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IMPACTS OF CLIMATE CHANGE ON WATERSHED AND LIVELIHOOD OF PEOPLE LIVING IN ITS VICINITY

(A CASE STUDY FROM THOTNEKHOLA AND PATALESWARA CFUGs OF PHEWA WATERSHED)

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Abstract

Climate Change is the global challenge of our time to watershed conservation and livelihood security. Although Nepal has a negligible share in the global emission of Greenhouse gases, it is vulnerable to climate change impact due to its fragile mountain ecosystem, which is characterized both by a highly variable climate regime and by fragile ecosystems. Its temperature is increasing at alarming rate 0.06°c per annum more than the global average. To verify this, a case study entitled "Impact of Climate Change on watershed and livelihood of People living in its vicinity" was conducted in Phewa watershed of Kaski district.

The main objective of the study was to present the local level climate change impacts on watershed and livelihood of the users" and to identify adaptation measures for improving livelihoods of the people while reducing their vulnerability to climate change. Also, the objective of the program is to assess the trend of change in temperature and rainfall in the study area. Various participatory rural appraisal tools and techniques such as household survey, key informants interview, focus group discussion, and trend analysis were done for collecting primary data. Households of all caste and all categories of well-being of people were selected by simple random sampling method. Meteorological data of the study area form the Department of Hydrology and Meteorology, Pokhara supplement primary information and various published and unpublished literatures were used for collecting secondary data. Collected data were analysed using MS-Excel 2010. The study revealed that majority of the people were dependent on agriculture and it was found this sector had been adversely affected by the climatic variability. Decrease in agricultural production, loss in biodiversity, depleting of water resource and decrease in soil productivity in the area were the impacts observed during field study. A key conclusion coming out of this review is that climate change is not only an issue of international concern but is now a local problem in Nepal.

Key words: Climate change, watershed, livelihood, CC impact, CC adaptation

Introduction

Climate change is the change in the statistical distribution of weather patterns when that change lasts for an extended period of time (i.e. decades to millions of years). Climate change may refer to a change in average weather conditions over long period of time. The Intergovernmental Panel on Climate Change (IPCC) defines climate change as “all evolution of the climate in the time that is due to the natural variability or to the human activities”. But for the United Nation Framework Convention on Climate Change (UNFCCC), climate change means “all change in climate, directly or indirectly attributed to human activity that alters the composition of global atmosphere and which is in addition to natural climate variability observed over comparable time period” (UNFCCC, 1992, p4).

It is evidence that the average temperatures are increasing, and extreme weather events are frequent, and frequency of drought, flooding and storm events and other climate induced disaster are projected to intensify (UNFCCC, 2007). These consequences of CC are evolving rapidly. Recent studies suggest that the impacts of CC may be even more severe and more rapid than those reported by the IPCC in 2007 (Practical Action, 2008). Global warming is due to emissions of greenhouse gas that result from human activities such as deforestation particularly from developing countries, and the burning of fossil fuels specifically from developed countries. As a result of global warming, frequency and intensity of extreme events, such as tropical cyclones (hurricanes and typhoons), floods, droughts and heavy precipitation events are occurring and rise even with relatively small average temperature increases (UNFCCC, 2007).

Sea level rise, change in precipitation pattern (up to ±20%), and change in other local climate conditions are expected to occur as a consequence of rising global temperature (Cubasch et al. 2001). This is expected to have a potential impact on different socio-economic sectors (IPCC, 2001). The best estimates indicate that the Earth could warm by 3 degree Celsius by 2100. Even if countries reduce the emission of greenhouse gas, the earth will continue to warm (UNFCC, 2007). From 1906 to 2005 the global average surface temperature increased by 0.74 (0.56 to 0.92)0C. The linear warming trend over the 50 years from 1956 to 2005 was 0.13 (0.10 to 0.16)0C per decade is nearly twice that for the 100 years from 1906 to 2005 (IPCC, 2007). IPCC

has also projected that by 1990 global average surface temperature will increase by 1.8 – 4.00C. It is expected that the impacts would be harsh if active efforts are not taken to limit GHG emission.

The most studied climate variable in the context of CC is temperature. Its average value has increased by approximately 0.6 ºC from the end of the nineteenth century. The warmest decade since data have been registered was the 1990s. Precipitation in the tropics has increased slowly, but a measure of the increase has not been apparent in recent decades. Monitoring data show that the sea level has risen by about 1 to 2 mm per year, with a mean value of 1.5 mm/year. The best estimates indicate that the Earth could warm by 3° C by 2100. Even if countries reduce their greenhouse gas emissions, the Earth will continue to warm (UNFCCC, 2007).

Watersheds and resources available in watershed areas are critical to economic development and environmental protection in Nepal and are likely to be affected by future climate change. More than 70% of the country's total land area lies within certain watersheds. Forests and water resources of a watershed provide a host of environmental as well as livelihood services to farmers. Also, it is estimated that most of the agricultural lands of our country currently derive irrigation water from watersheds. Moreover, nearly one-third of the country's total population, inhabit the uplands of many watersheds, majority of whom depend on watershed resources for survival.

Nepal is one of the world's poorest countries having few industrial emissions. Nepal is responsible for only about 0.025% of the total annual GHG emissions of the world (Karki, 2007). Temperature of Nepal is increasing rapidly. Between 1977 and 1994 Nepal's average temperature rise at a rate of 0.03-0.06 degree Celsius per annum with higher rate in mountains than in lowlands(Shrestha et al. 1999).Nepal is ranked as 4th most vulnerable country in the world by the CC Risk Atlas 2010 and top ten countries most likely to be impacted by global CC (WFP, 2009). Several studies confirm that Nepal is among the most highly vulnerable countries to climate change for two major reasons. First is that the mountains of Nepal have already exhibited the signs of serious impacts through high rate of temperature increase. Second is that our country Nepal is one of the least developed mountain country, majority of people lacks capacity to adapt to climate change. It is experiencing increase in dry periods, intense rainfall, floods, landslides, forest fires, glacial retreats and Glacier Lake Outburst Flood (GLOF) threats (Shrestha, 2007). Temperature observations in Nepal from 1977 to 1994 show a general warming trend (Shrestha et al. 1999). The warming is significantly greater at higher elevations, i.e. mountainous region, in the northern part of the country than at lower elevations, i.e. Terai in the south (Agrawala and Berg 2002).

Materials and Methods

Study Area

Kaski District

Kaski is situated in Gandaki Province and its headquarter is Pokhara. It has an area of 2,017 square km and had total population of 492,098 according to 2011 Census. It is one of the best tourist destinations of Nepal. Kaski district politically has one metropolitan city, 4 Gaupalika and 3 electoral sectors. Major tourist attractions of this district are Phewa Lake, Begnas Lake, Rupa Lake, Devis Fall, Bindhabasini Temple, Gupteshwar Cave, and Mahendra Cave etc.

