different. And so the local people planting the crop and tree species in two study areas were not similar (Table 10). Regarding socio-economic factors, the caste composition and their occupations were also

different in the study area. There were greater number of higher castes people such as Brahmin and Chhetri in Laxmi Mahila CF. They were involved mostly in non-agricultural activities like teaching, working in offices whereas the middle and lower castes people in Jalbire Mahila CF were mostly involved in agricultural activities including keeping livestock and vegetable farming.

Besides, local people of Jalbire Mahila CF were more involved in local trade than Laxmi Mahila CF such as selling local alcohol, fishes, vegetables, bamboo and wooden products. As already mentioned above, the local river named “Daraudi” was flowing close to Jalbire Mahila CF which was suitable for fishing and selling in local markets in order to adapt with extreme weather events and climatic variability that can support livelihoods too. There were no such rivers nearby Laxmi Mahila CF. Some local people of Jalbire Mahila CF were also engaged in rubber factory named “Gorakhkali Rubber Factory” which was located only few kilometres away from their community. Most of the local people were found diversifying away from the agriculture since around 10 years due to less output from agriculture which could not complement the expensive local market.

The main forest products like fuel wood and timber were used by all the social groups of the community but other products like bamboo were often used by the marginalised community for making several local products and selling them in the markets. According to the information obtained from questionnaire survey and interviews, some of the adaptation activities were directly and indirectly benefited from CF such as using of forest products for people and livestock, poor people often taking loans from local people’s collective fund for pig-keeping, goat-keeping, poultry farming, vegetable cultivation and so on. The poor people were found relying more forest products because they had limited livelihood options. Poor people felt marginalised because they were not included in decision-making regarding the forest, and so the use of CF alone was insufficient to reduce their vulnerability or address social differences and marginalisation that is creating vulnerability in the first place.

In Nepalese calendar, there are also 12 months as in English Calendar. The different activities that the local people carry out during the year and in a day (during busy season) are summarised in the seasonal calendar and daily time use table below (Table 11 and 12). The presented in Table 12 was implemented in the very busy period, and in the other time they wake up little late.

Table 11. Seasonal Calendar of local people in the study area

Months	Activities in Khet	Activities in Bari	Income generating activities	Problem	Festivals	Agr. load	Activities
Baishakh (April 15-May 14)	Wheat cutting and ploughing (<i>Khan Jot garne</i>)	Millet bed preparation, (<i>Maize godne</i>)			Nepali New year	Busy	Litter, Firewood collection
Jesth (May 15-Jun 14)	Wheat cutting and ploughing	Wheat cutting, Chilly planting, <i>Maize doryaune</i>		Fever, diarrhoea, common cold	Udhyauli and Uvauli	Busy	Litter collection
Ashad (Jun 15-Jul 14)	Paddy, <i>Lintels</i> and (soyabean) cultivation	Millet planting	making leaf plates			Very Busy	
Shrawan (Jul 15-Aug 14)	-		making leaf plates	Diarrhoea	Sahuney Sankranti	busy	Cleaning and weeding
Bhadra (Aug 15-Sep 14)	Paddy Cleaning (<i>Godmel</i>)	Maize harvesting +Millet cleaning and vegetables planting, chilly harvesting	potato selling,		Teej, Janai Purnima	busy	
Ashwin (Sep 15-Oct 14)	-	Wheat sowing	Ginger selling		Dashain	busy	
Kartik (Oct 15-Nov 14)	Garlic farming	Millet harvesting	Chilly selling		Tihar	busy	Fodder collection, Firewood collection for daily use
Mangsir (Nov 15-Dec 14)	Paddy cutting and Wheat sowing	Millet harvesting	Making local products from bamboo and straw of paddy, wheat		-	Very Busy	Litter, fodder and firewood collection
Poush (Dec 15-Jan 14)	-	-	Making local products from bamboo and straw of paddy, wheat		-	Free	Litter and fodder collection, Thinning and pruning, firewood collection for daily use
Magh (Jan 15-Feb 14)	-	Ginger cultivation	Garlic selling		Maghe Sankranti	busy	Litter collection, firewood
Falgun (Feb 15-Mar 14)	Irrigation to Wheat	Potato cultivation			Fagu Purnima	busy	Litter and fodder, firewood collection
Chaitra (Mar 15-April 14)	-	Maize sowing		Irrigation problem, grain shortage	Chaitre Dashain	Free	Litter collection, firewood cutting for rainy season

