Proceeding of Research Seminar on Climate Change

8th March, 2019
Hetauda, Makwanpur, Nepal

This proceeding is prepared based on the presentations delivered on the Research Seminar on Climate Change and all the papers mentioned in this proceeding were presented in the seminar. Different articles presented here in this proceedings are the sole work of the researcher and it does not resembles the voice of CEN and other organizers in any way although CEN is the publisher of this proceeding.

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Clean Energy Nepal would like to express its sincere thanks to Faculty of Forestry – Agriculture and Forestry University (FoF-AFU), School of Environmental Science and Management – Pokhara University (SchEMS-PU), Least Developed Countries University Consortium on Climate Change (LUCCC) for the continuous collaboration and support provided in successfully organizing the research seminar on climate change. We are grateful to Prof. Dr. Balaram Bhatta, Dean, FoF-AFU for his continuous guidance and support in successfully organizing the program. We must thank Principal and Associate Professor of SchEMS-PU, Mr. Ajay Mathema, and Asst. Prof. Pramod Ghimire from FoF-AFU for the coordination and collaboration in organizing this research seminar successfully. We would also like to thank Christian Aid Nepal for the support provided in organizing this event successfully.

We would like to appreciate the effort of the technical committee in organizing this research seminar and thank Prof. Dr. Sanjay Nath Khanal, Assoc. Prof. Dr. Sudeep Thakuri and Mr. Manjeet Dhakal for their technical contribution before, during and after the programme. The programme would not have been successful without the tireless effort of CEN team, especially Mr. Shankar Prasad Sharma for the overall leadership and coordination and Mr. Lal Mani Wagle, Mrs. Mangleshwori Dhonju, Ms. Sanju Shrestha and Mr. Bimal Chhetri for their contribution in the program.

We would like to thank all the young graduates who participated and delivered the presentation in the program. We must thank all the guests and participants of the programme for their valuable presence and contribution on the program. We also thank all the researcher who have shown their interest and submitted abstract of their research to CEN targeting the research seminar. Lastly we would like to thank all the helping hands who directly or indirectly supported in organizing this research seminar successfully.

Clean Energy Nepal
Talchikhel, Lalitpur, Nepal

CLEAN ENERGY NEPAL

Ref. No.:

Message from the Executive Director of Clean Energy Nepal (CEN)

Nepal is highly vulnerable to climate change and many people in Nepal are already struggling with the impacts of climate change. Various initiatives have been taken to address this global issue. They include formulating and implementing policies and programs at different levels. Climate change, being a cross cutting issue and impacting different sectors, should be dealt with through a multipronged approach that also includes rigorous research and knowledge management.

Considering this fact, CEN is collaborating with different stakeholders, including academic institutions, to strengthen the knowledge base in the climate change sector in Nepal. This research seminar is one such collaboration that CEN has taken forward together with various academic institutions. Besides this, CEN is also encouraging the active participation of young graduates and early career professionals by providing them research grant on climate change. In addition, CEN is also collaborating with academic institutions to further strengthen the technical capacity of faculty members of different colleges and universities inside and outside the Kathmandu Valley.

CEN will continue to collaborate with its partners and relevant stakeholders, including government agencies, on climate change related research in Nepal.

Sincerely,

Suman Basnet
Executive Director

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Message

Academic Institutions are the places where the knowledge generation, transformation and management takes place. Research is an important and crucial component in the academic institutions without which knowledge generation cannot be expected and in addition, our focus should be on qualitative knowledge generation rather than increasing the number of researches. The other important aspect is we should focus on strengthening the application of research findings in various aspects of development planning.

Faculty of Forestry, Agriculture and Forestry University hosted the Research Seminar on Climate Change together with the other organizer of the program and it was a great platform for the young researchers to showcase the findings of their robust researches in such forum. Very recent researches conducted by graduates from different disciplines of different Universities selected on competitive basis were presented in the seminar and it is our pleasure to publish this proceeding including the researches presented in the seminar.

The key things that I want to highlight here is that we were able to organize this important program outside the Kathmandu valley which is normally lacking even the country has adopted the federal structure; the another important aspect of this program is we were able to engage the graduates and young faculties which are our tremendous force with the potential to contribute in knowledge generation. The program was important as it provided the platform for young researchers from various parts of the country doing their research in different theme linked with the climate change regime.

I would like to thank all the supporting hands who directly or indirectly supported in successful organization of this research seminar and wish to continue this type of collaboration in the future to come.

With best regards,

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Message from Prof. Dr. Sanjay Nath Khanal, Technical Committee Chair

Climate Change is a pertinent issue for Nepal. We have been ranked high in terms of climate change vulnerability. However, we still lack adequate data and information on the subject as limited science based researches and activities have been undertaken in the country. We, at universities, feel that a large amount of investments have been directed towards climate change adaptation work, however, without substantial scientific bases. At the same time, we, at academia, have been undertaking researches with our students on climate change for several years already. We have now realized that substantial researches have been undertaken, which need to be consolidated. Internalization of the findings of these researches can significantly update our understanding of climate change. This consolidation of knowledge at academia has largely been ignored till date. Thus, we, by ourselves, have taken this noble goal of encouraging our graduates and students to pursue their interest in climate change by recognizing their scientific contribution through the medium of this seminar.

This document records proceedings of the seminar. I am extremely satisfied with the seminar as it could cover diverse questions of climate change. Furthermore, I am confident that readers will find it interesting as well as useful to improve their understanding of climate change. I am very much hopeful such initiations will be continued in future so that we could continuously upgrade and update our knowledge base.

I congratulate the students and all other involved in this process, and I am very much thankful to those who have helped in organizing this seminar.

Dr. Sanjay Nath Khanal
Chair, Technical Committee
Professor, School of Environmental Science and Management (SchEMS), Pokhara University

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Program Summary

Clean Energy Nepal (CEN) together with Faculty of Forestry, Agriculture and Forestry University (FoF-AFU), School of Environmental Science and Management - Pokhara University (SchEMS - PU) and LDC University Consortium on Climate Change (LUCCC) organized the Research Seminar on Climate Change on 8th March 2019 (24th Falgun 2075) at Hetauda, Makwanpur. 70 participants from governmental bodies, CSO representatives, University Professors, Students from different educational background, Youth and Media representatives participated in the seminar. The Call for Abstract for the seminar was announced focusing on the following themes: climate change impact and vulnerability assessment, adaptation, limit to adaptation and loss and damage, mitigation, low-carbon development and energy efficient technologies, sustainable development goals and disaster risk reduction, social dimension and ethics of climate change that also includes livelihood options, gender and social inclusion, indigenous knowledge and practices. Around 50 abstract papers were received from the researchers and 10 selected papers and posters were presented in the seminar.

The seminar was organized with the main objective of sharing and documenting the researches done by young graduates in climate change regime from various discipline and this proceeding is the compilation of the researches presented in the research seminar by various young graduates from different universities of Nepal. Ms. Sanju Shrestha from CEN initiated the program and Basu Dev Pokharel Assistance dean of FoF-AFU delivered the welcome remark. Mr. Manjeet Dhakal, Board Member of CEN then delivered a presentation focusing on trend of researches on climate change and the recent policy initiatives at various levels to address climate change. During his presentation, he highlighted about the key policy initiatives and the gap in technical research and implementation of formulated policies in climate change sector and its contextualization in federal Nepal.

Speaking at the program Mr. Shiva Kumar Wagle, Secretary of Ministry of Industry, Tourism, Forest and Environment of Province No.3 said that Maintaining synergy of economic development with environment and climate change sector actions is important and considering the federal context all the concerned stakeholders should work in a collaborative way to maintain the coherence and synergy among the intervention of various agencies.

Dean of FoF-AFU, Prof. Balaram Bhatta, PhD. said that instate of organizing these type of programs only in Kathmandu, we are able to bring it to Hetauda and he also emphasized in continuation of such initiatives. He highlighted about the importance of this seminar mainly in providing such forums for young graduates and youths from various disciplines while also sharing and documenting the latest and contextual researches in climate change regime with all the concerned stakeholders. Prof. Dr. Sanjay Nath Khanal shared his remark and highlighted that technical research led by scientific community is of crucial importance in climate change sectors. Prof. Nabaraj Devkota, Director of DOREX at AFU expressed about the crucial importance of research in climate change sector and continuous collaboration and support among all the stakeholders should take place for effective climate Action. Assoc. Prof. Dr. Sudeep Thakuri, from CDES briefed about the key different researches in Nepal and possible way and topics to focus in the future by the young scientist and academia.

The technical session was observed after the opening and introductory session in which the paper and posters were presented by the researcher to the participants and discussion on all the research were observed alongside. The paper presentation session was chaired by Prof. Dr. Sanjay Nath Khanal, and poster presentation session was chaired by Assoc. Prof. Dr. Sudeep Thakuri. Mr. After the technical sessions were over, Mr. Lalmani Wagle from CEN delivered the closing remark thanking all the organizers and participants and announced the end of the program.

Effectiveness of Vehicle-Free Zone in Thamel, Kathmandu

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Abstract: Air pollution is choking in the major urban areas of the world. The development in Kathmandu Valley is leading the ambient air pollution more rapidly by impacting to the people's health condition The valley have attracted the tourist widely due to the religiously and culturally filled environment with serene mountains, but the tourist hub, Thamel, itself is registered as one of the polluted place. In 2016, a part of Thamel was designated as the vehicle free zone. In this study, an effectiveness of vehicle free policy enforcement in Thamel area is carried out. The field survey was focused on the core area of vehicle free zone i.e., Kathmandu Guest House Chowk for two seasons (Post-Monsoon and Winter), each with 7 days (12 hr/day). During Post-Monsoon, the concentrations of $PM_{2.5}$ and PM_{10} were 28.49 ± 15.10 $\mu g/m^3$ and 83.78 ± 46.24 $\mu g/m^3$, respectively. In winter, $PM_{2.5}$ and PM_{10} were 62.49 ± 34.36 and 87.16 ± 25.28 $\mu g/m^3$, respectively. The $PM_{2.5}$ concentration was the highest in morning hours and considerably; lower during afternoon and evening time. In winter, $PM_{2.5}$ significantly high above the guideline value, i.e., 70.6-113 $\mu g/m^3$. The particulate matters were found be lower in vehicle free zone as compared to the reference stations, outside the area. The vehicle free zone have high emission of particulate matter and carbon monoxide during winter season, this means background pollution and atmospheric conditions have greater effect on the levels of ambient air pollution in this zone to which the population is continuously exposed. Besides this, due to lack of monitoring, the vehicular movement in the zone, also have an influencing role in increased ambient air pollution. We recommend that awareness should be raised about the vehicle free zone and monitored the regular vehicle movement to effective implementation of the provision.

Keywords: *Vehicular emission, Particulate matter, Carbon monoxide, Pollution, Thamel*

1. Introduction

Air pollution is the presence of undesirable materials in the air that can degrade the quality of air by creating the harmful effects. People are witnessing the degradation in the quality of air since long time. Industrial Revolution of the mid-19th century introduced new sources of air pollution whereas changes i.e., effects, had been seen during middle of the 20th century. During 1960s-1970s, many environment movements tided up on combating this burning issue around the world, such that, Clean Air Act (1970) in USA came across to establish the air quality goals, such as to protect human health and the environment from emissions that pollute ambient, or outdoor, air which later on resulted in a major shift in the federal government's role in air pollution control (McCarthy et al., 2011) Through this Clean Air Act, EPA has established standards for six common air pollutants, which are referred to as "criteria" pollutants, i.e., Carbon monoxide (CO), Lead (Pb) Nitrogen dioxide (NO_2), Ozone (O_3), Particulate matter (PM), and Sulfur dioxide

(SO_2) (Indiana Department of Environmental Management, 2012). Despite of such impressive efforts since 1970s, still 4.6 million people die each year from causes directly attributable to air pollution (WHO, 2018). Besides this, air quality can impact climate change and conversely, climate change has its effect of ambient air quality. Different components of particulate matter have either cooling or warming effects on climate (EPA, 2018).

Air pollution is most visible components that are degrading environmental quality in Nepal. Especially, rapid unmanaged urbanization in the Kathmandu valley has resulted in a significant deterioration of air quality. Mainly the vehicular emission, re-suspension of street dust due to different construction works, vehicular movement are the major causes for the degradation of air quality. Along with such physically visible causes, the topography of the Kathmandu valley adds the pressure to retain the pollutants in the atmosphere. In the recent times, the impact of the both the above factors have made, Nepal positioned among the bottom five countries on the Environmental Performance Index 2018 (Yale Center for Environmental Law & Policy, 2018).

Nepal does not have the separate act dedicated for curbing the air pollution, somehow, other legal aspects do support and comply with an aim to curb it. The legal measures enforced in order to manage the air quality are Industrial Enterprises Act 1992, Vehicle and Transport Management Act1993; In-use Vehicle Emission Standards and Emission testing of vehicles since 1995, EPA 1997; EPR 1997; Nepal Vehicle Mass Emission Standard 2000 (for new vehicles) and National Ambient Air Quality Standards 2003 (updated in 2012) (MoSTE, 2014). Other policies such as National Low Carbon Economic Development Strategy and National Pollution Control Strategy and Action Plan are still on draft, are subjected to deal with this air pollution. To aware the people about the quality of air they breathe, Department of Environment have aimed to establish the monitoring stations throughout the country, but, as of now, there are nine stations. Similarly, some of the initiation has been enforced in ground level. Thamel, a tourist hub have been officially announced the vehicle free zone on October 22, 2017 to control the rising air pollution in the Capital and preserve tourist ambience (The Rising Nepal, 2017). Hence, this research work studies the effectiveness of vehicle free zone in terms of air pollution.

2. Data and Methods

2.1 Study area

Kathmandu valley is an oval shaped tectonic basin, occupying about 656 sq. km, situated in the middle sector of Himalayan range. The valley is known for its ancient art, culture, numerous monuments of historic and archaeological importance. This is the reasons behind there is an increasing number of the tourists every year. Thamel, a tourist hub, known to be one of the popular tourist destination and also belongs to the place where the history of Newar Communities resides. This research was carried out in Kathmandu Guest House (KGH) chowk, a core area of vehicle free zone in Thamel, where vehicles except non-motorized vehicles are prohibited to enter. It is located in the northern region of Kathmandu. Thamel is known for numbers of narrow alleys almost covered with shops, vendors, craftsmanship, hotels, especially for Tourists. Hence, known as tourist hub wholly. The two Air Quality Monitors (AQMs) installed by US Embassy, Kathmandu which is located on the Embassy grounds and at the Phora Durbar Recreation Center in the Thamel area were taken as a reference monitoring sites for this research work. US Embassy is about 100 m from the Maharajganj Road, situated in the residential area and Phora Durbar is about 50 m from the Kantipath Road. These AQMs collect data on two types of pollution: Ozone (O_3) and particulate matter (2.5 microns and less, referred to as "$PM_{2.5}$").