Coordinates and Location

Latitude (DMS): 28.2622°N

Longitude (DMS): 84.0167°E

Altitude: 450m to 8091m

Phewa Watershed

Phewa Lake lies in the southern part of Pokhara valley of Kaski district in Gandaki Province of Nepal. It is situated at an altitude 742 m and lies within latitude 28°11'37" to 28°17'26" North and longitude 83°48'02" to 83°56'50" East. Out of total areas Phewa watershed, 44% is forest, 44.5% is agricultural land, 4.4% is built up area, 4.1% is water body, 1% is barren land, 0.9% is sand land, 0.7% is wetland and 0.2% is grassland (Subedi, 2013).

There are six Community Forest User Groups (CFUGs) in Phewa watershed areas. But this study is conducted only in two CFUGs of Phewa lake watershed areas. One will be Thotnekhola CFUG, Sarangkot and another will be Pataleswara CFUG, Pumdibhumdi.**Figure 1** show the location map of the study watershed areas, which is situated in Kaski district.

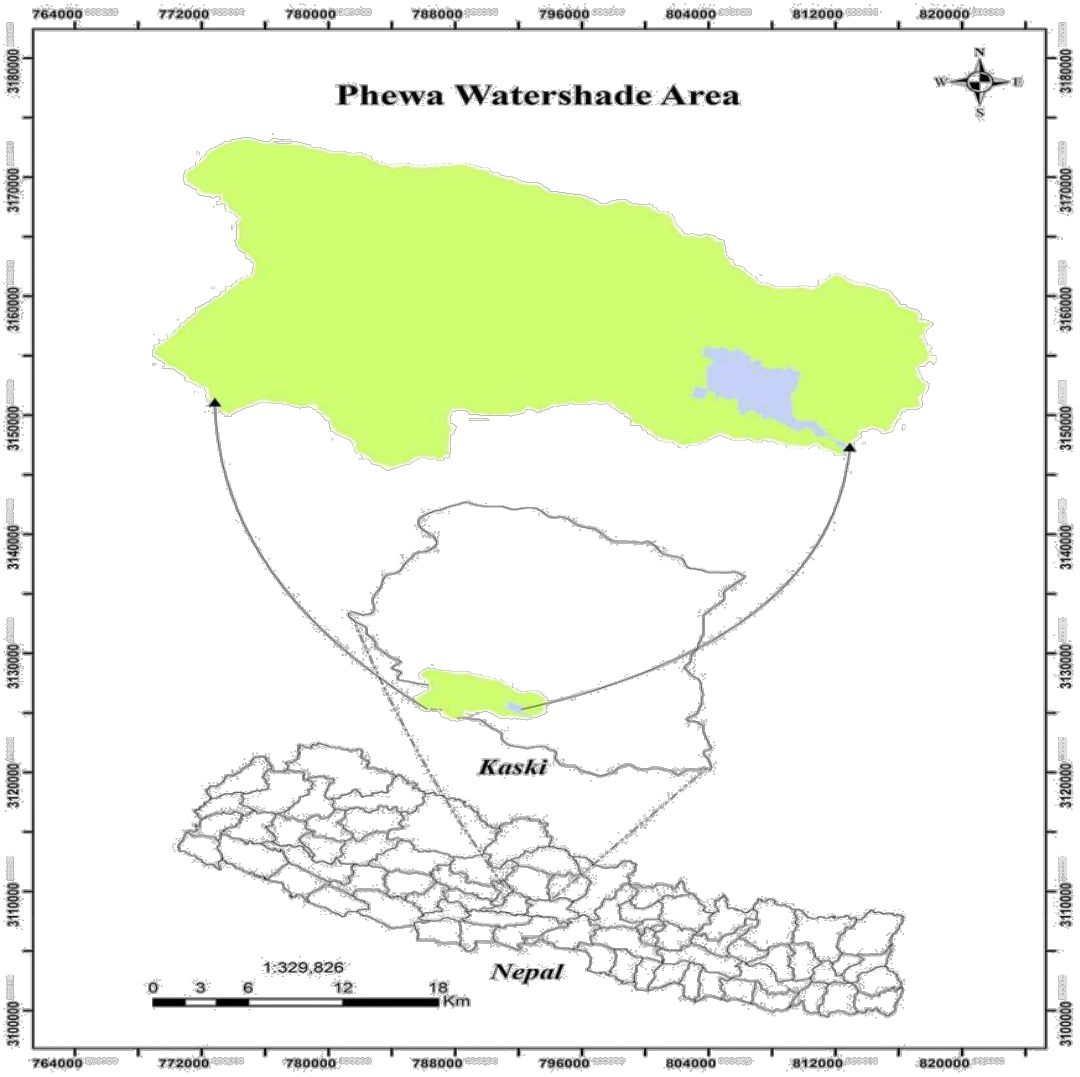

Figure 1(Source DSCO: Location Map of Phewa Watershed Areas)

Sampling Design

Simple random sampling is the basic sampling technique where I selected a group of subjects (a sample) for study from a larger group of CFUGs. I used Cochran formula in order to calculate sample size from total population size.

(Cochran, W.G., 1977)
n1=z^2 pq/e^2
Where e is the desired level of precision (i.e. margin of error)
p= 50% i.e. 0.5
q=1-p
Confidence level 80% i.e. z=1.28
n=n1/ 1+ (n1-1)/N
n= sample size
N= total household number

In Thotnekhola CFUG there are 152 total household and in Pataleswara there are 79 household so according to the above formula 79 and 54 household will be taken as sample respectively.

Data Collection

Both primary and secondary data was collected. Primary data was collected from the study sites while secondary data was collected from published and unpublished documents regarding climate change, its impacts, and adaptive measures. Both primary and secondary data was collected using Participatory Rural Appraisal (PRA) tools and techniques discussed in following section.

Primary Data Collection

a) Household survey

Household interviews are the most crucial component of the data collection process in this research. First of all, questionnaire was developed and pre-tested and then household survey was conducted in randomly selected Households. Both close and open ended questions were asked to the respondent for this purpose. The purpose of conducting this survey is to collect information about livelihood profile of households, different aspects of climate change elements and adaptation measures they had adopted in response to the change.

b) Key Informant Interviews

Key informant interviews was conducted with CFUG committee members, village leaders, local teachers, individuals affiliated to NGOs, government officials of Municipality and Division Forest Office, leader from disadvantaged group, etc. They were interviewed about changes in rainfall and temperature pattern and changes in resource availability and its impacts on CFUG member's livelihoods. The questionnaires for this purpose were open-ended.

c) Field Observation

The field observation was done to observe and gather information on local, social and physical features for getting field insights on the consequences of disasters and measures adopted by people to cope with climate change.

d) Group Discussions

Group discussions was conducted to gather information on past natural disaster events in the watershed areas, observed environment changes and change in forest productivity and water sources of watershed areas due to climate change in recent years & adaptation measures adopted by local people. Both male and female participants from all well-being and ethnic groups were involved in the group discussion.