Table 12. Daily time use table of local people during the busy season

Time	Activities	Remarks
04-09	Household work	In case of Women
09:00-10:00	Lunch	Both male and female
10:00-18:00	Outside work in Farm (<i>Khet/Bari</i>)	Both male and female in the summer season.
14:00-15:00	Snacks	
18:00-19:00	Sanitation and rest	
19:00-21:00	Meal preparation for entire family and have meal	Mostly, meal is prepared by female
21 onwards	Take rest and sleep	

In both CFs, there were no great conflicts or controversies among the users regarding management of CFs but there were some problems faced by local people. Some users living near the boundary of Laxmi Mahila CF encroached the CF area because there was no fence or boundary protection on both CFs whereas the seedlings and small vegetation of some areas of Jalbire Mahila CF were damaged by the cattle of some local people. Besides, some CFUGs on both CFs claimed that sometimes there was illegal collection of fuel wood and timber by the poor people from CF. Although there were rules in the constitution of both CFs regarding the type of punishment to those users, they were not strictly followed.

On both CF, there were only female members in the management committee. It was great challenge for the female to solve the above problems of CFs because the efforts of women were not addressed in male-dominant society of Nepal. Also, since the areas and the income of both CFs were less (Laxmi Mahila CFOP , 2009 and Jalbire Mahila CFOP, 2011), the male were not so much interested to support women regarding management of CF because the benefits of CFs could only support the livelihoods of local people to some extent. There were also rules in operational plan of CFs that users could get any type of forest products (after permission from users committee) during the time of requirements and emergency; however, some socially marginalised groups “dalits” had argued that they had not got the required forest products.

Some users of both CF reported that there were minor discussions and conflicts between the higher castes / rich people and lower castes / poor people regarding the distribution of forest products. The conflicts were mainly based on: the poor people claimed that they should get more forest products than rich people whereas the rich people strained that the forest products should be distributed equally. Since most of the users of both CF were engaged on their own

occupations and activities for their livelihoods, the management of CFs was not significantly supporting their livelihood. In some other CFs of Nepal, severe conflicts or controversies among the users regarding the decision-making and benefit-sharing were reported (Parajuli et al., 2010).

5.4 Amount of carbon pool in community forest and impact on sustainable livelihood

The mean above ground biomass in Jalbire Mahila CF was found to be considerably higher than in Laxmi Mahila CF (Table 13). Likewise, under-growth (live and dead) biomass of Jalbire Mahila CF was found to be slightly higher than that of Laxmi Mahila CF (Table 13). The under-growth biomass contributed only about 2.10% of the total above ground biomass in Jalbire Mahila CF whereas about 4.96% of the total above ground biomass in Laxmi Mahila CF.

Table 13. Vegetation biomass ($t\ ha^{-1}$)

CF	CF	Above ground tree	Under-growth (live and dead)	Total
1	Laxmi Mahila	117.213	5.817	123.03
2	Jalbire Mahila	299.615	6.295	305.91

The above ground carbon pool (both tree and undergrowth) in Jalbire Mahila CF was found to be greatly higher than Laxmi Mahila CF (Table 14). The data shows that the carbon pool of above ground tree biomass in Jalbire Mahila CF was found to be 47.7 times higher than carbon pool in the under-growth biomass whereas it just 20 times higher in Laxmi Mahila CF.

Table 14. Vegetation carbon pool ($t\ ha^{-1}$)

CF	CF	Above ground tree	Under-growth (live and dead)	Total
1	Laxmi Mahila	50.401	2.501	52.90
2	Jalbire Mahila	128.834	2.707	131.54

The biomass of tree and undergrowth vegetation for a particular stand varies with site quality, stand condition, species composition, and many others. The above ground carbon pool in Jalbire Mahila CF was found to be greatly higher than Laxmi Mahila CF (Table 14) due to

larger sized trees (greater dbh and height) which have higher biomass values (Table 5). This variation in biomass was seen in different sample plots of same CF and within different CFs due to variation in tree size and density. The CF blocks where silvicultural operations such as thinning, improvement felling were less carried out had higher number of trees per plot than in CF where these operations were carried out. Besides, various factors such as net primary productivity of plants, biomass decomposition, size of trees, age of stands may affect carbon stock in ecosystem. Vegetation types, age of stands and environmental quality changes the net primary productivity (Shrestha and Singh, 2008). The tree size (both dbh and height) were higher in Jalbire Mahila CF compared to Laxmi Mahila CF though the densities of stands are similar to each other (Table 5).