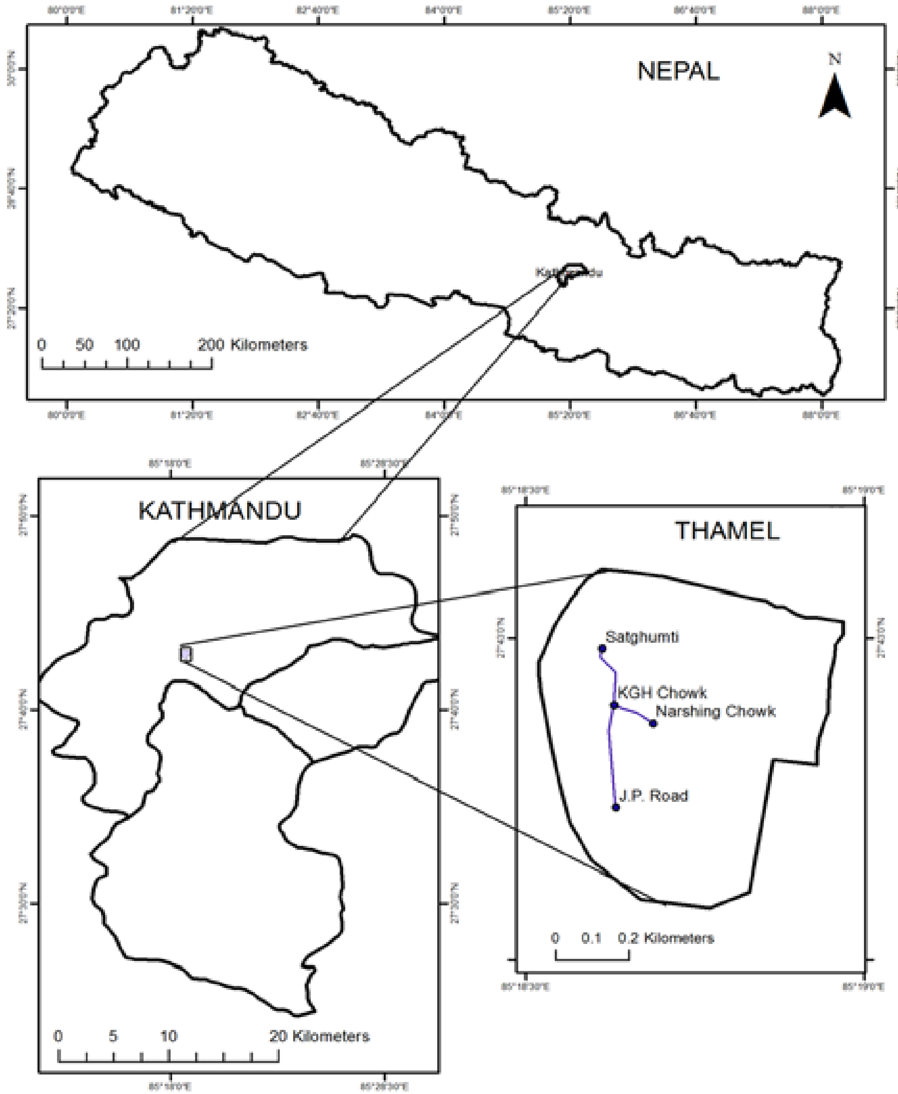


Figure 1. A map showing the study area.

2.2 Data collection

A total of 14 days data were collected from the KGH chowk in post-monsoon (November 2018) and winter (January 2019). The monitoring was done for 7 days for each of the parameters for each season in alternative days for 12 hours (8 am to 8 pm). The parameters includes: Particulate Matter (PM_{10} and $PM_{2.5}$), and CO with the traffic data. The sampling devices were kept in as in such a way to eliminate the insignificant disturbance caused by the dwellers, hence the samples were collected on the rooftop of a hotel property (18 feet height).

The vehicles were counted in Narshing Chowk, a vehicular area for 12 hours. In Nepal, Sunday to Friday is working days and Saturday is a weekend, hence assuming the same traffic pattern for the working days, the vehicular count was done for three consecutive Mondays indicating the same traffic flow throughout the working days and three consecutive Saturdays for weekends.

Table 1. Associated Instrument

Air Quality Parameters	Instrument	Method for data collection
$PM_{2.5}$	HAZ-Dust, Environmental Particle Air monitor Model (EPAM- 5000)	8:00 am to 8:00 pm (continuous real time data collection), Flow rate 3 L/min
PM_{10}	Envirotech Handy Sampler (APM 821)	Gravimetric Method Data collection (8:00 am – 12:00 noon, 12:00 pm- 4 : 00 pm and 4:00 pm – 8:00 pm) Flow rate 1.9 L/min
CO	Portable Gas detector (RH-2000 series)	8:00 am to 8:00 pm (continuous real time data collection)

The secondary air quality data for the research period were collected reference stations from Phora Durbar and Ratna Park and other necessary relevant journal articles, research paper, conference proceedings, etc.

3. Results

3.1 Weekly variation of PM_{10}, $PM_{2.5}$ and CO concentration

In the diurnal cycle, $PM_{2.5}$ mostly showed two peaks i.e., between 8:00 to 9:00 am and another after 17:00 pm. The $PM_{2.5}$ concentrations was lowered considerably after 12:00 noon – 16:00 pm, but in both weekends and working days, especially in winter, the concentration in the morning hours (before 10:00 am) was much more higher than throughout a day.

Post-Monsoon

Within the difference in emission between the working days and weekday, the weekday i.e. Saturday have a high average PM_{10}, $PM_{2.5}$ and CO emission – 112.1, 33.9, and 21.9 $\mu g/m^3$, respectively compared to working days – 84.4, 27.60, and 12.2 $\mu g/m^3$, respectively. Despite, the higher average PM_{10} concentration on weekday, considering daily average concentration, it was observed that Wednesday had a high PM_{10} concentration (142.9 $\mu g/m^3$).

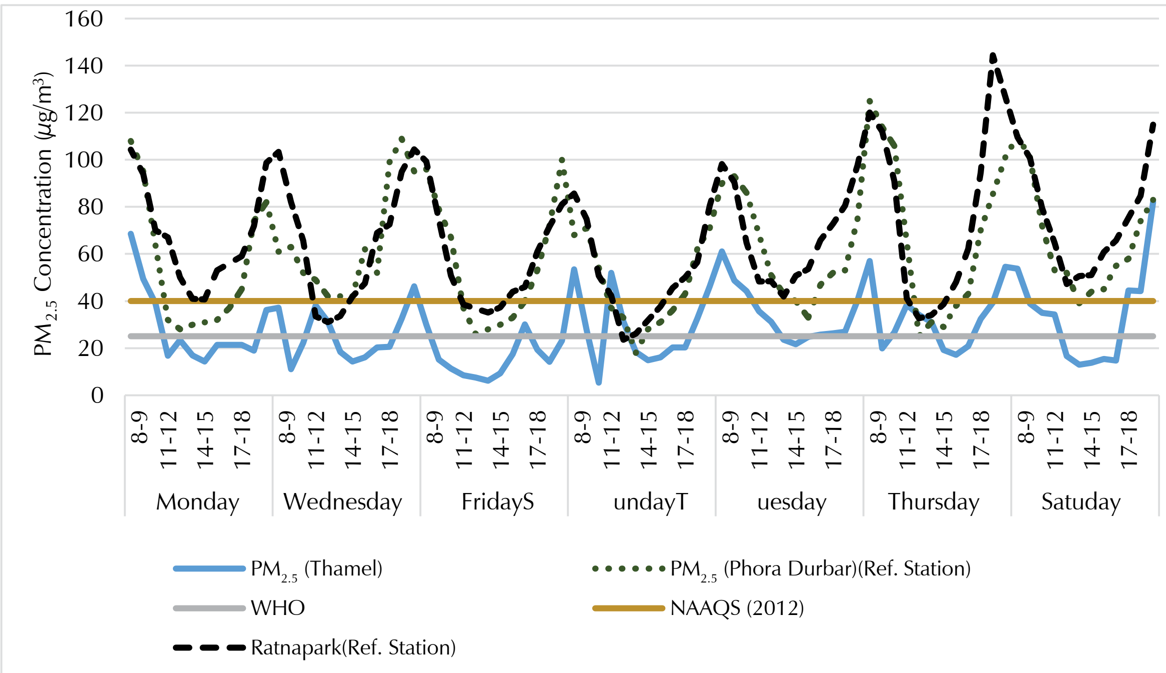


Figure 2. Weekly variation of $PM_{2.5}$ of study site and comparison with reference stations (post-monsoon)

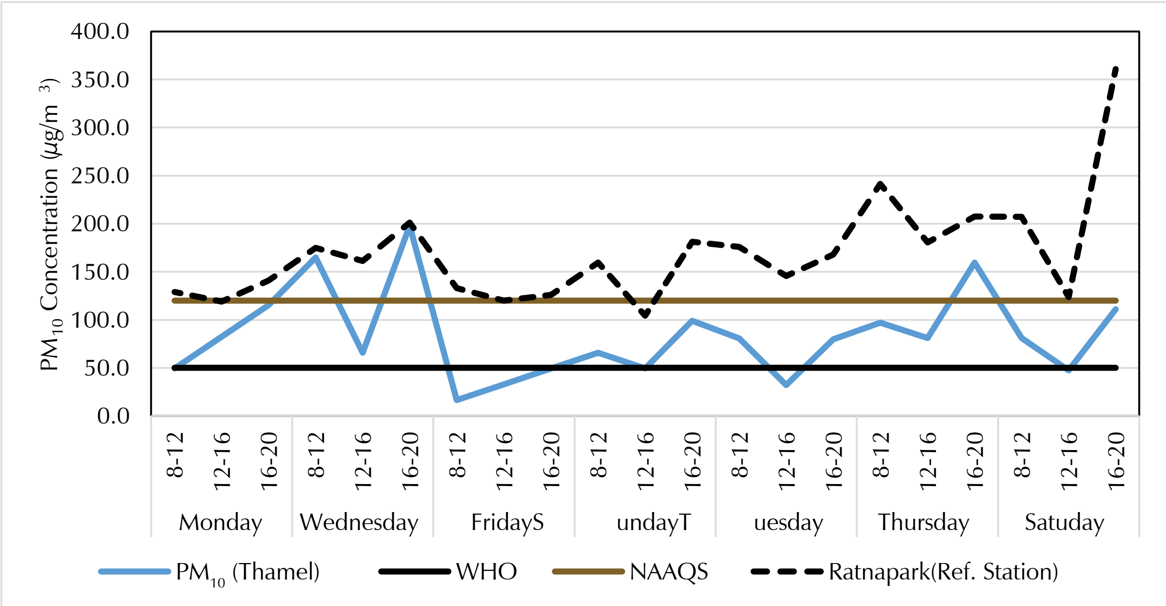


Figure 3. Weekly variation of PM_{10} of study site and comparison with reference station (post-monsoon)

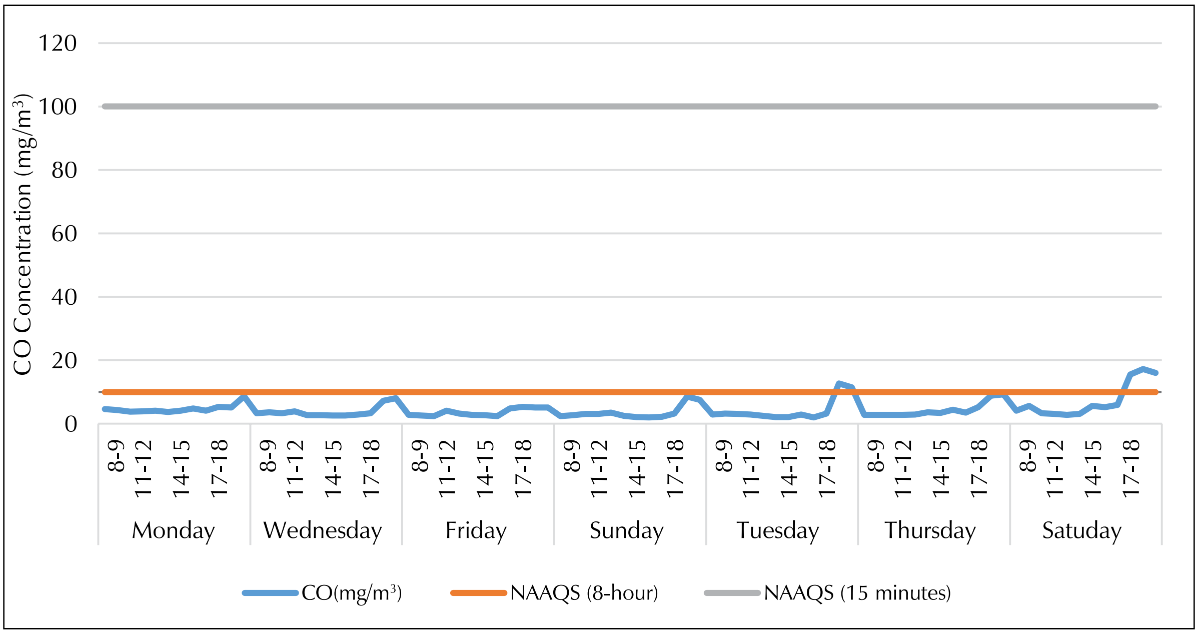


Figure 4. Weekly variation of CO of study site (post-monsoon)

In comparison with reference stations, the weekly variation of PM_{10}, $PM_{2.5}$, and CO of study area was considerably low (Figure 2 to Figure 4). According to WHO standard for ambient air quality, the value of $PM_{2.5}$ and PM_{10} must be within 20 µg/m³ and 50µg/m³ respectively, but these concentration level at the study area had crossed respective guideline values. In reference to NAAQS (2012), during the morning hours, throughout the week had $PM_{2.5}$ of the study area crossed the threshold value of NAAQS (40 µg/m³) i.e. Monday (68.3 µg/m³), Tuesday (61.04 µg/m³), Wednesday (40 µg/m³), Thursday (57.06 µg/m³), Friday (46.27 µg/m³), Saturday (54.61 µg/m³) and Sunday (53.04 µg/m³). Unlike $PM_{2.5}$, PM_{10} concentration level was observed to be within the NAAQS (120 µg/m³) except few days in a week (Wednesday and Thursday) especially during evening hours (197.8 µg/m³ and 159.7 µg/m³) as shown in Figure 3.

Winter season

The PM_{10}, $PM_{2.5}$ and CO concentrations were typically higher during winter seasons as shown in Figure 5 to Figure 7.

In Figure 5 and Figure 6, throughout the week, the PM concentration level was generally high during the morning shift from 8-10 am and as in the Post-Monsoon, its concentration level decreased significantly in afternoon (11 am to 17 pm) and increased in evening time period (after 17 pm). The concentration level reached to peak point on Sunday (155.4 $\mu g/m^3$), Wednesday (150.6 $\mu g/m^3$) and Saturday (140 $\mu g/m^3$).