Secondary Data Collection

Secondary data was collected from various published and unpublished article, reports, climatic data obtained from the Department of Hydrology and Meteorology, socio economic data obtained from DFO profile, CFUG record etc.

Data Analysis

The data collected from the field work was categorized into separate variables. After that these variables were categorised, tabulated and analysed using Microsoft Exel-2010 and other simple statistical tools. Information collected through focus group discussion and key informant interviews was analysed via matrices, descriptive information and case studies. Findings of the study were presented in tables, bar diagrams, pie charts and line graphs.

Result and Discussion

Socio-economic Characteristics of the Respondents

Characteristics such as age, sex, caste, education status, family size, occupation, land holding, food sufficiency, cropping pattern and livestock management system, etc. of the respondent's give quick understanding of the socio-economic conditions of the users in the study area. During my study 79 sample household from Thotnekhola CFUG and 54 sample household from Pataleswara CFUG were taken and questions were asked to different age class and caste. As a result different socio-economic aspects were observed so it is presented and analysed under this heading.

Ethnic groups

In Pataleswara CFUG among 54 respondents 37% were Brahmin, 15% were Chhetri and 48% were Dalit.

In Thotnekhola CFUG among 79 respondents 48% were Brahmin, 33% were Janajati, 11 were Dalit and 8% were Chhetri.

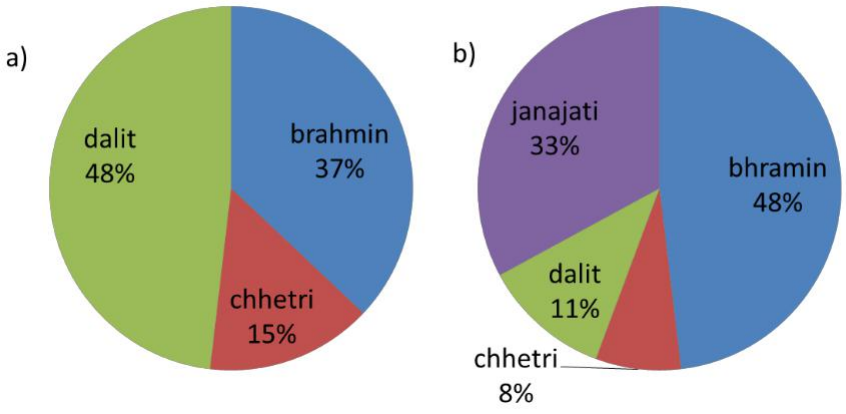

Figure 2 Ethnic Group of a) Pataleswara CFUG, b) Thotnekhola CFUG

Gender of the Study population

Both male and female were participated in questionnaire survey. But the involvement of women was very low with compared to men. In Pataleswara CFUG involvement of female was 19% whereas involvement of male was 81%.

Similarly in Thotnekhola CFUG involvement of female was 22% and involvement of male was 78%.

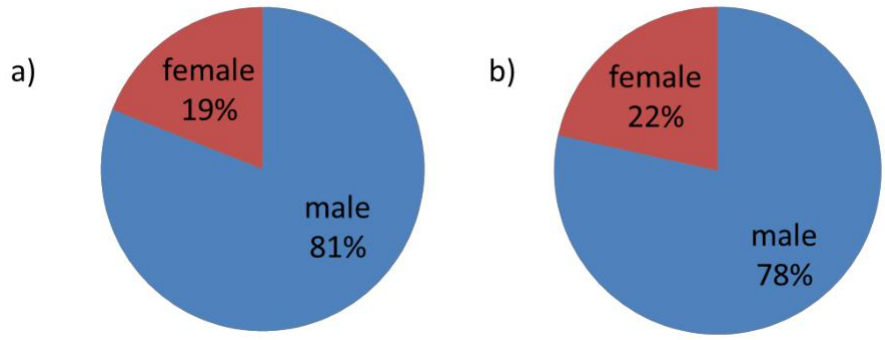

Figure 3 Gender of Respondents a) Pataleswara CFUG b) ThotnekholaCFUG

Occupation of the Respondents

In both CFUG most of the people were involved in agriculture. Other people were involved in job, business, service and foreign employment. People who were involved in government job and driving were categorized under service.

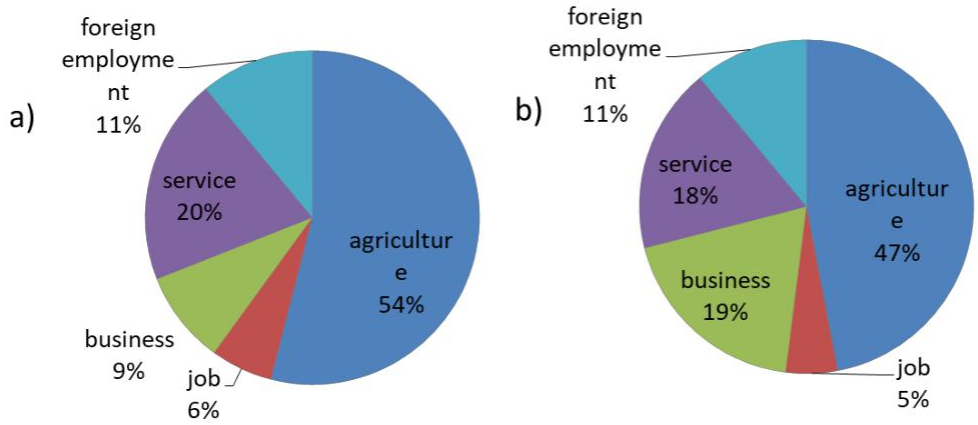

Figure 4 Occupation of Respondents a) Pataleswara b) Thotnekhola

Age class of Respondents

All respondents were divided into three categories i.e. youth (below 35 years), adult (35-55 years) and elder (above 55 years). In Pataleswara CFUG 11% were youth, 56% were adult and 33% were elder. Where as in Thotnekhola CFUG 4% were youth, 47% were adult, and 49% were elder.