Among different parts of vegetation, the carbon sequestered by stem was found to be highest and under growth vegetation was found to be lowest in both CFs (Fig. 12). There is similarity between two CFs in terms of percentage of carbon sequestration by different parts of vegetation. This is due to similar type and composition of species. The similar growth and development of species in both CF is also responsible for this result.

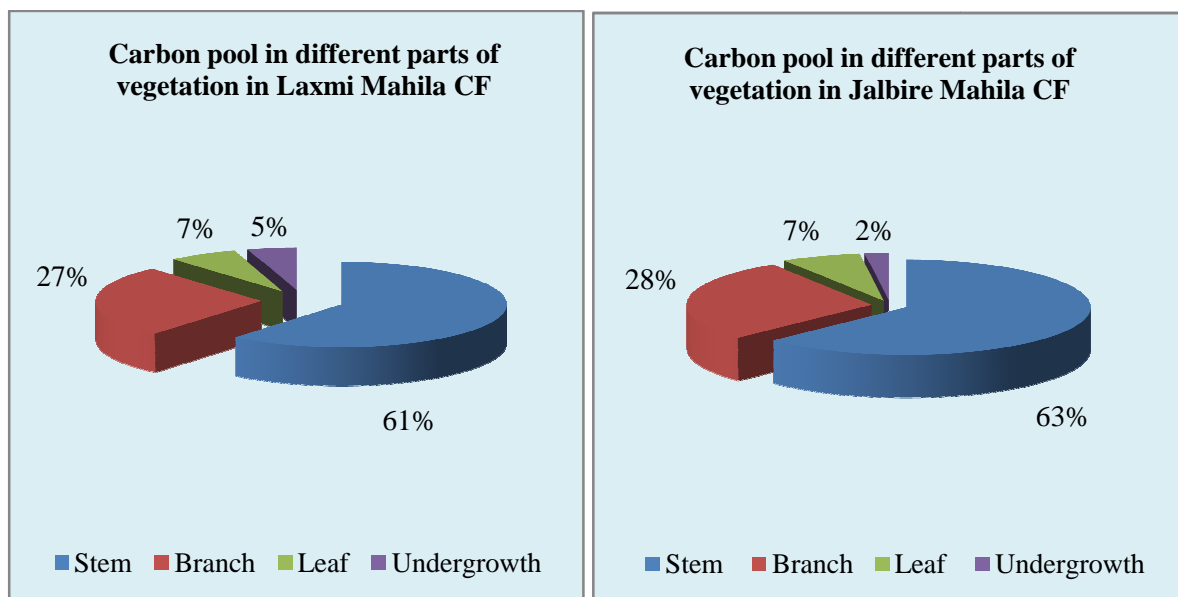


Figure 13. Carbon pool in different parts of vegetation in two CFs

Species wise carbon pool by CFs

Species-species carbon pool by the two CF is shown in the pie-chart below (Fig. 13). Among the species found in both CFs, the carbon pool rate was found to be highest in *Shorea robusta* species (i.e., 48.03 t ha⁻¹ in Laxmi Mahila CF and 110.51 t ha⁻¹ in Jalbire Mahila CF). Similarly, another species having more carbon pool was *Dalbergia sissoo* found in Jalbire Mahila CF. The least carbon pool species was *Lagerstromia parvifolia* in Laxmi Mahila CF whereas *Magnifera indica* in Jalbire Mahila CF. This result suggests that *Shorea robusta* should be promoted in Laxmi Mahila CF while *Dalbergia sissoo* along with *Shorea robusta* should be promoted in Jalbire Mahila CF.