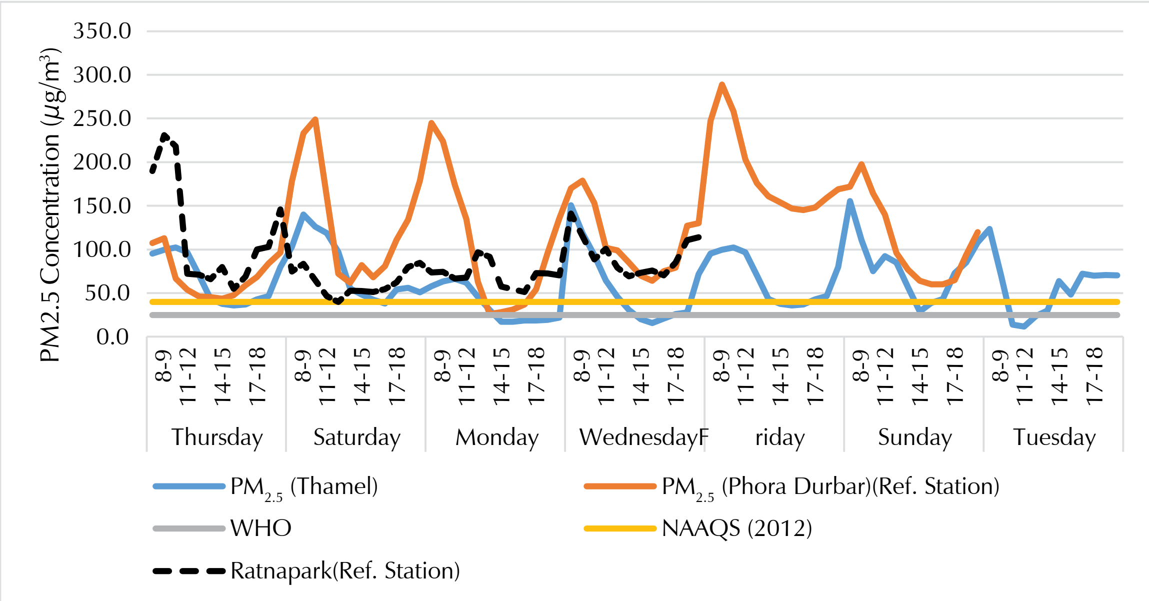


Figure 5. Weekly variation of $PM_{2.5}$ of study site and comparison with reference station (winter season)

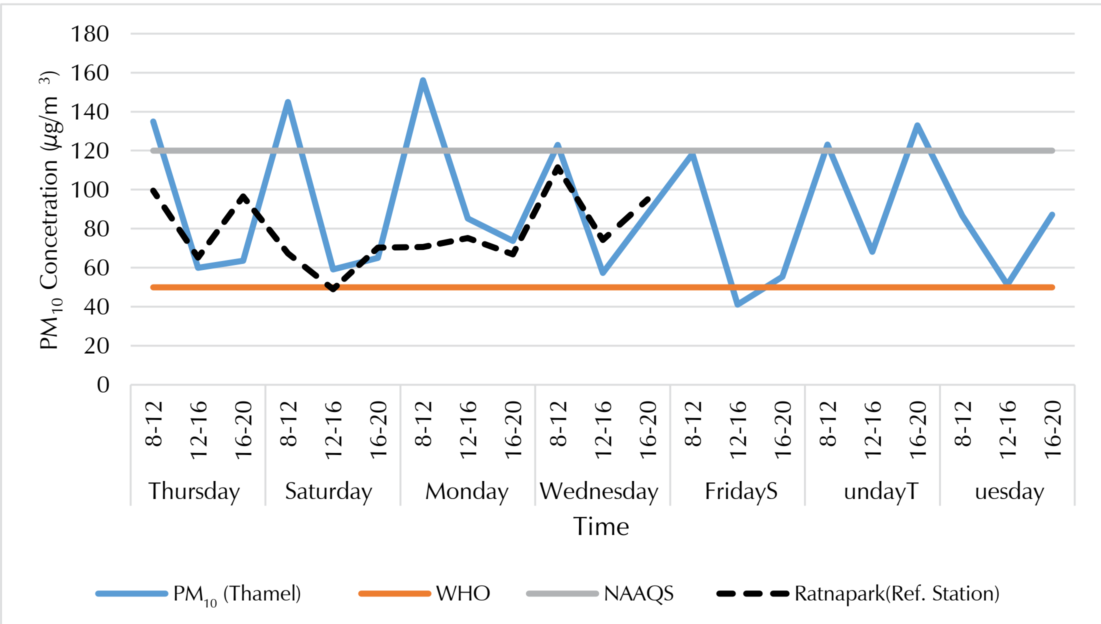


Figure 6. Weekly variation of PM_{10} of study site and comparison with reference station (winter season)

Similar trend as that of $PM_{2.5}$ can be observed in PM_{10}) (Figure 6) i.e. high peak concentration in morning shift from (8-12 noon) and decreased significantly afterwards. During Saturday and Monday, the concentration level increased to its peak point (145 $\mu g/m^3$ and 156 $\mu g/m^3$) crossing the permissible level as guided by WHO and NAAQS. But, Sunday, during morning and evening shift, the concentration reached the highest i.e., 123 and 133 $\mu g/m^3$, respectively.

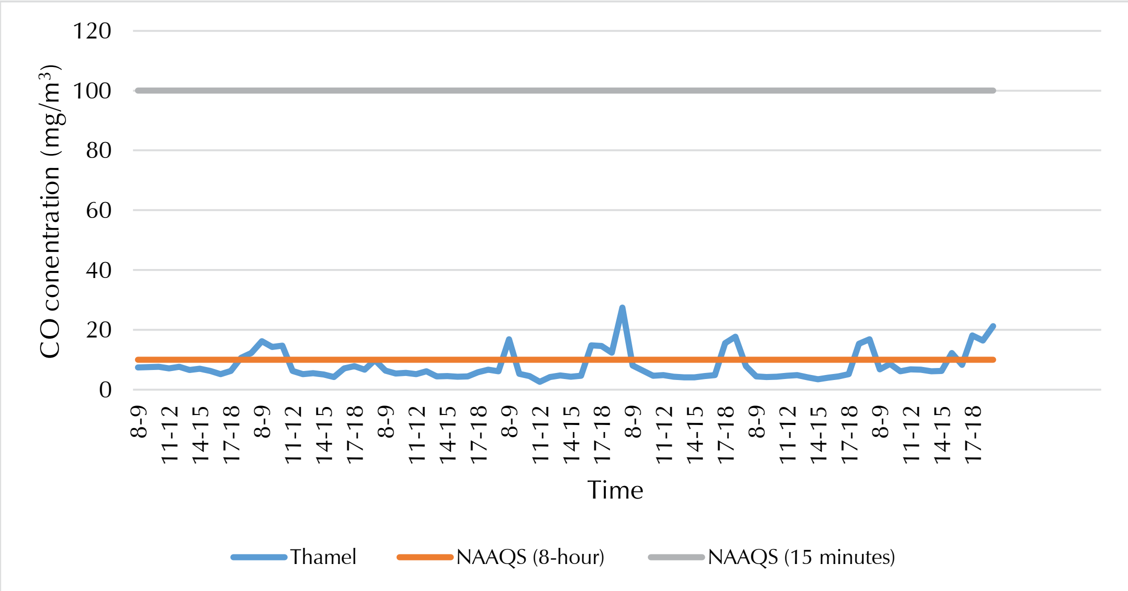


Figure 7. Weekly variation of CO of study site (winter season)

3.2 Comparison from past data for $PM_{2.5}$ and PM_{10}

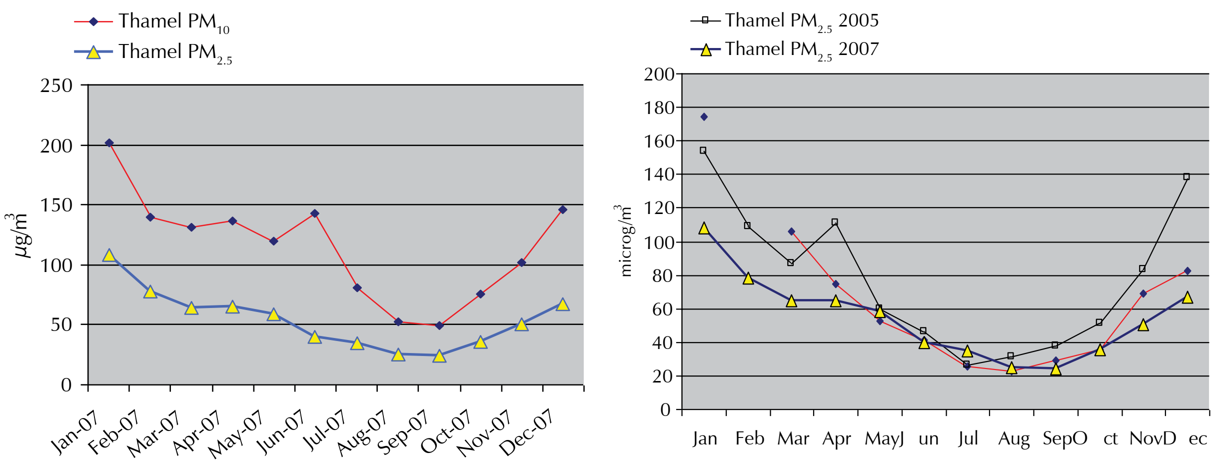
Figure 8 shows the monthly averaged concentrations of PM_{10} and $PM_{2.5}$ level recorded for past years of Thamel without measures (No designation of vehicle free zone). The pattern of monthly variation is the same as for the previous years 2005 to 2007 and the trend seen over the year clearly depicts that winter and dry months are highly polluted in the valley both for $PM_{2.5}$ and PM_{10}. In 2007, $PM_{2.5}$ level in Thamel was in range of 150-160 $\mu g/m^3$ in January and in November, it ranged in between 50-60 $\mu g/m^3$. Now, after measures, $PM_{2.5}$ considerably decreased to 28.49 $\pm$ 15.10 $\mu g/m^3$ in November and 62.49 $\pm$ 34.36ug/m3 in January. Similarly,

Figure **8.** Past data of study area before measures (Source: MoEST, 2007)

Table 2. Present Thamel data after measures

Parameters	November		January	
	Mean	SD	Mean	SD
$PM_{2.5}$	28.49	15.10	62.49	34.36
PM_{10}	83.78	46.24	87.16	25.28

Table 2 indicates decreased in PM_{10} concentration level in January 2018, which was around 200 $\mu g/m^3$ in 2007 and increased in $PM_{2.5}$ concentration level in November which was around 50 $\mu g/m^3$ in 2007.



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PM_{10}	83.78	46.24	87.16	25.28

4. Discussions

4.1 Weekly variation of PM_{10}, $PM_{2.5}$ and CO concentration

From the results, two peak concentration for PM in both the season reached to the highest in morning and evening and fell down during day time. In winter, according to Regmi et.al. (2003), during the nighttime and in the early morning, the Kathmandu valley remains calm thus creates temperature inversion reducing the vertical mixing of the pollutant, whereas, wind regularly starts to blow in the afternoon and continues till the evening .

In context of CO, its emission level is not just related to the diurnal wind and temperature cycle, but heavily dependent on anthropogenic activities. The winter had the highest CO emission amongst the seasons with morning and evening peaks. This higher concentration especially in evening time is due to the combustion of biomass for heating purpose. Also due to high number of visitors in this touristic place especially in Weekend (Saturday), the concentration reached to 21.2 $\mu g/m^3$ from 13.43 $\mu g/m^3$ (normal Working days) in winter and from 16.01 to 8.34 $\mu g/m^3$ in Post-Monsoon. Besides CO, the burning of biomass had some extra contributions to both PM_{10} and $PM_{2.5}$ (Kumar et al., 2015).

4.2 Concentration of particulate matter before and after the measure

The concentration of $PM_{2.5}$ was decreased by 30% from 2005 to 2007 (MoEST, 2007). Since then, there were no any monitoring stations to measure the ambient air quality of Thamel area. Hence, only up to 2007 data are available for comparison. So, the $PM_{2.5}$ level decreased by 27% from 2007 to 2018 in November and 42% in January. Similarly, PM_{10} in January decreased by 39%. But, this level increased in post monsoon (November) as compared to the past data. The reason might be the background pollution such as dusting, cleaning and construction activities in the study area. But then, decrease in $PM_{2.5}$ concentration as a result of the measure is a very positive trend, especially as these fine particles are particularly harmful to human health (MoEST, 2007).

5. Conclusions

The ambient concentration of the vehicle free zone in Thamel is observed to be lowered as compare to the reference stations of the Ratnapark and Phora Durbar. Though the concentration is below in comparison but, high with NAAQS and WHO guidelines Only CO is within the permissible limit with NAAQS in Post-Monsoon expect is winter which is higher in morning and evening. The study conducted in vehicle free zone although have a less concentration in comparison to the reference stations, but, still due to the background pollutions such as heating activities especially during winter, constructions activities, have their own contribution to the concentration of the different pollutants in ambient atmosphere of Thamel area. Also, during evening time period, most of the vehicles violating the rules enters into the zone. Hence, additionally, this activity also adds the emission level in the ambient atmosphere.

Despite the vehicle restriction initiation in the study area, due to inadequate cross checking mechanism and inspection by the government itself, there is a movement of vehicles, which seems to have role to increase the PM concentration in the ambient atmosphere of the study site. Thus, this indicates, the vehicle free zone is necessary but it requires measures and complementary strategies to be implemented to control the ambient exposure.

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Major Springs and Their Status in Mid-Hills of Nepal: A Case Study of Samdi Micro-Watershed of Dhandkhola Watershed, Tanahun

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Abstract: Spring water is the major source of water for residents of mid-hill and mountains of Nepal. Previous studies have reported that springs are drying up rapidly in last few decades due to natural hazards, climate change coupled with anthropogenic causes, and haphazard infrastructural development. The problem of water scarcity is rising at an alarming rate even in the villages. This study is conducted to identify major springs and their status in Samdi micro-watershed (MW) of Dhandkhola sub watershed (SW) in Tanahun district of Nepal. Result reveals that there are mainly 10 major springs that have direct contribution to livelihood of the areas. Spring water are tapped at the sources and supplied to settlements though pipeline commonly, called *"Dhara"*. According to local community, springs are drying and water flow is gradually decreasing in the past decades. The major reasons for this as perceived by local community are erratic rainfall and unplanned road construction. More than half of the beneficiary respondents are facing the problem of water scarcity, especially for livestock and irrigation. Further studies are recommended to revive the springs and explore the climate change adaptation technologies in the area.