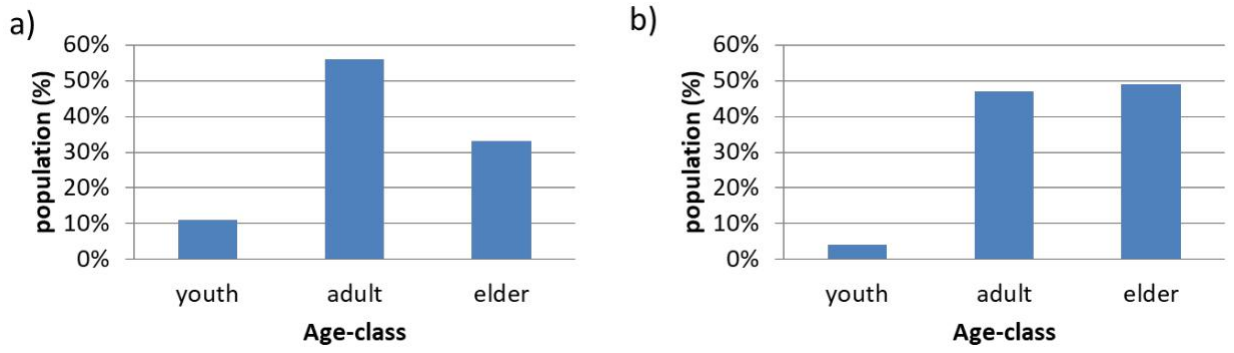

Figure 5 Age of Respondents a) Pataleswara b)Thotnekhola

Education level of the Respondents

Education level of the respondents was divided into four categories i.e. illiterate, primary, secondary and higher secondary. In Pataleswara CFUG 28% respondent were illiterate, 50% had acquired education up to primary level, 15% acquired education up to secondary level and remaining 7% acquired higher secondary level education.

Similarly in Thotnekhola CFUG 25% of respondent were illiterate, 51% had acquired education up to primary level, 16% acquired education up to secondary level and remaining 8% people acquired higher secondary level education.

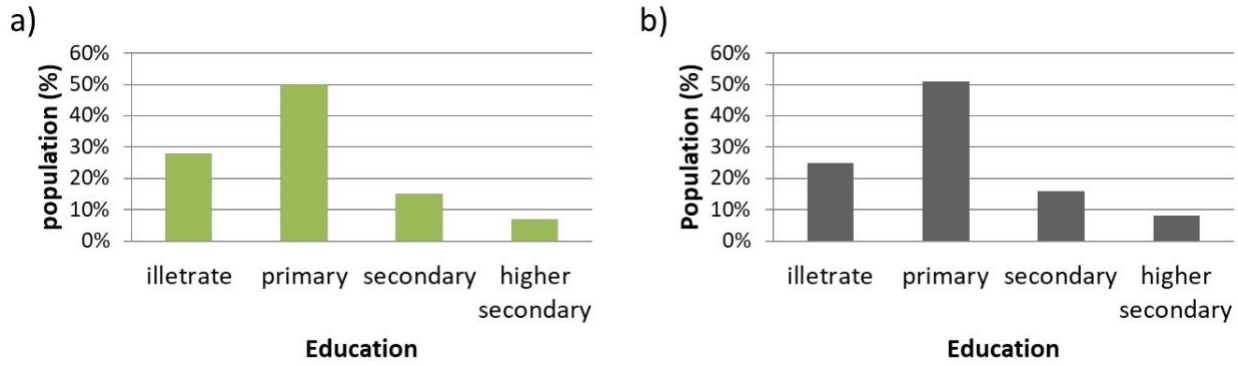

Figure 6 Education of Respondents a) Pataleswara b) Thotnekhola

Livestock Management

Most common animals reared in study area are buffalo, cow, ox, goat and poultry. In Pataleswara CFUG 37% people rear buffalo, 13% rear cow, 4% rear ox, 46% rear goat and 17% rear hen (poultry).

In Thotnekhola CFUG 24% people rear buffalo, 13% rear cow, 3% rear ox, 28% rear goat and 14% rear hen (poultry).

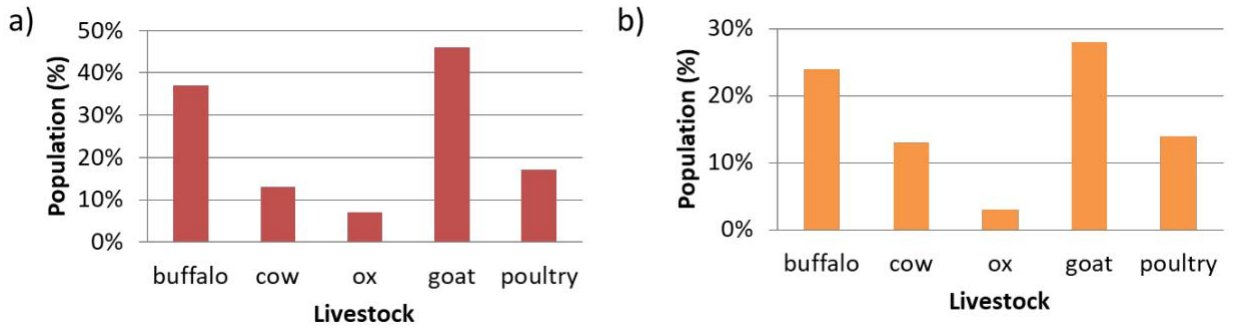

Figure 7 Livestock managed by respondents a) Pataleswarab)Thotnekhola

Food Sufficiency

In Pataleswara CFUG among 54 sample household 25.9% i.e. 14 households had sufficient food for a year,11.11% i.e. 6 households had sufficient food for 1-2 months, 48.14% i.e. 26 households had sufficient food for 2-3 months, 9.25% i.e. 5 households had sufficient for 3-4 months and 5.5% i.e. 3 households don't have any land for crop production.

Similarly in Thotnekhola CFUG among 79 sample household 6.32% i.e. 5 households had sufficient food for a year 18.98% i.e. 15 households had sufficient food for 2-3 months, 5.06% i.e. 4 households had sufficient food for 3-4 months, 6.32% i.e. 5 households had sufficient food for 4-5 months, 4% i.e. 3 households had sufficient food for 8 months and 59.49% i.e. 47 households don't have any land for crop production.

Knowledge of People on climate Change

Knowledge and understanding of people about climate change is discussed in this topic. It includes climatic parameters like temperature, rainfall, hail stones, drought, rainfall intensity, etc.

Perception on Temperature Change

In Pataleswara CFUG of Phewa watershed among 54 sample households 43 (79.62%) people felt some changes in temperature, among them 38 (70.37%) people felt that the temperature is increasing and 5 (9.25%) people felt that the temperature is decreasing. Likewise 8 (14.8%)

people didn’t feel any change in temperature. Similarly 3 (5.55%) people said that they had no idea about the changes.