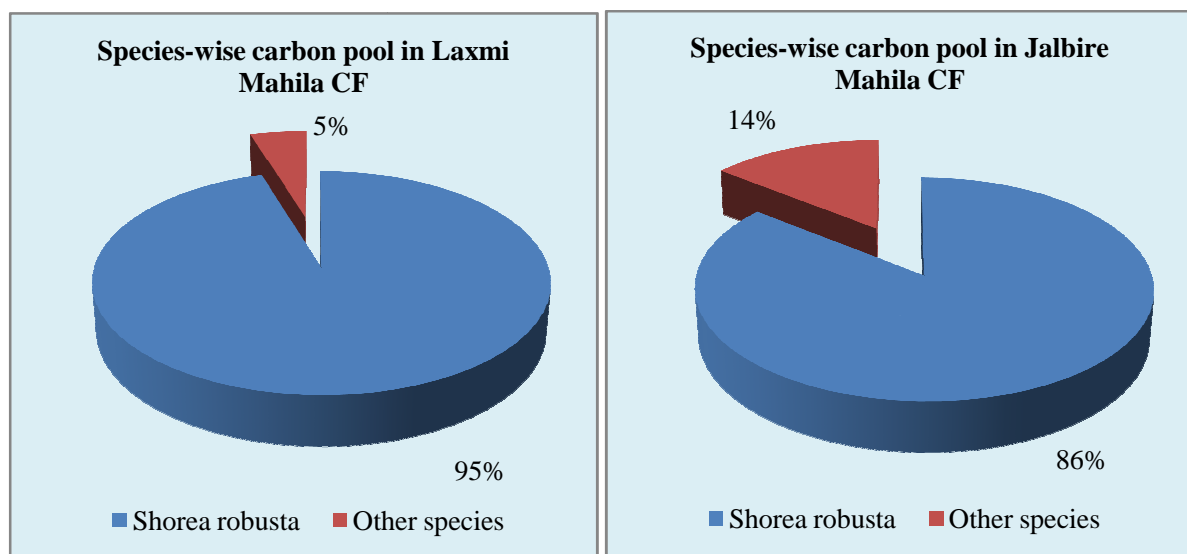


Figure 14. Species-wise carbon pool in two CFs

In both CFs, the major dominant species was *Shorea robusta*, having more carbon pool (Fig. 13). This result can be compared with some results of previous similar studies. (Baral et al., 2009) found that Hill *Shorea* forest sequestered 97.86 t ha⁻¹ C with maximum height of stand 30m, mean height 12.75 m and maximum dbh of stand 89 cm, mean dbh 19.56 cm. Similarly, (Shrestha, 2009) found that *Shorea* forest sequestered 78.80 t ha⁻¹ C with maximum height of stand 15.1 m, mean height 9.75 m and maximum dbh of stand 39 cm, mean dbh 11.11 cm. (Khanal et al., 2010) found the carbon pool of one of the mid-hill CFs of Nepal as 40.2 t ha⁻¹ C where the maximum height of stand was 22m, mean height 10.6m and maximum dbh 50.2 cm and mean dbh 16.22 cm.

The carbon pool of Jalbire Mahila CF seems to be greater than the previous results done by various researchers. However, the above carbon pool results seemed to be comparable and realistic with the recent and similar studies of ANSAB, Nepal in same district (ANSAB, 2011). Here are some of the causes of variations in carbon pool results performed by other researchers in different districts of Nepal. Both heights and dbh of the stands were greater in Jalbire Mahila CF than the forest where (Shrestha, 2009) carried out the research. So, it is obvious that the carbon pool becomes higher in Jalbire Mahila CF. Though the dbh of stand in Jalbire Mahila CF is less than of the dbh of Hill Shorea forest where (Baral et al., 2009) carried out the research, but the mean height and maximum height both are larger in Jalbire Mahila CF. So, this might result in greater carbon pool in Jalbire Mahila CF ($128.83 \text{ t ha}^{-1} \text{ C} > 97.86 \text{ t ha}^{-1} \text{ C}$). Most of the forests of Gorkha district have more carbon pool than forests of other districts in Nepal (Bhattarai et al., 2012). Several other physical and ecological factors such as slope, aspect, soil properties etc. might affect the total carbon stock in these forests.