Keywords: *Climate change, Springs, Discharge, Bucket method, Water scarcity*

1. Introduction

Water is a major life support substance on the Earth, but water availability is a global issue in 21st century. Springs (commonly called *Mul ko Paani* in Nepal) are the major source of domestic water supply for rural communities in the Hindu Kush–Himalaya. When they dry up or decline, the resulting water shortages become a big environmental threat. In Nepal, drying up of rivers, insufficient water availability for irrigation, and long queues at public water sources reveal that water is a scarce resource (Merz et al., 2003). About 80% of the 13 million hill and mountain people's in Nepal depend on springs as their primary source of water (Tambe et al., 2012; Sharma et al., 2016). The supply of freshwater is adversely affected because of widespread depletion of groundwater, surface water pollution, and climate change impacts (Gleeson et al., 2012). It is global perception that weather is getting warmer, the water sources are drying up, the onset of summer and monsoon has advanced since last 10 years and there is less snow in mountain than before (Chaudhary et al., 2011). Climate change has highly affected water resources, which eventually have reduced agriculture production (Chaujar, 2010). In recent years, the activities, like expansion of agriculture, damming, diversion, over-use, and pollution have threatened these irreplaceable resources in many parts of the globe (Pedro & Valley, 2001). Climate change has affected both the quality and quantity of water resources. The intensive monsoon is not enough to recharge the groundwater reservoirs, though there is high total precipitation leaves the site through surface runoff. In addition, the decrease in precipitation during the dry season has an adverse impact on groundwater recharge (Gurung & Bhandari, 2009). Water sustains agriculture and finally supports our food chain. According to the recent report of Intergovernmental Panel on Climate Change (IPCC) states that global warming will lead to "changes in all components of the freshwater system," and concludes that "water and its availability and quality will be the main pressures on, and issues for, societies and the environment under climate change" (Morrison et al., 2009). The Himalayas are assumed to be undergoing rapid climate change resulting serious environmental, social and economic consequences for more than two billion people. But data on the extent of climate change or its impact on the region are not enough (Chaudhary & Bawa, 2011). The pressure on drinking water supply is high. Almost all major rivers have been tapped at source for drinking-water supplies; but there is lack of monitoring of water quantity or quality on regular basis (Sharma et al., 2005). In this situation, this pilot study may serve as a baseline data for further researches in the related field. The objectives of this study are to identify springs of Samdi MW and their status in terms of water flow and condition of water scarcity.

2 Materials and Methods

2.1 Study Area

The study was carried out in Samdi micro-watershed (MW) of Dhand Khola watershed in Tanahun district. This is the most critical micro-watershed among 12 MW of Dhandkhola watershed. This MW is critical in terms of impact of hazards, high dependency on natural resources and agricultural intensification. Samdi MW covers an area of 4.75 km^2 covering 3 wards of Bandipur Rural Municipality-2, 4 and 6 wards. Population in these wards is 2154. Dhand (Sukaura–Khudi) Khola watershed is located between 27° 52′ 10′′ to 27° 56′ 59′′ N latitude and 84°18′ 30′′ to 84° 26′ 2′′ East longitude (Hariyo Ban,2017).

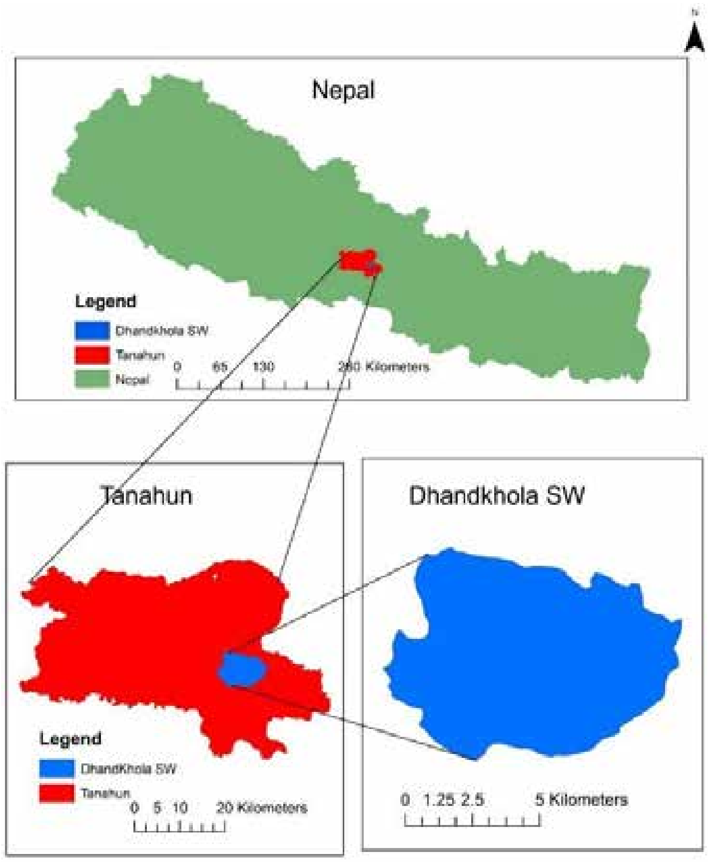

Figure 1. Map of study area

2.2 Data Collection

a) Social data

i) Participatory resource mapping (PRM)

To get basic idea of location of springs, PRM was conducted with some focal persons of three different wards (ward number 2, 4 and 6) of Bandipur Rural Municipality. Those locations were later verified in the field observation.

ii) Household survey

In questionnaire survey, 50 respondents from beneficiary households (with 2.5% sampling intensity) were interviewed. Perception on water availability and condition of water scarcity was the main areas of interview.

Table 1. Information about respondents in Household survey

Male respondents	Female respondents	Average age	Major ethnic groups
27	23	45	Gurung, Magar, Thakuri, and Bishwokarma

b) Field data

i. *Identification of springs*

Major springs were identified and recorded their GPS location. History and present status of those sources were asked to key informant.

ii. *Discharge measurement (Bucket/stopwatch method)*

Only one spring i.e., Rithepani, had discharge measurable by the bucket method.

Secondary data

Secondary data were collected from different literatures, integrated watershed management plan of Dhand khola sub watershed, published and unpublished reports, articles, journals and records from Bandipur Rural Municipality were reviewed.

2.3 Data analysis

- Quantitative data were analyzed using appropriate statistical tools such as mean, percentage etc. using Ms. Excel and ArcGIS Qualitative data was analyzed in descriptive manner and presented in graphs, pie charts.
- Discharge Calculation:

Firstly, the flow was concentrated in one channel/drain and water was collected in bucket of 2 liter volume. The time to fill the bucket was recorded. Discharge was calculated by dividing volume with time taken to fill the bucket.

Discharge (Q) =Volume of bucket (V)/time taken to fill bucket (t)

Unit: liter/minute

3. Results and discussion

Total 10 major springs were identified in the study area. Maximum number of springs (8) was identified in Bandipur Rural Municipality 6, just two springs ,one on each ward were identified in Bandipur 2 and 4 within the area of Samdi MW.

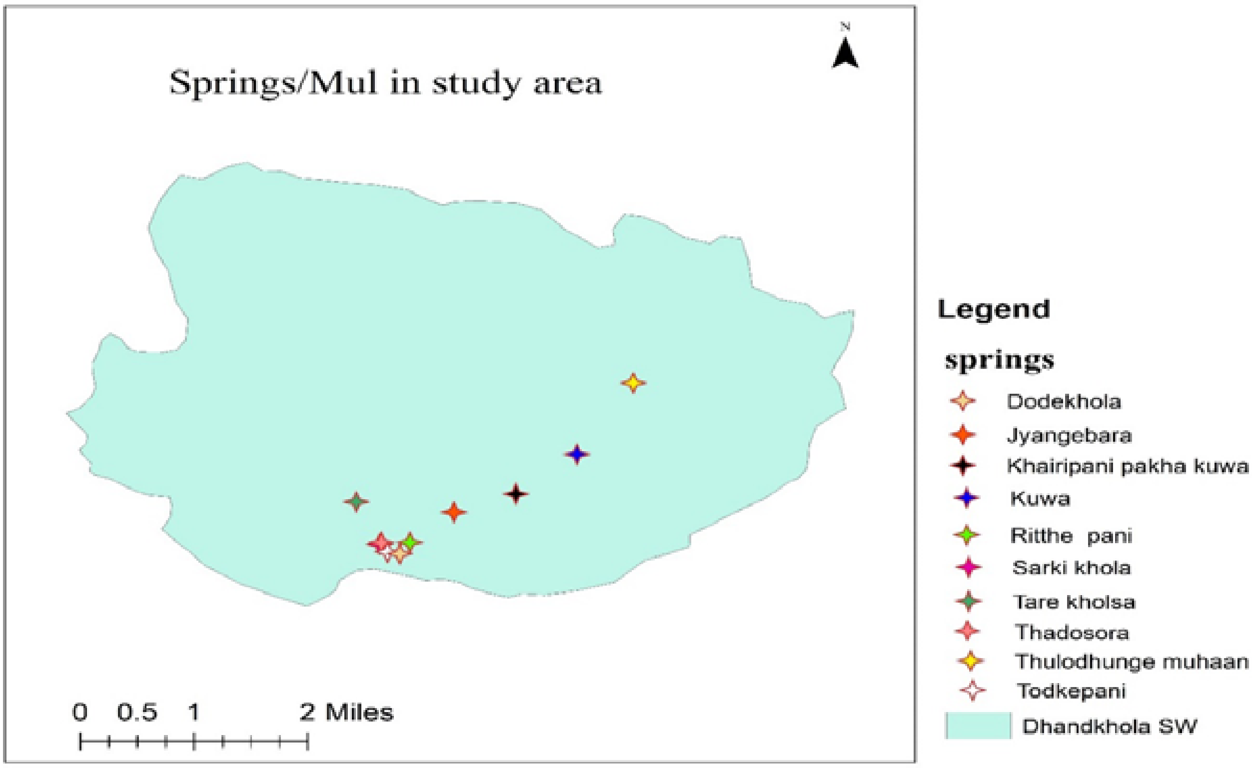

Figure 2. Locations of springs in Samdi MW

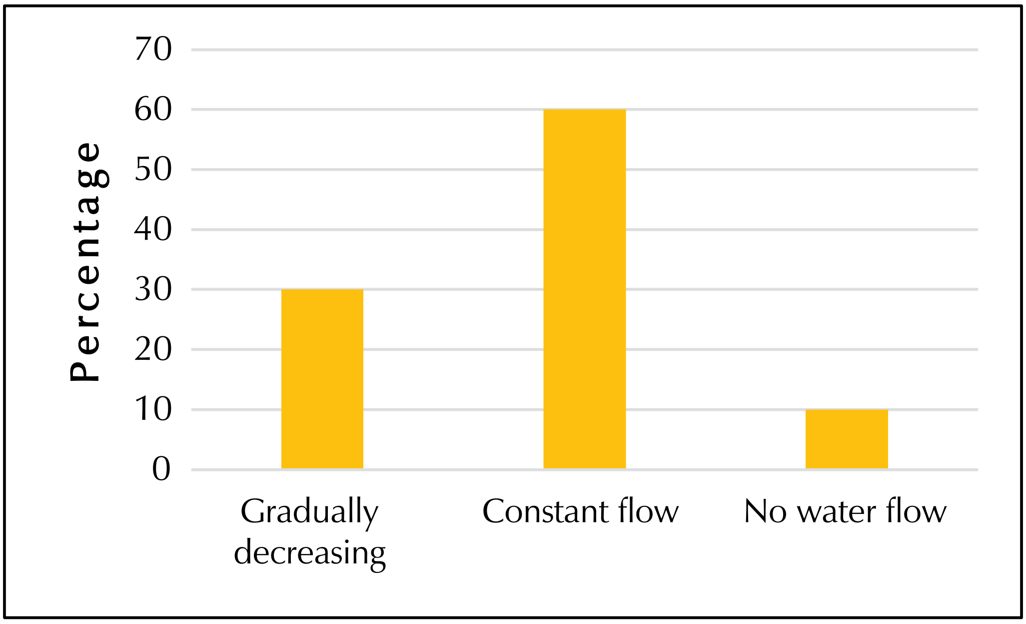

Figure 3. Condition of water flow in Springs

After field observation, it was found that 1/3rd of springs have water flow in gradually decreasing trend. This might be the result of erratic rainfall. One of the springs (named Todkepani) has dried completely because its source has been submerged during road construction. The water flow in springs of Samdi MW is gradually decreasing & similar condition is seen in Sikkim Himalayan (Tambe et al., 2012).

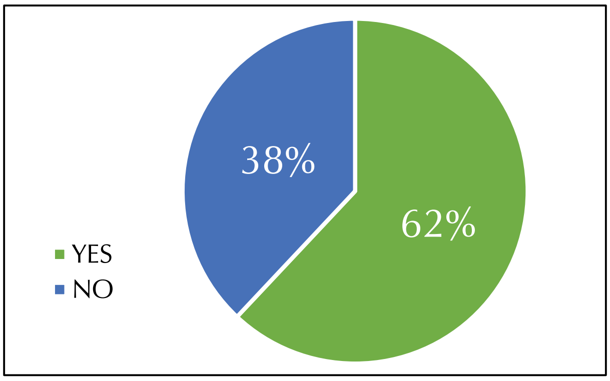

Figure 4. People facing water scarcity

Water scarcity was noticed as a rising problem in the study area as water sources along with their flow were found to be in decreasing trend. Water has not been enough for local residents for their household activities especially for irrigation and livestock. Springs were found to be drying years by years resulting in lowering of agricultural and livestock productivity and agricultural activities are being adversely affected. Water scarcity for irrigation, vegetable farming is felt by people in Samdi MW and they have abandoned winter rice cultivation and some fields are converted to shrub lands and grasslands. Similar case is seen at Thulokhola Watershed of Nuwakot district (Poudel & Duex, in 2017).

- ✓ The most used sources are taps as springs are tapped at the origin and piped to settlement. The main uses of water from spring were drinking, cleaning, livestock and irrigation.
- ✓ Discharge (liter/min) of Rithhepani as measurable by bucket method was found to be 5.494 liter/min in February 2018. The condition of water scarcity indicates that this rate of discharge is not enough for the settlement.

Table 2. List of springs with some detail information.

Name of springs	Importance	Condition of water flow	Issues
Tare Kholsa	Irrigation	Gradually decreasing	
Sarki Khola	Drinking, washing and domestic animals.	Constant flow	Use when water in pipelines gets turbid
Thadosora	Domestic animals	Constant flow	
DodeKhola	Drinking, domestic animals, wildlife	Gradually decreasing	
Ritthepani	Drinking, washing, domestic animals, wildlife, irrigation	Constant flow	Can be tapped at source and supply to settlement
Khairipani Pakha Kuwa	Domestic animals, wildlife, irrigation	Constant flow	
Todkepani	Drinking, washing, domestic animals	No water flow	Water source got submerged during road construction
Kuwa	Drinking, domestic animals	Constant flow	
Thulodhunge Muhaan	Drinking, domestic animals, wildlife	Constant flow	
Jyangebara	Domestic animals, wildlife, irrigation	Gradually decreasing	

4. Conclusions

Ten major springs are identified in the study area. Many people depend on spring water for daily household activities .One third of the identified springs are gradually decreasing in terms of water availability. Water source is being scarce which have resulted agricultural lands into grasslands. One of the springs (Todkepani) among ten have no water flow at all due to the haphazard road construction. Some springs have potential for pipeline water supply to settlement of that area if managed properly. Well planned and environment friendly infrastructure should be conducted. Action research to revive springs, monitoring of other water sources, integrated watershed management programs and climate change adaptation programs are highly recommended in the area.