In Thotnekhola CFUG among 79 sample households 69 (87.34%) people felt some changes in temperature, among them 66 (83.54%) felt that temperature is increasing and 3 (3.79%) people felt that temperature is decreasing. Likewise 7 (8.86%) people didn’t feel any change in temperature. Similarly 3 (3.79%) people said that they had no idea about these changes.

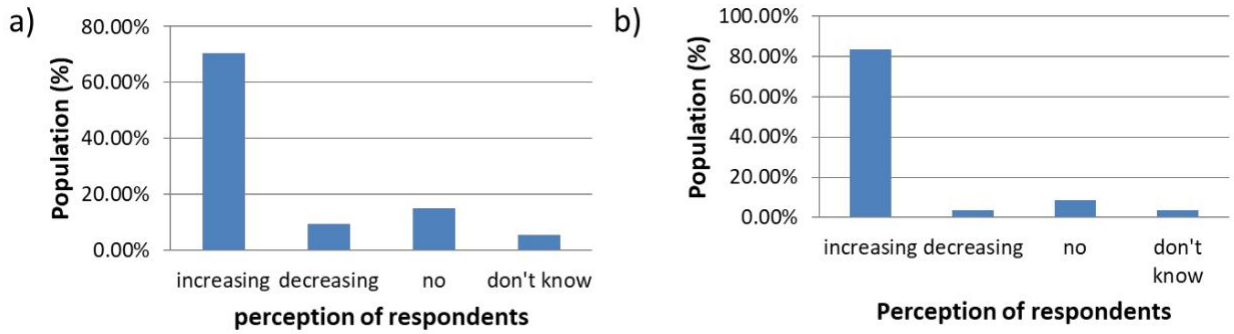

Figure 8 Perception of respondents on temperature change a) Pataleswarab)Thotnekhola

Perception on rainfall change

Change in rainfall pattern

In Pataleswara CFUG among 54 sample households 50 (92.59%) people felt changes in rainfall pattern, among them 46 (85.18%) people said that the rainfall is decreasing and 4 (7.40%) people said that rainfall is increasing. Likewise 3 (5.55%) people said that the rainfall pattern was same i.e. rainfall pattern has not changed. Similarly 1 (1.85%) of people don’t have any idea about these changes.

In Thotnekhola CFUG among 79 sample households 73 (92.40%) people felt changes in rainfall pattern, among them 70 (88.60%) people said that the rainfall is decreasing and 3 (3.79%) people said that rainfall is increasing. Likewise 3 (3.79%s) people said that the rainfall pattern was same i.e. rainfall pattern has not changed. Similarly 3 (3.79%) of people don’t have any idea about these changes.

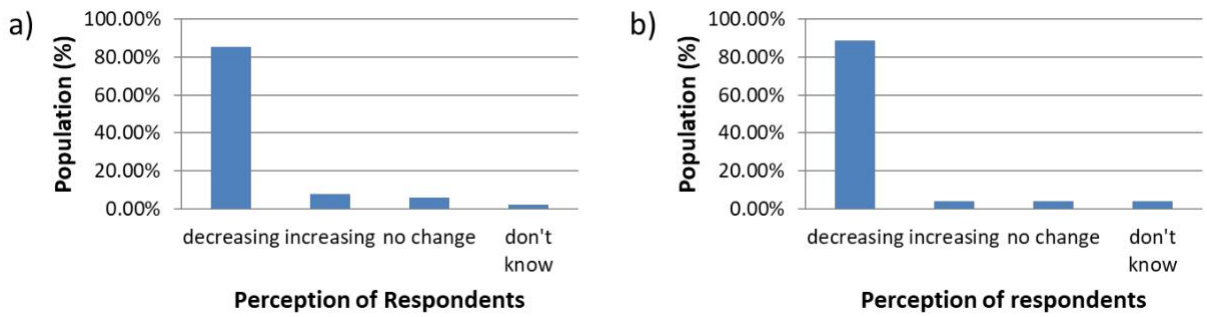

Figure 9 Perception of Respondents on rainfall pattern a) Pataleswara b)Thotnekhola

Change in winter rainfall

In Pataleswara CFUG 49 (90.74%) people said that the winter rain has decreased, 2 (3.70%) people said that the rainfall in winter has increased and 3 (5.55%) people said that the winter rainfall is normal.

In Thotnekhola CFUG 68 (86.07%) people said that the winter rain has decreased, 2 (2.53%) people said that the rainfall in winter has increased and 9 (11.39%) people said that the winter rainfall is normal.

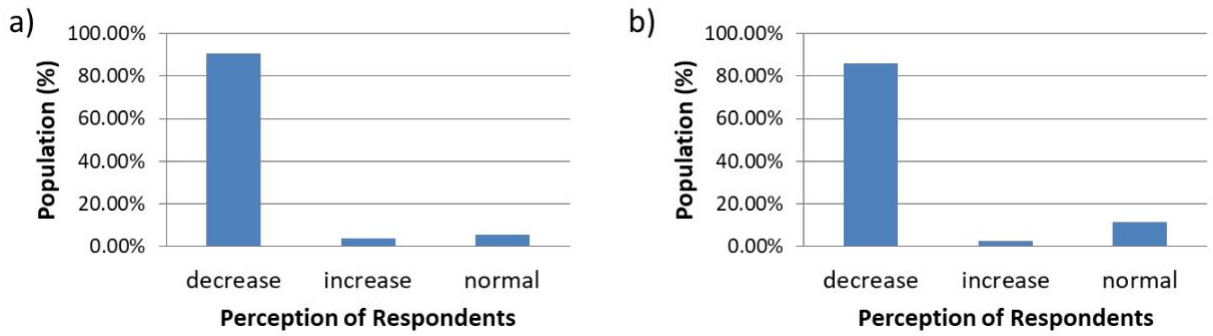

Figure 10 Perception of Respondents to winter rainfall a) Pataleswara b) Thotnekhola

Climatic Data Analysis for Assessing Climate Change

In this section analysis of temperature and rainfall data from 10 years (2007-2017) were collected from Department of Hydrology and Meteorology, Pokhara.

Average Minimum Temperature (2007-2017)

The average minimum temperature of Pokhara is slightly increasing. The trend of average minimum temperature is shown by the red line shown in the figure below.