Likewise, the result of (Khanal et al., 2010) had lower carbon pool because the species composition was different there. The main species there was *Schima-castonopsis*. The previous studies showed that the carbon pool of shorea forest was greater than that of *Schima-castonopsis* forest. (Shrestha, 2009) found that the above ground carbon pool in *Schima-castonopsis* forest was $34.55 \text{ t ha}^{-1} \text{ C}$ whereas in shorea forest was $78.80 \text{ t ha}^{-1} \text{ C}$ even though the mean diameter of stand in *Schima-castonopsis* forest (14.27 cm) was higher than shorea forest (11.11 cm) and mean height of stand in *Schima-castonopsis* forest (10.03 m) was also higher than shorea forest (9.75 m). Similarly, the above ground carbon pool of *Schima-castonopsis* forest was found to be less than that of *Shorea robusta* forest ($34.30 \text{ t ha}^{-1} \text{ C} < 97.86 \text{ t ha}^{-1} \text{ C}$) (Baral et al., 2009).

5.5 Combining carbon pool and adaptation to climate variability at local level

There are arguments that adaptation to climate change and mitigation are often combined for providing greater benefit to the people (Bernier and Schoene, 2009). This study also shows that adaptation and mitigation can only be best combined when the local people are capable to develop income generating activities and be able to gain the opportunities from the protected forests (criteria). The interactions are illustrated in Fig. 15.

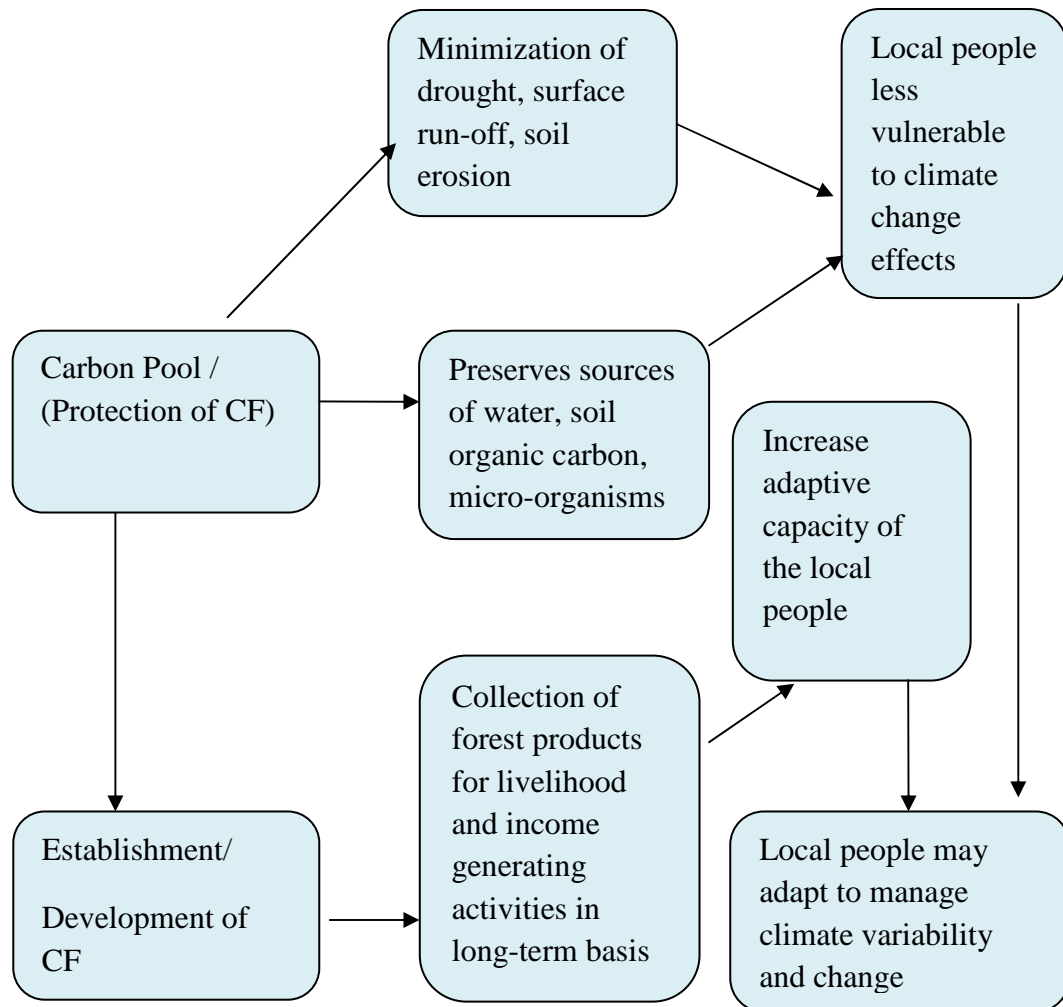


Figure 15. Linkage between C pool and adaptation to climate variability and change