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Entailment of Climatic Factors on Human Health Due to Malaria

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Abstract: This study was designed to analyze influence of climatic factors on occurrences of malaria, and it further explored role of climatic factors in eliminating malaria from the study area *i.e.* Bharatpur Municipality. The study area is considered to be highly vulnerable to climate change as well as has moderate risk towards Malaria. This study had extensively analyzed climatic data obtained from Department of Hydrology and Meteorology (DHM), and primary data from the survey of 362 households. The study findings revealed that temperature and rainfall contributed positively to occurrences of malaria. However, occurrence of malaria was found to be decreasing due to malaria eradication program, availability of moderate level of health facilities and urbanization in the study area. Since malaria occurrences is positively correlated to temperature and rainfall, precautionary measure to prevent malaria is required during hot and wet period, particularly during monsoon.

Keywords: *Malaria, Climate change, Climatic factors*

1. Introduction

Malaria is one of the major health concerns of South Asia including Nepal which often results in deaths. Though malaria control programs had been implemented in Nepal from 1950s, 50% of the population is still considered to be at risk (Malaria Micro-Stratification, 2016). As a result of it malaria is still considered as one of the major public health problems of Nepal. A report published in 2016 by the Government of Nepal showed that 12 districts of the country are at highly-risk zone, 27 districts are at the moderately risk zone, and 38 districts are at the low-risk zone, and remaining are categorized as no risk zone.

Malaria is more common to the working age group as they likely to be exposed to the vector more often; however, we have to realize that children and senior citizens are relatively more vulnerable to malaria. Nepal government has also prioritized malaria program in its Second Long-Term Health Plan (SLTHP) 1997-2017. Poor and vulnerability people like older adults, children and woman are also affected most due to the lack of accessibility and knowledge on malaria preventive measures such as mosquito nets and protective cream. Most of the countries in the world already eliminated malaria due to the availability of effective methods of prevention and treatment of malaria which pushes Nepal to take it as priority health problem and walk together with world for its elimination.

Climate change is considered as a threat to the health, though its impact might vary within a population. Furthermore, it might also be the direct cause of health impact in some cases, and indirect in other cases. Temperature and precipitation had been reported as causes that can lower or raise transmission of malaria, as temperature, precipitation, humidity, and wind can create favorable condition for vectors to flourish and thus transmit malaria. Hallegate, et al.(2016)

reported that 2°C increase in global temperature can result 5% increase in number of people at risk to malaria.

2. Data and Methods

2.1 Study area

The study area Bharatpur of Chitwan district lies under high vulnerable zone for climate change (National Adaptation Programme of Action, 2010), and lies on moderate risk area for malaria (Malaria Micro-Stratification, 2016). According to the Malaria micro-stratification 2016, Wards number 6, 11, 14, 18, 19, 20, 23, 25, 26, and 27 were the most vulnerable wards of Bharatpur which had the population of 50967 (Malaria Micro-Stratification, 2016) and an estimated household number in the study area is 6371.

2.2 Data collection

The climatology data was collected from Department of Hydrology and Meteorology (DHM), data of malaria incidents was collected from District Public Health Office (DPHO), Bharatpur, Chitwan, which were the source of secondary data collected for the period of 13 years. The primary data was generated from questionnaire survey, for the purpose of triangulation and verification of findings from secondary data. Questionnaire survey was carried out only on vulnerable wards. The sampling size 362 households were taken using snowball sampling technique to figure out the finding.

2.3 Data analysis

Trend analysis of all variables was done to see the differences within years. Spearman correlation analysis has been done to examine the relationship between meteorological variable (Independent variable) and malaria cases (Dependent variable). In order to assess the degree to which the malaria data correlated with the climatic data, linear regression analysis was done.

3. Results

3.1 Trend of climatic variables

The following charts represent the trend of climatic variables: maximum temperature, minimum temperature, humidity, and rainfall.

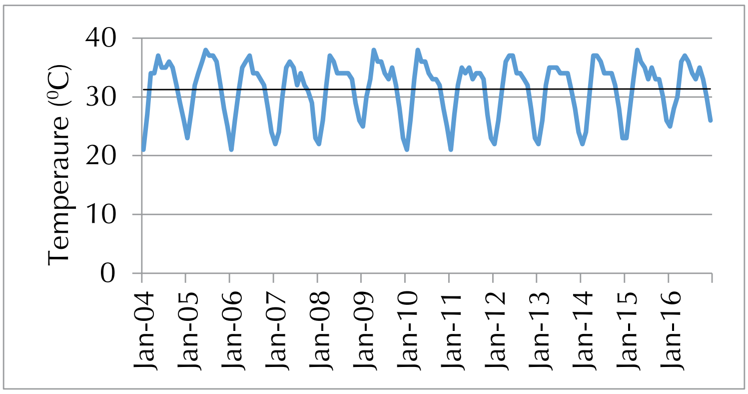

Figure 1. Trend of Maximum Temperature

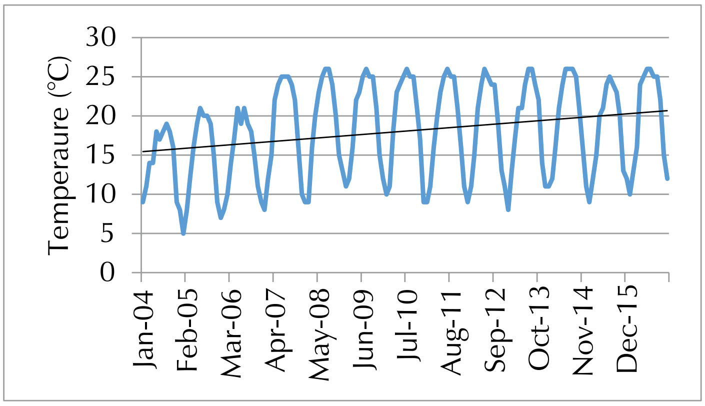

Figure 2. Trend of Minimum Temperature

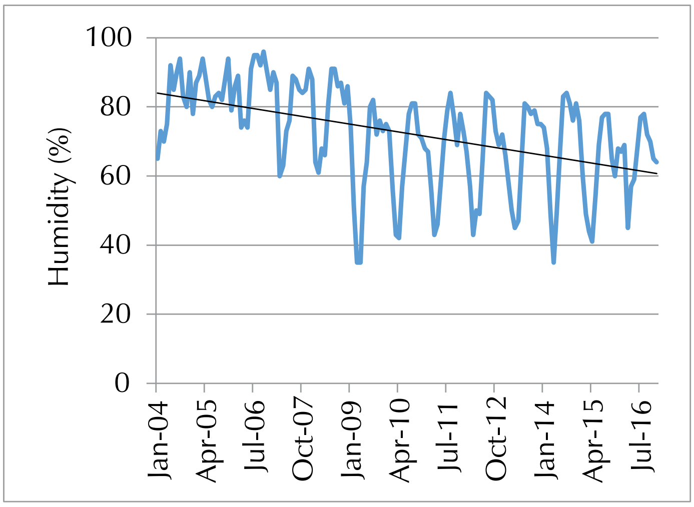

Figure 3. Trend of Humidity

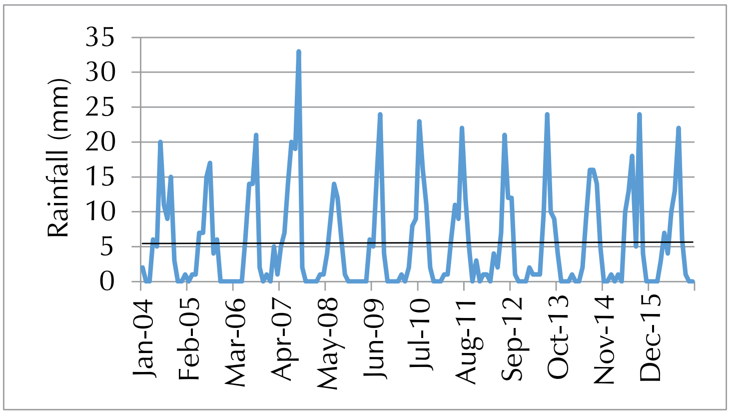

Figure 4. Trend of Rainfall

The trend line of maximum temperature does not show a clear increasing or decreasing trend. On the contrary to maximum temperature, minimum temperature shows the clear increasing trend (Figure 2). The trend line of humidity shows that there is a continuous decreasing trend of the relative humidity with huge fluctuation within years. On other hand, it's hard to predict the exact trend of rainfall from the thirteen years data since in each year the pattern has been fluctuating.

Result clearly shows that the temperature has been increasing with increasing the number of hot days.

3.2 Trend of Malaria

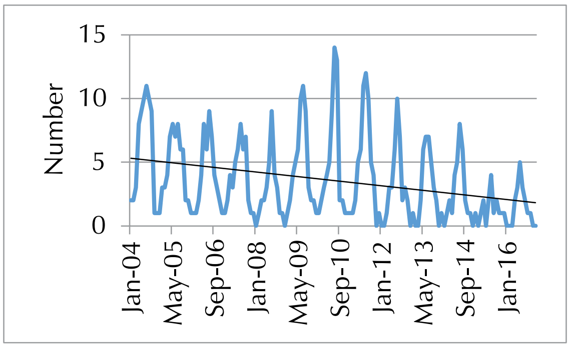

Figure 5. Trend of malaria

The above figure shows that the incidents of malaria clearly are in decreasing trend. The maximum cases of malarial incidents were recorded from April to September and it was observed that July had the highest number of cases recorded. Likewise, no cases were recorded in the winter season (November, December, and January). The study revealed that the cause of increment of malarial incidents in the study area is due to imported malaria rather than indigenous cases of malaria.

3.3 Statistical Analysis of relation between climatic factor and malaria

Table 1. Correlation of climatic factors and malaria

Incident of Malaria		Rainfall	Humidity	Temperature
	Pearson Correlation	.661	.193	.637
	Significance level	.000	.016	.000
	N	156	156	156

From the calculation on the above table, the correlation of malaria cases with respect to maximum temperature and rainfall had been found 0.661 and 0.637 respectively, which clearly indicates that it has strong positive correlation having statistically significance at the level of 0.01. Similarly, there is a very weak relationship between cases malaria and humidity with poor significant level (0.016). The value of adjusted R square is 0.556 which means that there is around 55.6% variations in the dependent variable due to changes on three explanatory variables: Rainfall, humidity, and maximum temperature.

The estimation of the regression equation is **ln cases of malaria = -5.266 + 2.769 ln maximum temperature + 0.756 ln humidity + 0.1 ln rainfall**. Here, ln indicated natural logarithm as data are converted into natural logarithm.

There are some other factors as well that affect malaria. During study some of the factors were explored and found. For example, malaria and urbanization have strong negative correlation with r = -0.77 value. This indicates that the trend of urbanization is increasing each year in the study area which has controlled the malaria. During the sampling survey, among 362 respondents 71% of them had knowledge about malaria. This showed that local government had launched the effective control program against malaria.

4. Discussion

Average temperature per year was in increasing trend with the increment in hot day and decrease in frequency of cold days with rising of minimum temperature from 5°C to 10°C. Frequency of light rainfall is decreasing year by year. In comparison to heavy rainfall, light rainfall is far better for crops since it helps to recharge the ground water. If temperature increases, the capacity of air to hold water vapor increases which leads to decrease relative humidity. So, decrement of humidity in the atmosphere indicates the increment in temperature.

There is decreasing trend in overall incident of malaria diseases by 75% (67 in 2004 vs. 17 in 2016). The numbers of indigenous cases were decreasing with the increment of imported malaria cases. From the result it is observed that the target of Government to reduce indigenous cases by 70% in 2018 was achieved if we see the data of recent years in the study area. However, Government should pay attention to reduce number cases importing from outside.

Effective eradication programs of government against malaria, public awareness, behavioral changes of people regarding sanitation and increment of urbanization might be some reasons of declining incidents of malaria. The statement of researcher (Hallegatte et al., 2016), "malaria will reduce if temperature is above 34 °C, because both vector and parasite face difficultly for survival" is not applicable in case of study area if we analyze the finding. For example in the study area, there were many cases of malaria, in the temperature above 34 °C. It shows that a finding cannot be generalized for all cases since temperature tolerance capacity of mosquitoes and parasites might be different from place to place.

5. Conclusions

The study revealed that temperature and rainfall contributed positively to occurrences of malaria. However, occurrence of malaria was found to be decreasing due to malaria eradication program, availability of moderate level of health facilities and urbanization in the study area. Since malaria occurrences is positively correlated to temperature and rainfall, precautionary measure to prevent malaria is required during hot and wet period, particularly during monsoon.

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Climatic Trends and its Impacts on Agriculture of Mustang, Nepal

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Abstracts: Agriculture is the mainstay of the economy for people living in Nepal, and agricultural activities are directly linked with the changing patterns of climate. This study intends to assess the impact of climate change in agriculture and livelihood of people in Thasang Rural Municipality, Mustang district of Nepal. Climatic trends and its relationship with different crop analysed through available meteorological and agriculture data. Further, the field survey and satellite data are analysed. Results show that the agricultural land use decreased by about 18% between 2000 and 2010, and 39% between 2010 and 2016. Meteorological data analysis of 36 years (1981-2016) of Jomsom, Thakmarpha, and Lete indicated that the mean air temperature is increasing at 0.0248, 0.0275, and 0.0034 ˚C/yr with statistically significant, except Lete, and total annual precipitation is increasing by 1.8, 0.13, and 6.28 mm/yr with statistically not significant, except Lete, respectively. Correlation of 17 years (1999-2016) of maize and barley yield with climate variables show heterogeneous relationships, and the climatic influence is statistically not significant. The minimum temperature of Lete is decreasing (0.0387 ˚C/yr), while the maximum temperature is significantly increasing (0.0456 ˚C/yr). The changes in temperature might be the reason of changing trends of crops including the apple in selected locations. Majority of farmers perceive that climate change is responsible for the decreasing agricultural productivity in the area.

Keywords: *Climate change, GIS and remote sensing, Crop calendar, Climate trend*

1. Introduction

Agriculture is the mainstay of the economy and the people living in Nepal (Bhandari, 2013). The productivity of the crops depends on the climatic factors (Khanal, 2015). The degree of association between crop and climate is given by analysis of climatic factors. Moreover, analyzing the impacts of historic climatic factors trends on crop production helps to identify the possible impacts of future climate, which also reviews the on-going efforts of adaptation and change in production (Lobell et al., 2011). Both maximum and minimum temperature and both the intensity and distribution of rainfall have impact on agriculture production (Khanal, 2015). Drought has a negative impact on rural livelihoods that mainly depend upon rain fed subsistence agriculture (Khanal, 2015).