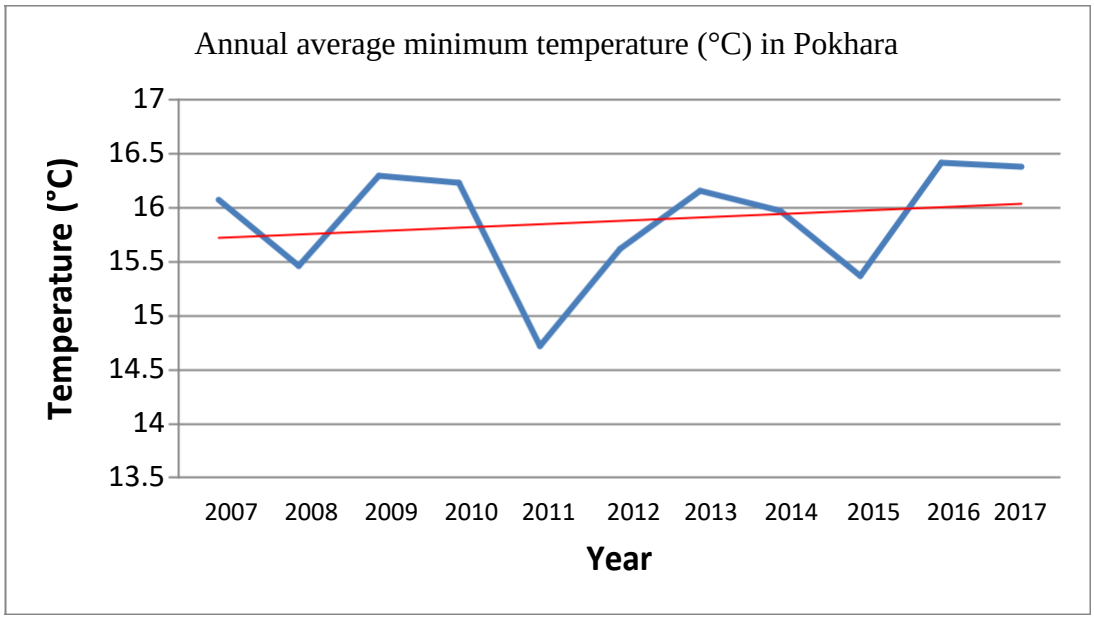

Figure 11 Average Minimum Temperatures (2007-2017)

The average maximum temperature of Pokhara is increasing..

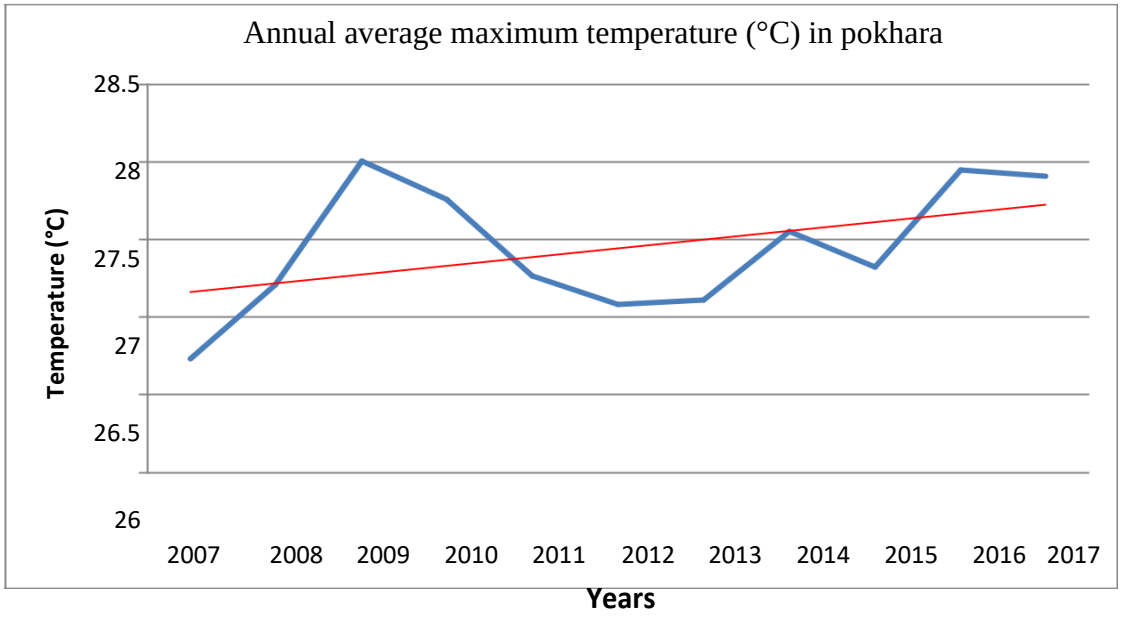

Figure 12 Average Maximum Temperatures (2007-2017)

Rainfall Pattern

Rainfall data available from Department of Hydrology and Meteorology, Pokhara of last 10 years (2007-2017) was used to analyze rainfall pattern. The rainfall patterns of both CFUGs are shown in the figure below.

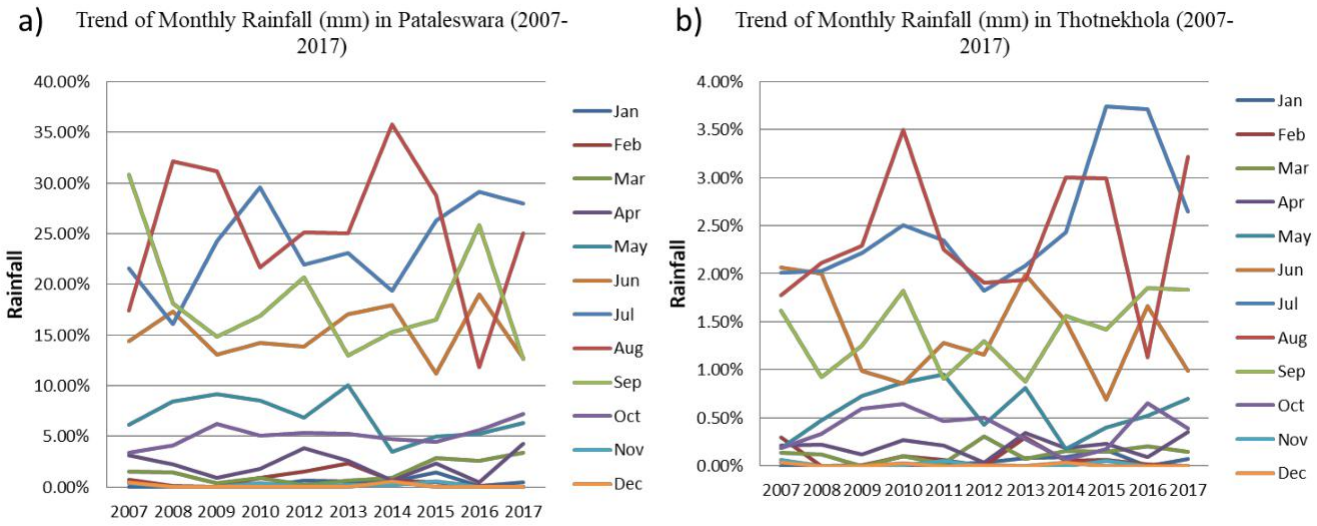

Figure 13 Rainfall Pattern a) Pataleswara b)Thotnekhola

Average Annual Rainfall

The average annual rainfalls of both CFUGs are shown in the figure below. The rainfall of Pataleswara is slightly decreasing whereas the rainfall of Thotnekhola is slightly increasing.