Most of the adaptation activities practised by rich people of both CF were not linked with role of CF. Those users were engaged in their own jobs, local business which has no any connection with the role of CF directly. However some people were benefited by the CFs in adapting to climate variability and change (Table 9 and Box 3). The poor users were able to get loan from the collective fund created from the income of CF in order to perform different

adaptation activities like vegetation production and selling, goat and pig farming (indirect contribution of CF). Besides, some users were also benefited by the forest resources directly. For example, collecting and making leaf plates from the leaves of *Shorea robusta* species, making various bamboo and wooden products from *Bambusa* and other available tree species of the CF.

Although the adaptive capacity of some forest resource dependent community was inhibited by the establishment of CF in short-run but they were benefited by the CFs in the continuous and long-run basis. Those users were able to receive forest products for their personal uses continuously from the CF but they were not able to sell the forest products on their own wishes for managing the impact of climate variability. CF allowed extracting limited forest resources in definite time (Jalbire Mahila CFOP, 2011 and Laxmi Mahila CFOP, 2009). Since, the carbon pool is more in stem of the stand (Fig. 13); the local people could get benefits from other products such as fuel wood, leaves etc. than the timber. This would not affect more on overall carbon pool of the CFs.

Besides, both CF had great opportunities get monetary benefits from REDD program in future. A Total of 31 CFs of same district had been already benefited by REDD project (Adhikari, 2012). Such financial aid would greatly support the poor people of the community to carry out adaptation activities in managing climate variability.

Chapter 6: Conclusions and the ways forward

6.1 Conclusions

- Among various climatic risks and hazards, long dry periods and irregular rainfall were often experienced by the local people in the study area. Since more agriculture dependency community is likely to be affected by differences and shifts in climatic conditions, so people of Jalbire Mahila CF were more affected by local climatic risks and shocks due to their more dependency on agriculture than Laxmi Mahila CF.

- The agriculture, local labour and trade were regarded as more vulnerable sectors in terms of climatic variability and change in the study area. Livelihoods of local people especially belonging to castes Newar, Magar, Sarki and Damai were highly affected by climatic variability and change. Among these castes, Sarki and Damai even belong to poor and marginalised groups.

- The trend of out-migration of adults and youths was reflected mainly by the low income from agriculture sector and lack of local employment opportunities. Due to lack of such manpower, the adaptive capacity of other people in agriculture sector was reduced.

- There was greater proportion of higher castes people in Laxmi Mahila CF than in Jalbire Mahila CF. These higher castes people Brahmin and Chhetri were found to be more educated than other castes in the study area. However, there was social differences and marginalisation between higher castes and lower castes within the community. This caste and social marginalisation had also resulted in less capacity of poor people to adapt with climate variability and change.

- The utilization of forest products was socially differentiated in the study area. Mainly the castes Magar, Damai and Sarki were more dependent on forest resources for their livelihoods. However, the establishment of CF was not the major solution in order to strengthen the adaptive capacity and improve the livelihoods of local people.