The amount of carbon dioxide (CO_2) in atmosphere is increasing by 1.4 ppm/yr (IPCC, 2007). The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, sea level has risen, and the concentrations of greenhouse gases have increased. Human influence has been the dominant cause of the observed warming since the mid-20th century (IPCC, 2013). Climate change is becoming one of the challenges for nature and humanity in this century.

Climate change has a particularly strong effect on developing countries. Nepal has low adaptive capacity and agriculture is highly dependent on climatic factors (Manandhar et al., 2010). Food production systems in Nepal are highly vulnerable to increasing climate variability and change. Agriculture production is constrained by altered frequency, timing and magnitude of climate variables such as precipitation and temperature (MOAC, 2011). Changing temperatures and erratic rainfall pattern are also affecting crop production in Nepal (Malla, 2008).

Maize (*Zea mays L.*) is the major traditional cereal crop in rain-fed ecosystem of the hills and mountain (Sapkota & Pokhrel, 2010). Maize is main crop after Rice in Nepal in term of area and production (MOAD, 2014). Maize is grown under rainfed conditions during the summer (April-August) as a single crop or relayed with millet later in the season (KC et al., 2015). It is reported that the demand for maize has been growing by 5% over the last decade and the area, production and productivity of maize are slowly and constantly increasing since 1984 in Nepal (Sapkota & Pokhrel, 2010). Maize is cultivated in Terai, inner-Terai, valleys, and low-lying river basin areas in the winter and spring with irrigation too (Paudyal et al., 2001).

Barley (*Hordeum vulgare L.*) is the winter cereal crop of high mountain areas of Nepal (Gupta et al., 2009). Nepalese high lands are considered a center of diversity for barley (Witcombe & Gilani, 1979). It is grown in different cropping patterns in both Khet and Bari land conditions (Gupta et al., 2009). Although, barley production area is small in Nepal, it is very important crop in remote and food deficit areas (Gupta et al., 2009).

Nepal Himalaya climate is changing in higher rate compared to the global average. This applies especially to temperature rise, which at higher altitudes is more pronounced than at lower altitudes (Baidya et al., 2008). Changing temperatures and erratic rainfall pattern are affecting crop production in Nepal (Malla, 2008) Agriculture sector has played fundamental role in human welfare especially in rural Nepal, where people heavily depend on agricultural exports for their fiscal and socio-political stability. However, the contribution of agricultural sector to the national economy is challenged by its vulnerability to climate change. A very few researches have been done in agriculture relating with climate change. Farmers' capacity to observe and understand climate could provide the basis for a locally based monitoring system to supplement the network of weather stations, which is rather thinly spread in Nepal, especially at higher altitudes, where climate change impacts are most strongly felt (Manandhar et al., 2010).

In this study, we will explore the climatic trends and its possible impacts to the agriculture crops, with examples of major crops (barley and maize) in Thasang Rural Municipality, Mustang district, Nepal.

2. Data and methods

2.1 Study area

Thasang Rural Municipality (TRM) lies between 28.56 and 28.81° N latitude and 83.50 - 83.73° E longitude. The TRM is newly formed by merging four old Village Development Committees (VDCs) namely, Kobang, Lete, Tukuche, and Kunjo. The Kobang is its headquarters. This rural municipality covers an area of 289 km^2 and consists of five wards. This rural municipality has spread from about 1759 to 6841 m asl (above sea level). Most of the villagers are involved in agriculture except for a few, who are working outside the region or who are involved in tourism. The major crops in this area are buckwheat, maize, potato, and barley.

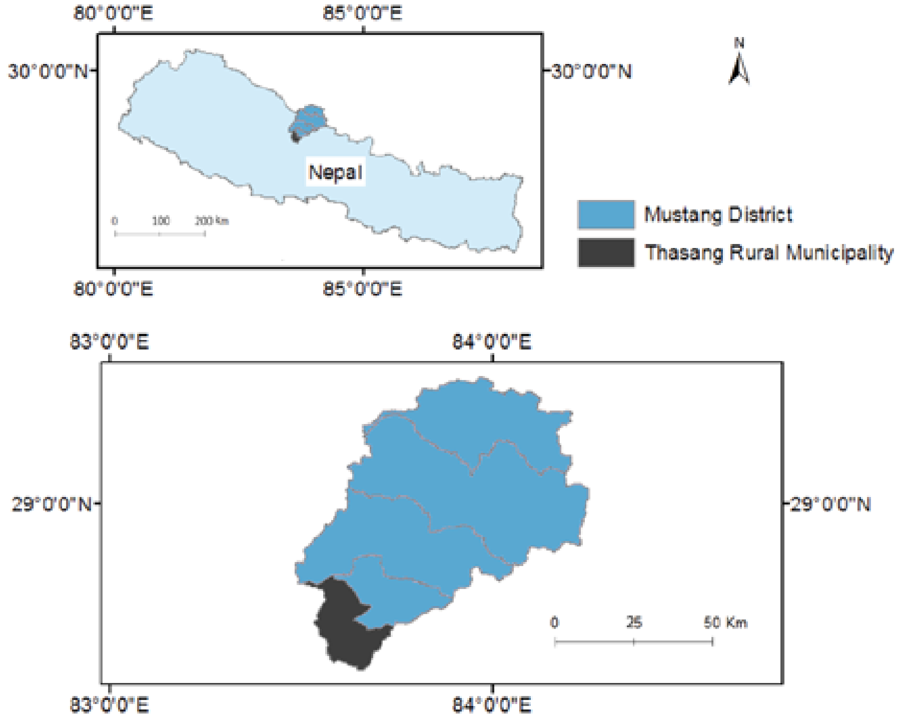

Figure 9. Map of Study Area

2.2 Data Collection

a) Remote sensing

Land cover data of Nepal of 2000 and 2010 were taken from International Centre for Integrated Mountain Development (ICIMOD). Further, Land Satellite Operational Land Imager (LANDSAT OLI) image of 2016 having 11 bands with 30 m spatial resolution for visible bands was taken from the United States Geological Survey (USGS) and was used to classify land use by supervised classification in ArcGIS 10.3. Field visit was carried out in the month of March, 2018 to collect training data for land use interpretation of the Landsat image of 2016 and quantitative description of the characteristics of each land cover classes.

Figure 2: Landsat satellite Operational Land Imager (OLI) image from 2016

b) Accuracy of measurement

Here,

Total GPS taken in land cover = 54

No. of GPS place in other land use than in field = 6

No. of GPS which are in same land use class as in filed = 48

The image classification of Thasang Rural Municipality of 2016 was found accuracy of 89%.

c) Climatic trend analysis

Meteorological data used in this study included precipitation and temperature data collected from the Department of Hydrology and Meteorology (DHM), Government of Nepal. Three meteorological stations (Jomsom-Station index (SI) -601, Thakmarpha-SI-604 and Lete-SI-607) are selected for the study. Daily temperature and precipitation data from 1981-2016 were collected from Jomsom and Thakmarpha stations. Temperature data of Lete from 1998- 2016 was collected and precipitation from 1981-2016 was collected. They were used to calculate yearly average to carry out trend analysis. The missing data were filled with the help of nearest station. First, the data was used to calculate yearly and seasonal average to carry out trend analysis using Mann- Kendall test with 5% level of significant.

d) Relationship between crops and climate variables

Maize and Barley yield of Mustang district were collected from ministry of agricultural development (MOAD) from 1999 to 2016. Karl Pearson's correlation (Parametric data) test for correlation between barley yield and climatic variables (temperature and precipitation) considered and Spearman's rank correlation rho (Non-parametric data) for correlation between maize yield and climatic variables (temperature and precipitation). Linear regression was used to check the influence of the variables on yields of barley and maize by using RGui software.

e) Questionnaire Survey

Questionnaire was designed to inquire the current practices of the agriculture, current problems and changes in the agricultural activities. Proportionate probability sampling was conduct to choose household. Participants whose age is above 25 years were interviewed using semi structured questionnaire schedule from randomly select households. Household sample size was determined using formula by Arkin and Colton (1963).

Where,

n = Sample size

N = Total number of Households (677), (Source; wards offices).

Z = Confident level at 95%, Z=1.96

P = Estimated population proportion (0.05)

d = Desired error, (0.05)

Here, n = 66 Households

Table 3. Sample Distribution

Ward No.	1	2	3	4	5	Total
No. of Household	12	16	15	10	13	**66**

f) Key informant interview and Focus group discussion (KII and FGD)
Key informant interviews (KII) were conducted with village/community leaders, individuals who have been living in the study area for long time and individuals affiliated to NGO's, CFUG's committee, women group, governmental staffs, and agricultural expert, news reporter. Focus group discussion (FGD) were conducted among local stakeholders, local persons, men and women to gather information on past and present climate, climatic stress, its impact in the area, the impact in agricultural disasters. FGD was done for the preparation of cropping calendar and also to fine current vulnerability. People's perception towards agricultural impacts, crop calendar and climate change were shown in bar diagrams and tables using MS-Excel.

3. Results and Discussion

3.1 Land use change

Agricultural land cover has decreased by 18% from 2000 to 2010 and again drastically decreased by 39% from 2010 to 2016. Forest coverage is relatively increased by 8% during the period 2000 to 2010 while slightly increased by 2% from 2010 to 2016. Increasing trends of forest coverage might be active conservation of wildlife activity by ACAP and consciousness toward wildlife conservation by local people for tourism development. Another reason for increasing forest coverage while decreasing agricultural area might be the loss of interested in farming practices, abandoning the high altitude agricultural land called "*Ban Khet*" and agricultural land which are nearby forest for agricultural practices. Most of farmers also do side business in tourism.

This type of results is also good agreement with precious study carried out by Rai (Rai et al., 2018) in trans-boundary Gandaki river basin. In his study, he found that under forest cover was 32.47% in 1990, whereas, it has increased to 33.22% in the basin. The increased forest cover converted from chiefly cropland land and small patches from other different land cover types over 25 years.

Table 4. Changes in land cover

Land class	Area change (%)	
	2000-2010	**2010-2016**
Forest	8	2
Shrubland	-15	10
Grassland	2	-39
Agriculture	-18	-39
Barren area	17	18
Water body	453	104
Snow/glacier	-16	16

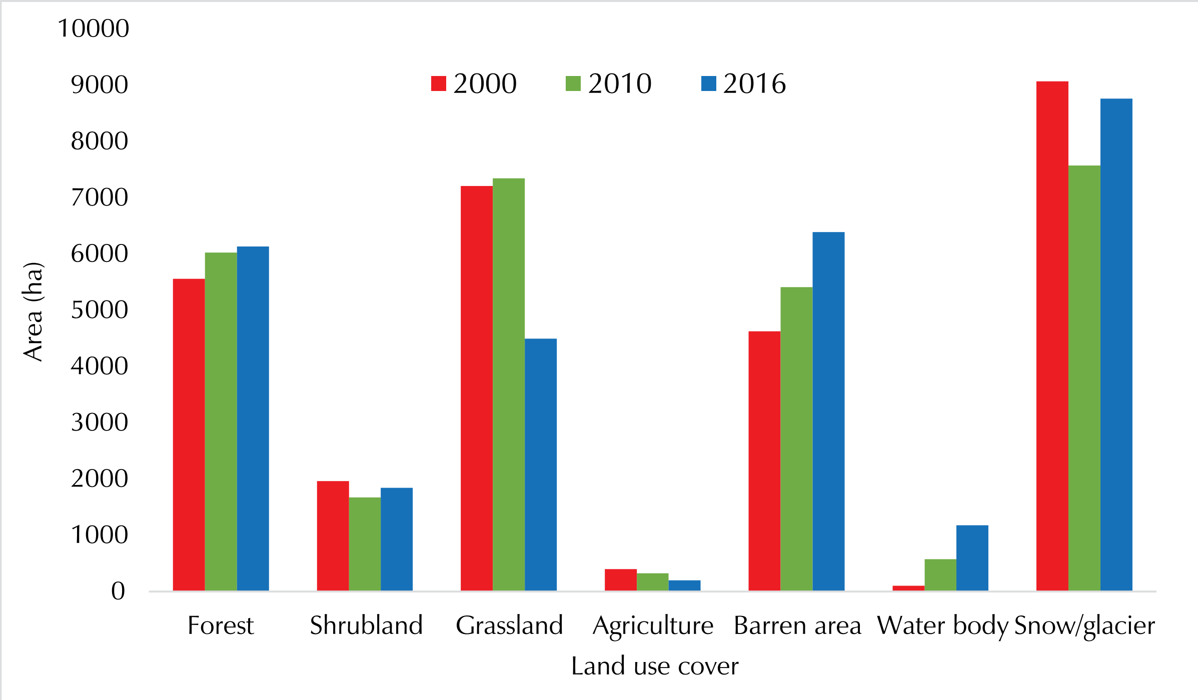

Figure 3. Land use change in the study area

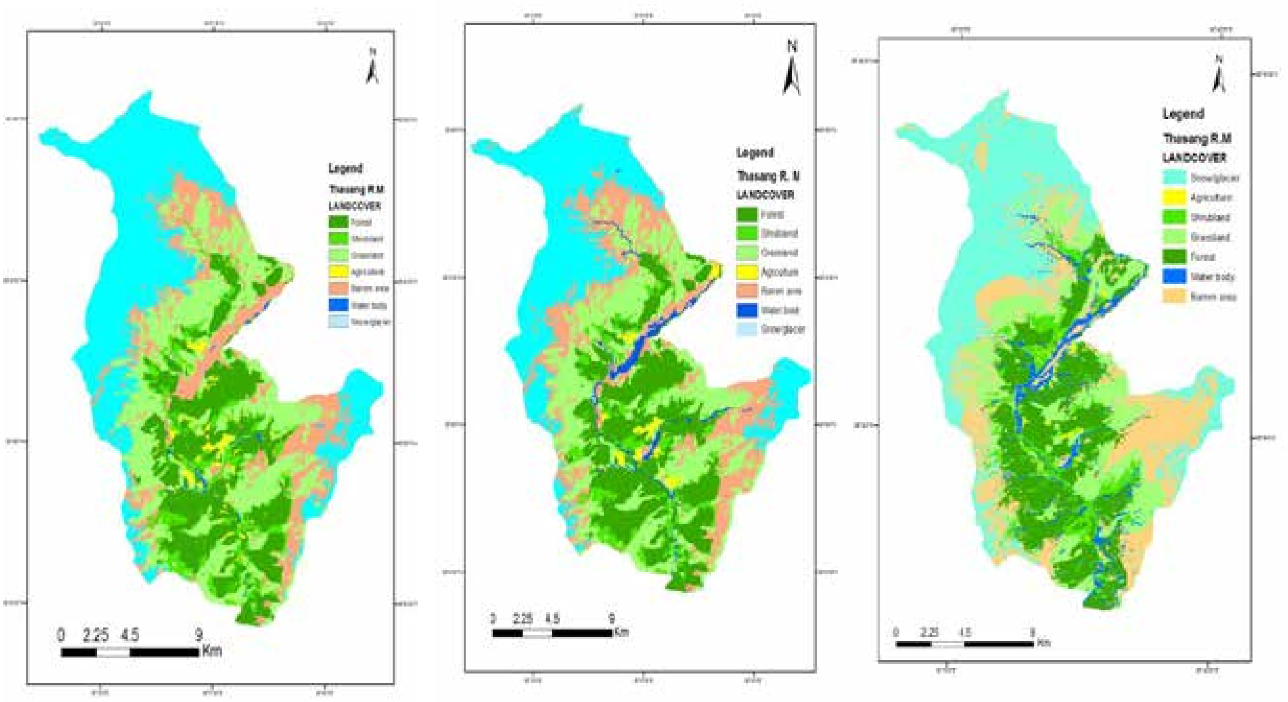

Figure 4. Land use classification for the year 2000, 2010, and 2016

3.2 Trend of observed precipitation and temperature of the area

There is annual increase of about 1.8 mm/yr in Jomsom meteorological station and that the trend was statistically not significant which is higher than Thakmarpha and lower than Lete. The precipitation trend of Thakmarpha is decreasing of about 0.1 mm/yr and that the trend was statistically not significant and trend of Lete is increasing of about 6.3 mm/yr and the increase was statistically significant. The study carried out by (Devkota, 2014) found that the average rainfall in Nepal is in increasing annually by 13 mm/yr and (Malla, 2008) found that average annual rainfall was increasing by 0.81 mm/yr.