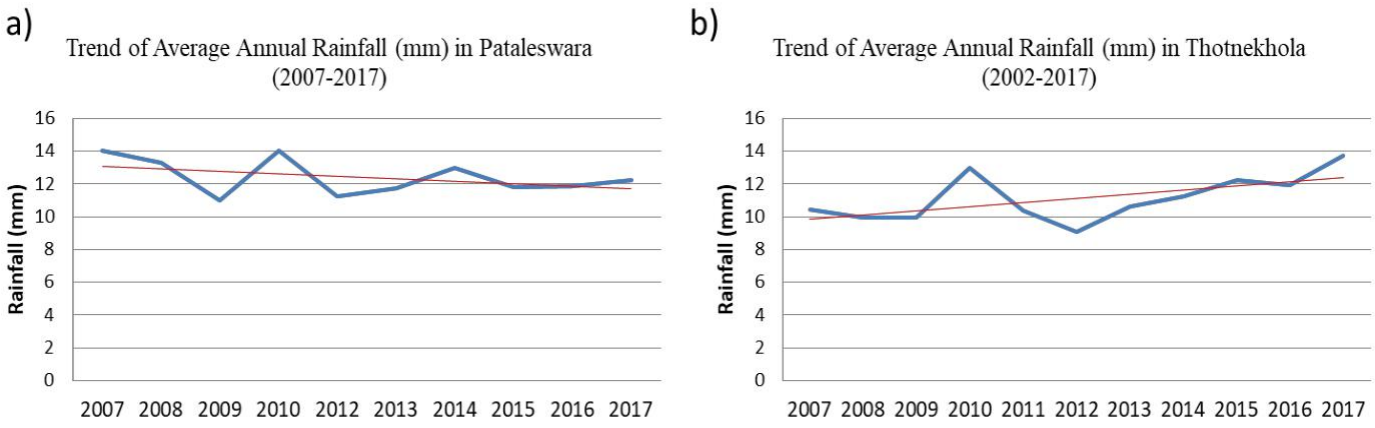

Figure 14 Average Annual Rainfall Trend a) Pataleswara b) Thotnekhola

Impacts of Climate Change

Nepal being a poor and agricultural country, climate change such as increase in temperature, change in rainfall pattern, drought, and disasters has affected agricultural production, livelihood, water resources, forest and biodiversity.

Impacts on Agriculture and livelihood

Nepal's economy depends on agriculture. Nepal is divided into three regions i.e. mountains (35%), hills (42%), and terai (23%) (Malla, 2008). 38.15% of Gross Domestic Products (GDP) is generated from 3,091,000 ha area. The country is susceptible to disasters, including flash flood, GLOFs and melting snow in the mountains and droughts and inundation in terai (Malla, 2008).

In my study area all the respondents said that the climate change have negative impact on agriculture. The production of millet is decreased in both CFUGs due to decrease in winter rainfall as well as irregular rainfall. Also respondents of both CFUGs are facing problem in paddy production due to the change in rainfall pattern and irregular rainfall. Respondents of Both CFUG are facing problems like soil compaction, low soil fertility and soil dryness. One of the major problems faced by respondents of both CFUGs is lack of irrigation facility. Almost all respondents depend upon rainfall for agriculture so change in rainfall pattern and untimely rainfall has resulted in decrease in agricultural production.

About 54% of respondent in Pataleswara CFUG and 38% of respondent in Thotnekhola CFUG depend on agriculture for their livelihoods and follow traditional cultivation practices that rely on seasonal rainwater. Change in climatic conditions affecting rainfall patterns is having an adverse impact on livelihoods of most of these communities, thus increasing their risks to food insecurity. The impact of climate change on agriculture has affected economic well-being of the population in study area.

Impacts on Water Resources

Our country Nepal is second richest country in water resources. Altogether there are 6000 rivers which provide a dense network of rivers with steep topographic conditions (ECOSEED, 2010). Climate change have adverse impact on water resources resulting decrease in amount of water, flowing intensity in rivers, and decrease in number of wetland species.

In both CFUGs perception of people regarding change in water surface, water quality and water flow were asked and the results of both CFUGs are shown in the figure below.

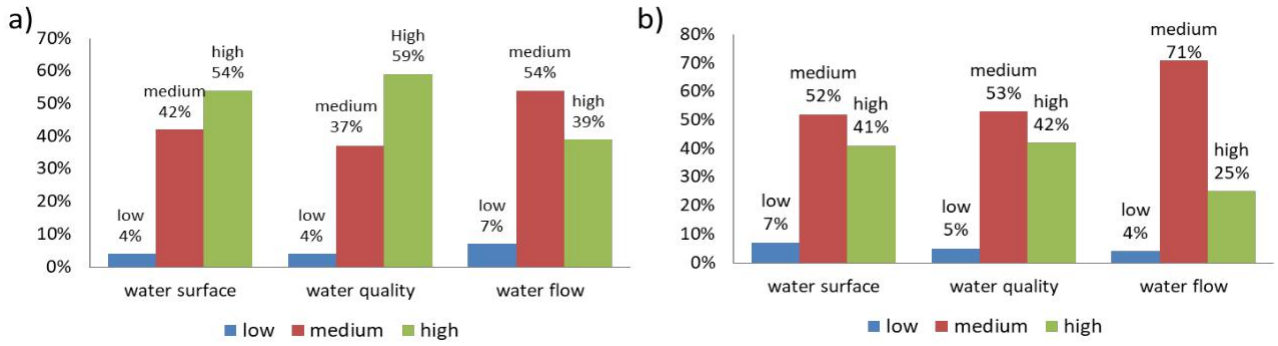

Figure 15 Perception of respondents to water resources a) Pataleswarab)Thotnekhola

Impacts on poor ethnic groups

Climate change affects poor people more than the rich people. Poor people are vulnerable to physical damage such as damage to house and infrastructure, social damage, as they have less land with compare to rich people so they are also vulnerable to loss of capital such as agricultural land etc. poor people are more likely to suffer from diseases and malnutrition as they don't have enough money to eat balanced diet and nutritious food. Degradation of livelihoods by climate change will thus leave poor people with fewer of the assets they need to withstand shocks and stresses. According to the focus group discussion held in both CFUGs poor, marginalized, women, children and the disabled are most vulnerable to climate change impacts as they have less capacity to cope up with such environmental changes.