- In the face of the above problems, the local people at the study area adapted some community-based coping and adaptation mechanisms such as change in cropping patterns, choice of crop species, involvement in seasonal jobs, adding chemical fertilisers in agriculture lands to increase productivity, local trade, out-migration and collection of welfare funds. Hence, most of the adaptation activities practiced by local people were not linked with benefits provided by the CF.
- There were some conflicts and quarrels between higher and lower castes people regarding illegal collection of forest resources, encroachment of CF boundary, forest products distribution, welfare fund distribution and fund transparency.
- In comparison to Laxmi Mahila CF (52.90 t ha⁻¹), Jalbire Mahila CF was found to be sequestering more carbon pool (131.54 t ha⁻¹) due to larger sized trees which consequently have greater biomass. In comparison to species-wise carbon pool, the species *Shorea robusta* was found to be sequestering more carbon pool on both CFs (48.03 t ha⁻¹ in Laxmi Mahila CF and 110.51 t ha⁻¹ in Jalbire Mahila CF).
- There were no any particular species from which the local people were directly benefiting in managing extreme weather events and climate variability. However, the species *Dendrocalamus strictus* (Bamboo) and *Shorea robusta* were utilised mainly by marginalised people belonging to caste “Dalits” (Damai and Sarki) and Magar for making and selling local products such as baskets, chairs, tables, stools, cupboards, racks, etc. which could support their livelihoods and helped in managing climate variability to some extent. But, the utilisation of these species was only in small extent.
- Besides, in comparison to other species, *Shorea robusta* was found to be more dominant and valuable timber species on both study sites. Most of those species were in growing stage. So, both communities could only generate some income by selling few matured *Shorea robusta* trees.

6.2 The ways forward

- It is essential to encourage and create awareness among the local people especially female of Jalbire Mahila CF and poor and marginalised people, in order to make aware about the impact of climate variability and change. Strategies should be developed to enhance the adaptive capacity of those people such as providing skill development trainings, local employment and sufficient welfare funds.
- Modern farming technologies with hybrids and resistant crops should be promoted to increase the output from agriculture sector. Also the employment opportunities should be developed especially for the youths and adults in the locality which can minimise the migration of such people towards cities and abroad.
- Awareness programs that can minimise social marginalisation and differences should be launched. Besides, the off-farm activities such as local trade and livestock rearing should be strengthened in order to promote the local level economy of the community.
- The growing species *Shorea robusta* should be promoted in both CFs because it will provide good returns after becoming matured. Since it is challenging to promote more carbon pool in the CFs by selling the matured trees for good income, so the harvesting should be carried out block-wise along with plantation programs side by side.
- In order to optimise the carbon pool of CFs by providing the socio-economic and environmental benefits to the community, the local people should promote non-timber forest products such as *Musa* spp., *Adhatoda vasica*, *Coffea Arabica*, *Zingiber officinale*, etc. and multipurpose species such as *Bambusa* species, *Thyrsanolaena maxima*, *Ficus* species, *Leucaena leucocephala*, *Morus alba*, *Melia azadirach* etc. in CFs as well as in their private lands.
- The local community should emphasise on the utilisation of forest products such as firewood, fodder and leaves but not timber or stem because the stem was found sequestering more carbon in all species of the study area.

- Since the communities were not paid for their carbon sequestration efforts through any kind of programs from the government, so the local governmental and non-governmental organisation should provide some sort of financial assistance to encourage the local communities.

- Local people should be technically trained for regular measurements and monitoring of carbon pool in their CFs which can help to reduce the high transaction costs of REDD+ scheme, which is going to be implemented soon in the community forests.

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Appendices

Appendix 1. Abbreviations

ANSAB	Asia Network for Sustainable Agriculture and Bio-resources
CBNRM	Community Based Natural Resource Management
CDM	Clean Development Mechanism
CF	Community Forest
CFUG	Community Forest Users' Group
Cm	Centimetre
CO ₂	Carbon dioxide gas
dbh	Diameter at breast height
FCTF	First Carbon Trust Fund
FECOFUN	Federation of Community Forestry Users, Nepal
GPS	Global Positioning System
Ha.	Hectare
ICIMOD	International Centre for Integrated Mountain Development
INGO	International Non-Governmental Organisation
IPCC	Intergovernmental Panel for Climate Change
LPG	Liquefied Petroleum Gas
Mm	Millimetre
m.s.l	Mean sea level
MS	Microsoft
NGO	Non-Governmental Organisation
NTFP	Non timber forest products
OP	Operational Plan
REDD	Reducing Emissions from Deforestation and Forest Degradation
SAS	Statistical Analysis System
SE	Standard Error
UNFCCC	United Nations' Framework Conference on Climate Change
VDC	Village Development Committee

Appendix 2. Photo plates of field visit



Photo Plate 1: Execution of social survey in the study sites



Photo Plate 2: Measurement of diameter and height of stands in the study sites



Photo plate 3: Collection of herbaceous and woody vegetation in the study sites