There was annual increase of minimum, maximum, and mean temperature by 0.0435, 0.0093, and 0.0248 °C/yr, and trends were statistically significant, statistically not significant, statistically significant, respectively in Jomsom meteorological stations. In Thakmarpha, there were slightly decreased minimum temperature by 0.0163 °C, but increased maximum and mean by 0.0712 °C, and 0.0275 **°C, and trend were statistically not significant, statistically significant, and statistically significant respectively. In Lete, there were annual decreased minimum temperature by 0.0387 °C, but increased maximum and mean temperature by 0.0456 °C, and 0.0034 °C and trends were statistically significant, statistically significant, and statistically not significant respectively. The mean temperature increases in Trans-Himalayas at 0.09 °C/yr (Shrestha et al., 1999). Another study by (Tiwari et al., 2010) showed that the annual temperature increasing trend followed >0.035 °C per year for Himalayan regions on the basis of study on Narayani Basin in Nepal. Rate of increasing trend of mean temperature from all station are less than these researches.**

Seasonal precipitation analysis of 601, 604 and 607 found that pre-monsoon, monsoon, and winter precipitation slightly increasing trend (Figure 6), and the post monsoon trend was decreasing (Figure 6) and all trends were statistically not significant, except post monsoon precipitation of 604.

The post-monsoon precipitation in Trans-Himalaya, winter and pre-monsoon precipitation in Mountain showed significantly decreasing trends while monsoon season shows increasing trend in both zones, although none of these trends were statistically significant (Panthi et al., 2015). Analysis of temperature and precipitation trend of maize and barley growing season, the average temperature and sum precipitation of April to August for maize and November to March (November and December of preceding year and January, February and March of succeeding year) for barley (Paudel & Shaw, 2016) were taken.

Trend of mean seasonal temperature and precipitation of the maize and barley growing months of 601, 604, and 607 by 0.0117 °C/yr, 0.0104 °C/yr, 0.0064 °C/yr, 1.9962 mm/yr, 4.8874 mm/yr, 1.0778 mm/yr, 0.0487 °C/yr and 0.0487 °C/yr and -0.0128 °C/yr, 1.1056 mm/yr, 0.2226 mm/yr, and 1.7331 mm/yr, respectively and all trends were statistically not significant except precipitation of maize in 601, temperature of barley in 601, and 604.

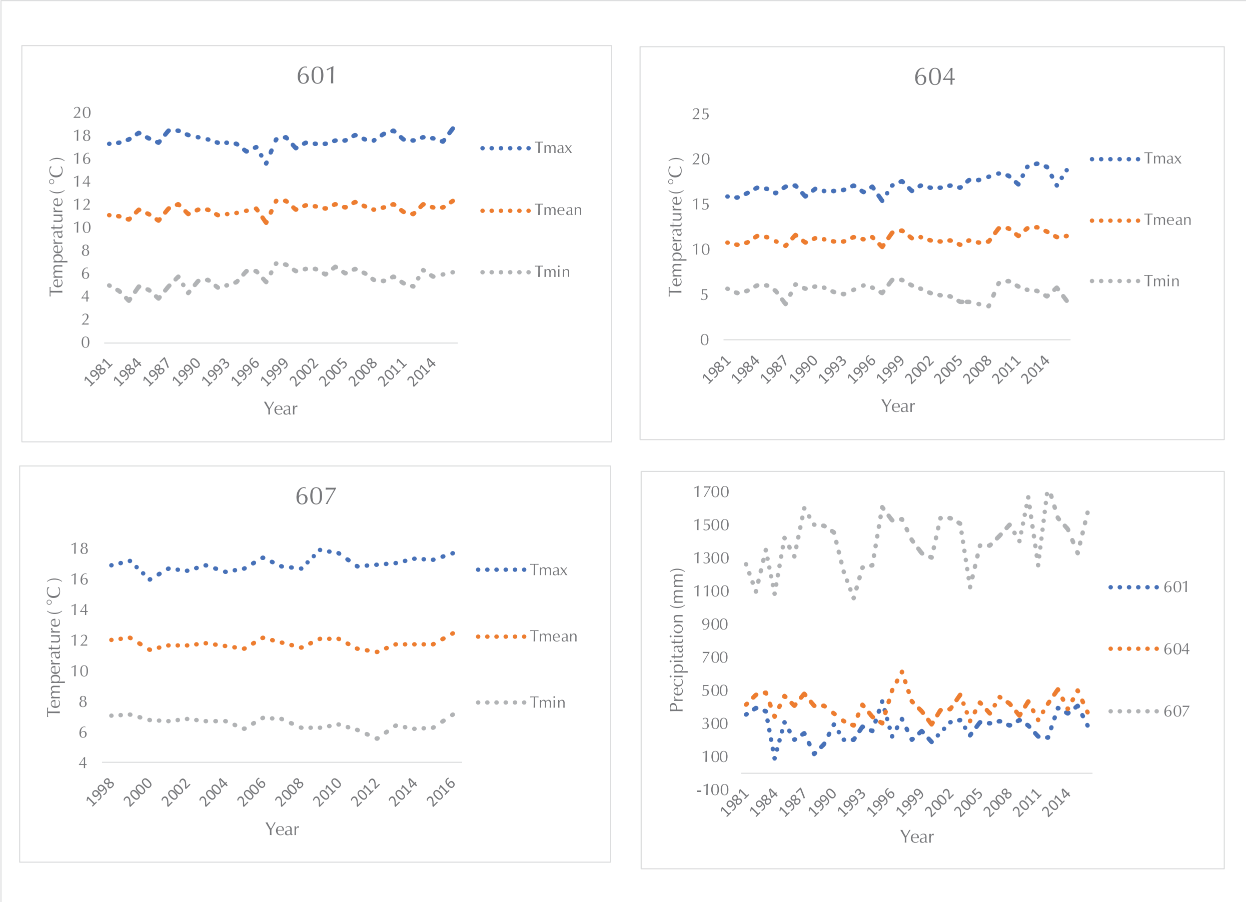

Figure 5. Trends of annual mean temperature and annual precipitation of 601, 604, and 607.

Figure 6. Seasonal precipitation from the stations 601, 604, and 607.

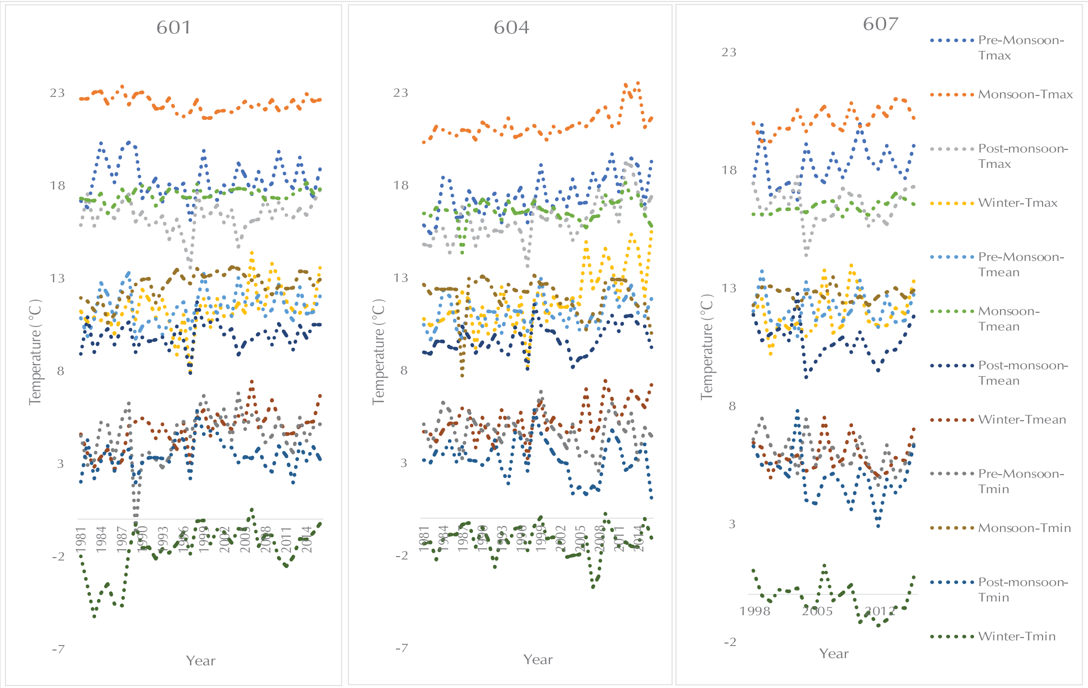

Figure 7. Seasonal temperature of 601, 604, and 607.

Table 5. The summary for temperature and precipitation for Mann-Kendall test statistics

SN	Station		Parameter	Linear trend line's slope	Mann-Kendall test statistics				Trend	Remark
					Sen's slope	Kendall's tau	P -value	Alpha		
1	Jomsom	Precipitation	Total annual	1.824	2.057	0.171	0.675	0.05	I	NA
2			Pre- monsoon	0.186	0.401	0.083	0.566	0.05	I	NA
3			Monsoon	1.177	1.306	0.222	0.106	0.05	I	NA
4			Post monsoon	-0.496	-0.025	-0.073	0.597	0.05	D	NA
5			Winter	0.958	0.745	0.258	0.06	0.05	I	NA
6		Temperature	Minimum	0.044	0.042	0.365	0.002	0.05	I	***
7			Maximum	0.006	0.007	0.092	0.44	0.05	I	NA
8			Mean	0.025	0.025	0.362	0.002	0.05	I	***
9			Pre-monsoon	0.017	0.019	0.194	0.214	0.05	I	NA
10			Monsson	0.012	0.011	0.208	0.146	0.05	I	NA
11			Post monsoon	0.0097	0.0097	0.083	0.548	0.05	I	NA
12			Winter	0.061	0.054	0.444	0.006	0.05	I	NA
13	Thakmarpha	Precipitation	Total annual	-0.129	-0.172	-0.006	0.967	0.05	I	NA
14			Pre- monsoon	0.47	0.496	0.153	0.274	0.05	I	NA
15			Monsoon	0.047	-0.435	-0.153	0.274	0.05	I	NA
16			Post monsoon	-1.313	-0.834	-0.361	0.008	0.05	D	***
17			Winter	0.666	0.594	0.222	0.106	0.05	I	NA
18		Temperature	Minimum	-0.016	-0.017	-0.168	0.154	0.05	D	NA
19			Maximum	0.071	0.071	0.597	< 0.0001	0.05	I	***
20			Mean	0.028	0.023	0.314	0.007	0.05	I	NA
21			Pre-monsoon	0.027	0.026	0.222	0.121	0.05	I	NA
22			Monsson	0.013	0.004	-.0139	0.964	0.05	I	NA
23			Post monsoon	0.026	0.029	0.167	0.294	0.05	I	NA
24			Winter	0.05	0.048	0.417	0.014	0.05	I	***

25	Lete	Precipitation	Total annual	6.281	6.433	0.257	0.028	0.05	I	***
26			Pre- monsoon	2.851	3.004	0.153	0.27	0.05	I	NA
27			Monsoon	2.39	2.54	0.153	0.274	0.05	I	NA
28			Post monsoon	-0.051	0.531	0.139	0.322	0.05	I	NA
29			Winter	1.089	0.518	0.014	0.958	0.05	I	NA
30		Temperature	Minimum	-0.039	-0.049	-0.404	0.016	0.05	D	***
31			Maximum	0.046	0.047	0.404	0.016	0.05	I	***
32			Mean	0.003	0.005	0.029	0.890	0.05	I	NA
33			Pre-monsson	-0.003	-0.001	0.083	0.826	0.05	D	NA
34			Monsson	0.029	0.031	0.25	0.448	0.05	I	NA
35			Post monsson	-0.033	-0.03	-0.333	0.305	0.05	D	NA
36			Winter	0.001	-0.011	-0.25	0.461	0.05	D	NA

Note: I Increasing; D decreasing; *** significant; NA Not significant

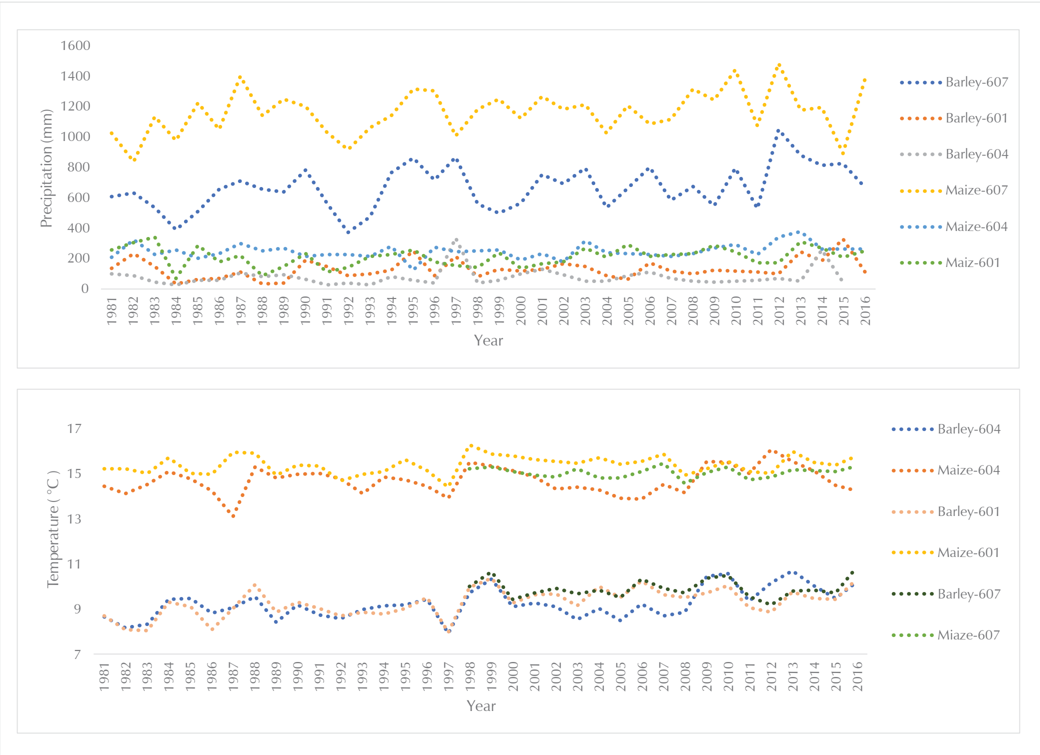

Figure 8. Trend of Precipitation and temperature of barley and maize growing season of 601, 604, and 607.