Similarly vulnerability and exposure depends upon the livelihood assets of the people. According to the finding impact of climate change such as disaster, water stress etc. is seen highly in poor people with compared to rich and well-off people.

Adaptation Strategies Adopted at the Local Level

Climate change is happening in each and every corner of the world. So, to reduce the impact of climate change and to make the human life more sustainable, adaptation strategies against climate change are developed. Some of the strategies are crop rotation, terrace farming, harvesting rain water, organic manure, drying of food etc.

In my study area questions about the adaptation practices were asked and respondents of both CFUGs said that they have adopted some traditional adaptation practices to minimize the impact of climate change. As both CFUGs are located in hilly reason, respondents who are involved in agriculture are practicing terrace farming to minimize the risk of disasters such as landslide and soil erosion. There is no irrigation management in both CFUGs respondents said that they are facing difficulties in crop production as they rely on rainfall. So in order to cope with the water stress people are harvesting rain water. Similarly crop rotation is also practiced in both CFUGs and majority of people are using organic manure to increase the crop yield. Some of the respondents in both CFUGs said that they are using chemical fertilizers as improved adaptation practices.

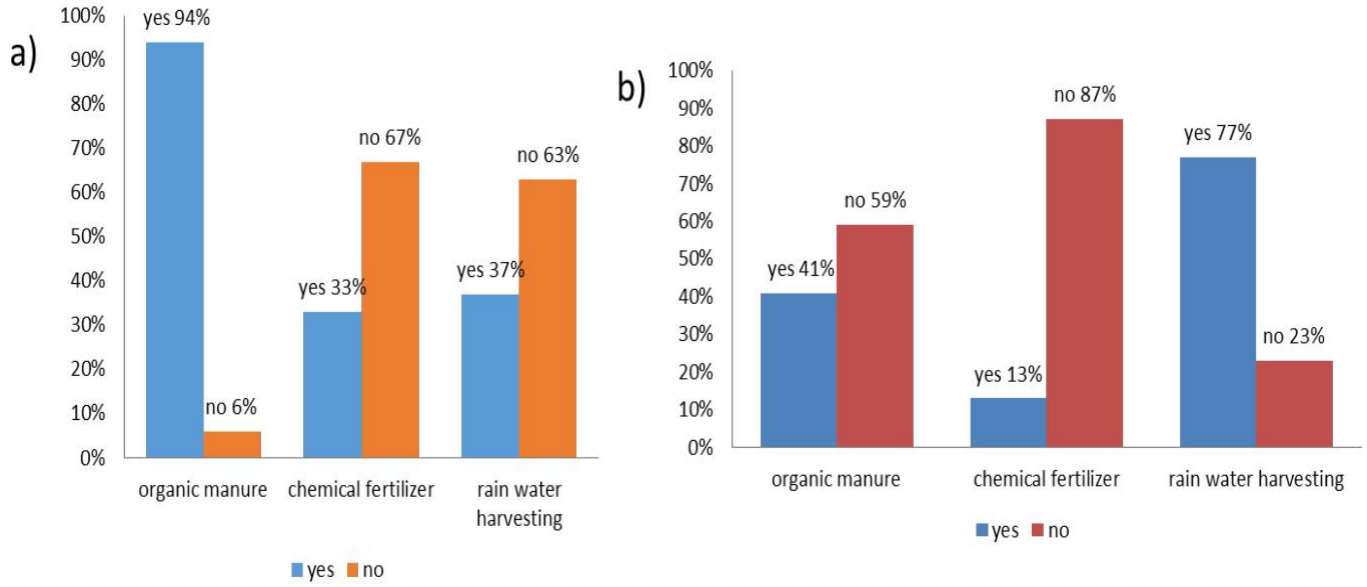

Figure 16 Adaptation Strategies Adopted at Local Level a) Pataleswara b) Thotnekhola

Conclusion and Recommendations

Conclusion

- From the result and discussion, it can be concluded that there was some change in temperature, rainfall pattern in both CFUGs. During the discussion in rainfall pattern, it revealed that the time, intensity and amount of rain have changed than before.
- Average annual temperature (maximum, minimum) of both CFUGs was increasing and the impact of increasing temperature are seen on agriculture, water resources and livelihood of poor people.
- Regarding the perception of climate change, 38% respondents of Pataleswara CFUG and 46% respondents of Thotnekhola CFUGs were familiar about the concept whereas remaining people of both the CFUGs were unfamiliar about the concept of climate change but they understood that the climate of their place is changing.
- In Thotnekhola CFUG soil erosion, landslide and flood were the main weather related disaster but in Pataleswara only soil erosion was seen.
- The study found out that the impact of climate change was seen more on rural community as the people of rural area directly depend upon climate sensitive sectors like agriculture, water resources etc.
- Impact of climate change was seen more in Pataleswara CFUG than Thotnekhola CFUG as more people in Pataleswara CFUG were dependent on agriculture.
- Regarding the adaptation measures people of both CFUGs were practicing rain water harvesting and utilization, terrace farming, crop rotation, plantation and bioengineering, using organic and chemical fertilizers to improve soil fertility.

Recommendation

Following recommendations have been made based on my study:

- Climate change have immediate impact on agricultural sector so training and awareness to the farmers, mixed cropping system, improved technologies, short rotational crops are recommended to combat with the risk associated to climate change.
- Mitigation measures such as improved technologies like biogas, improve cooking stove, solar energy generation for heating and cooking should be prioritized at local level to reduce the impact of climate change.
- It is recommended that plantation programs should be prioritized in disaster prone areas and Community-based action plan should be developed annually so that people could initiate environment friendly activities.

- Awareness and training programs should be conducted to raise the awareness of local people on climate change, its impact and possible adaptation measures focusing poor, women, dalit and disadvantaged group.
- Concerned authorities should formulate adaptive strategies for climate change in agriculture, biodiversity, health and water resources.

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Declaration of Interest Statement:

DECLERATION

The piece of work entitled "**IMPACTS OF CLIMATE CHANGE ON WATERSHED And LIVELIHOOD OF PEOPLE LIVING IN ITS VICINITY (A CASE STUDY FROM THOTNEKHOLA AND PATALESWARA CFUGs OF PHEWA WATERSHED)**" is our own work, except wherever acknowledged. We have not submitted it or any of its part to any other university for publication. There is no conflict of interest among authors for publication.

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