3.3 Relationship between crops and climate variables

The barley is increasing by 30.29 kg/ha/yr, while maize is increasing by 1.40 kg/ha/yr. Correlation of maize with Tmax of all three stations is slightly positively correlated, with Tmin, Tmean and Precipitation of all three station are slightly negatively correlated. Correlation of barley with Tmax, Tmin, and Tmean of Jomsom and Lete are slightly negatively correlated but with Tmax, Tmin, and Tmean of Thakmarpha are slightly positively correlated. Correlation of barley with precipitation of all stations is slightly positively correlated. Through linear regression, climatic influence on crop yield is statistically not significant. Not only climates, but many factors such as fertility of the soil, farm management practices, variety, prevalence of diseases and insects, are responsible for decreased or increased of production (Robertson, 1975). Young apple trees are particularly susceptible to cold temperature injury during late fall or early winter (Palmer et al., 2003).

Table 2. Crop yield and climatic variables correlation (r)

Yield	Station	Tmax	Tmin	Tmean	Precipitation
	601	0.0415	-0.3619	-0.2996	-0.2021
Maize	604	0.0321	-0.1036	-0.0072	-0.0590
	607	0.2592	-0.3245	-0.0404	-0.1399
	601	-0.2166	-0.4081	-0.3701	0.3419
Barley	604	0.1863	0.0437	0.1672	0.3510
	607	-0.1298	-0.4911	-0.3160	0.3510

3.4 Finding from Social Survey

About 45% respondents stated that the maize is most affected crop by pest and disease while 38% for apple is the most affected by extreme events. Slightly change on crop calendar has been observed on naked barley, buckwheat, and potato about a week in few wards. The minimum temperature trend of Lete is decreasing while the maximum temperature is significantly increasing. The changes in temperature might be the reason of changing trends of crops including the apple in ward 3, 4, and 5. According to perception the cause is attributed by increasing temperature, low snowfall, and pest increment in the area. Majority of farmer had perception that the climate change is responsible for the decreasing agricultural production in the study area.

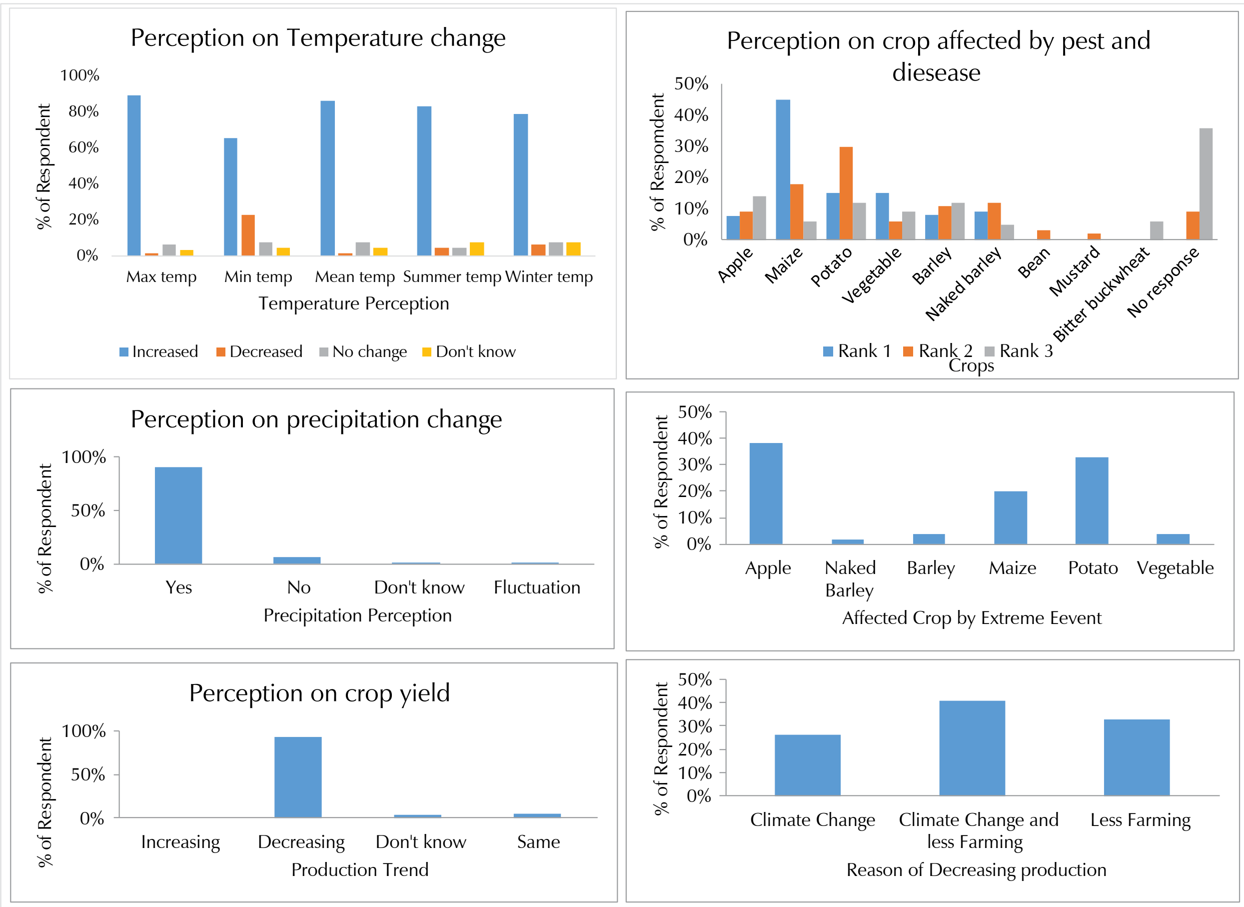

Figure 9. Perception of respondents on climate and crops.

4. Conclusions

A slightly decrease of agricultural land use from 2000 to 2010 and from 2010 to 2016 were found by 18% and 39%, respectively. Results of temperature data analysis of 31 years indicated that the mean temperature is increasing at 0.0248, 0.0275 and 0.0034 ˚C/yr based on the meteorological stations of Jomsom, Thakmarpha, and Lete (18 years data in Lete), respectively with statistically significant except Lete. Precipitation data of 31 years shows increasing by 1.8 mm/yr in Jomsom meteorological station that is higher than Thakmarpha (0.13 mm/yr) and lower than Lete (6.28 mm/yr) with statistically not significant except Lete. Correlation of 17 years of maize and barley yield with climate variables show heterogenous relationships and climatic influence on crop yield is statistically not significant. The minimum temperature trend of Lete is decreasing while the maximum temperature is significantly increasing. The changes in temperature might be the reason of changing trends of crops including the apple in ward 3, 4, and 5. Maize and apple are most affected by pest/disease and extreme event respectively. Majority of farmer had perception that the climate change is responsible for the decreasing agricultural production in the study area.

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Orange Farmers Knowledge and Experience on Climate Change in Namsaling Village of Ilam District

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Abstract: The aim of this paper is to explore the local people's knowledge and experiences on climate change based on ethnographic study at Namsaling village of Ilam district. It tries to document farmers' understanding and experiences on climate change through orange production. Moreover, this paper also discusses about the adaptive strategies adapted by the orange cultivating famers to cope with the climate change. In this paper farmers are not taken as homogenous group. They are social heterogeneous groups in terms of education, gender and class. This article is the product of ethnographic study between the years 2017 and 2018 among the orange cultivating farmers in Namsaling village of eastern Nepal. The local people are directly connected to environment and their eyewitness tells the story on the disturbance of climate change in orange production. People's life stories and data are gathered through observation, interaction with people and group discussion during field work. Ethnographic study can contribute in documenting the place and culture specific stories as powerful evidence to climate change and its impact on agriculture production.The findings reveal that orange farmers' knowledge and experience rest on the performance of orange quality and quantity. Moreover their knowledge and experience is highly influence by the social spaces like education, gender and class occupied by each orange cultivating farmer. Moreover, the orange cultivating farmers have started to grow new crops to cope with uncertainty created by climate change. People have taken various adaptive strategies depending on their level of education, economic condition, and educated people seemed to have adopted better and promptly. People with sound economic condition were found taking adoptive strategies faster in comparison to people with low economic status.

Keywords: *Orange cultivator farmers, local knowledge, climate change, adaptive strategies, ethnography, agriculture production*

1. Introduction

This is an ethnographic study of the local farmers' experiences and narratives on orange production in the context of climate change**.** The paper discusses how the orange farmers of Namsaling village have experienced the climate change, and how the knowledge is produced in local level, and their coping mechanism is also traced. Climate change means a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods (United Nation Framework Conversation on Climate Change, 2010). International Panel for Climate Change (IPCC, 2005) has defined climate change as any change in climate over the time due to natural variability or as a result of human activity. At present, the term -climate change- is generally used to refer to the statistical distribution of weather patterns. It may refer to a change in average weather conditions in the time variation of weather within the context of long-term which has been linked to increase in atmospheric carbon dioxide but, the local farmers' understanding on climate change differs than the scientific way of understanding (Roncoli, Vadwan and Rhoades, 2012).

Only last few years has a critical mass of anthropologist begun to focus on the social practice and cultural implications surrounding the production of climate change model and scenarios, and the implication of its impacts for people worldwide (Peterson and Broad, 2009), Anthropologists are more sensitive and devoted to address the global warming from the local perspectives based on local experiences, perception, knowledge and adaptive strategies (Roncoli et al, 2009). In this context, an anthropological work provides insights to our present climate crisis; local people have experienced and observed the climatic complexities from grounded perspectives where the vulnerability of community concerned much (Crate and Nuttal, 2009). Many climatic scientists and natural scientists take climate change as a single variable. But climate change is nexus of nature and culture, material and non-material, global and local phenomena (Barnes and Dove, 2014). Natural scientists use meteorological data to describe climate change. Such scientific studies are important but there is lack of human dimension (Carey, 2010). In this context, anthropologists argued that there is a critical need to understand how the local people on the ground understand about climate change (Riedlinger and Berkes 2000, Cruikshank 2001, Crate 2008, Crate and Nuttal, 2009, 2016, Barnes and Dove, 2014, Poudel, 2016) because they are the key eyewitness of climate change in their surroundings (Slaick and Byg, 2009, Crate 2009, Cruckshank 2005, Poudel, 2018). For the people of Namsaling, climate change is not just about hotter temperatures and shifting rainfall patterns. It is also about the stories, myths, and realities, loss of local knowledge about seasonality, shifting the growing pattern which had functionally operated in the area over many generations, is gradually being disrupted and finally breaking up due to the changing climate, which has unfortunately received very little attention from scholars.

Orange production is one of the main cash crops produce of Ilam district. People heavily depend on this product for their livelihood. And this paper is motivated by fluctuation of orange production in Ilam which is interpreted differently by different farmers. Some farmers said that the oranges are becoming smaller in size and less in number because they didn’t first offer the fruit to the Gods/Goddesses while others were found to believe that it is due to the God's anger. For instance, drawing on the study of Viliui Sakha of Siberia, the anthropologist Crate (2008) duly reminds us that local narrative or stories are primary research agendas. She explains her ethnographic moment about the age-old story narrated by Sakha elder regarding the temperature range of Sakha personifies winter as a bull. It may help us to understand how local people conceptualize and practice their relationship with their lived environment as an embedded part of their culture and history. This paper explores the farmer's understanding about climate change through orange production. The objective of this paper is to address two issues i.e. to document local people's knowledge and understanding on climate change, and find out local adaptive strategies adopted by orange producing farmers of Namasaling village in the context of climate change.

2. Methods

Fieldwork at Namsaling was undertaken between 2017 and 2018. The fieldwork was focused on collecting qualitative data related to the local knowledge, farmers' understanding and responses to climate change. The data obtained by ethnographer to understand the orange farmers' narratives, stories, and observed the natural settings and their everyday behaviors. It is found to help to contextualize the impacts of climate change. The informal conversations with the local elders and farmers led to a broad understanding about the change and its impact on agriculture production. The other data were provided by Namsaling Community Development Center (NCDC) and District Agriculture Development Office (DADO). After that, the data is classified according to the focus of problem to be studied. Furthermore, data analysis was carried out by organized, sorted, coded, reduced and patterned, coherent and comprehensible into a story of interpretation that responds to the questions that guided the study. Other sources used in this study were obtained through book, journals, and the internet and previous research studies.

2.1 The setting

In the Ilam district, there are several places where farmers have been cultivating orange commercially. Namsaling was a pocket area of orange production and it has long history of producing orange but orange cultivation of Namasaling has been gradually declining over the last few years due to climate change. The study site Namsaling is a hilly area situated in the eastern part of Ilam district. This area spreads over the height and attached with Churia range with varied topographic condition in southern part. It depends on the climatic condition of Himalaya range because of its height. It directly strikes over this area and balances the appropriate climate for orange production. Due to terrain landscape, the area was suitable for understanding the climate change and, its impact on orange production.

Six wards mainly depend on orange production in Namsaling village. Ramritar, Khaggaun, Tamanggaun and Dadagaun were selected for detail research purpose with recommendation of local people. Ramritar Village is located on the bank of Mai River which was good area for orange production until 1982 but it is almost declined and local farmer started to grow dry land cardamom locally known as '*Salakpure Allaiche*'. Similarly, Tamanggaun is located north face area which is largely sun shadow area. The famers of the area are still growing orange as they did in the past. Khaggaun located in the same hight but stopped giving yield of orange. Dadaguan is located in high altitude which was not suitable for orange production in past, but became good area for orange production along with increased temperature. Indeed, the farmers of the Dadagaun area are growing orange as a main source of income.

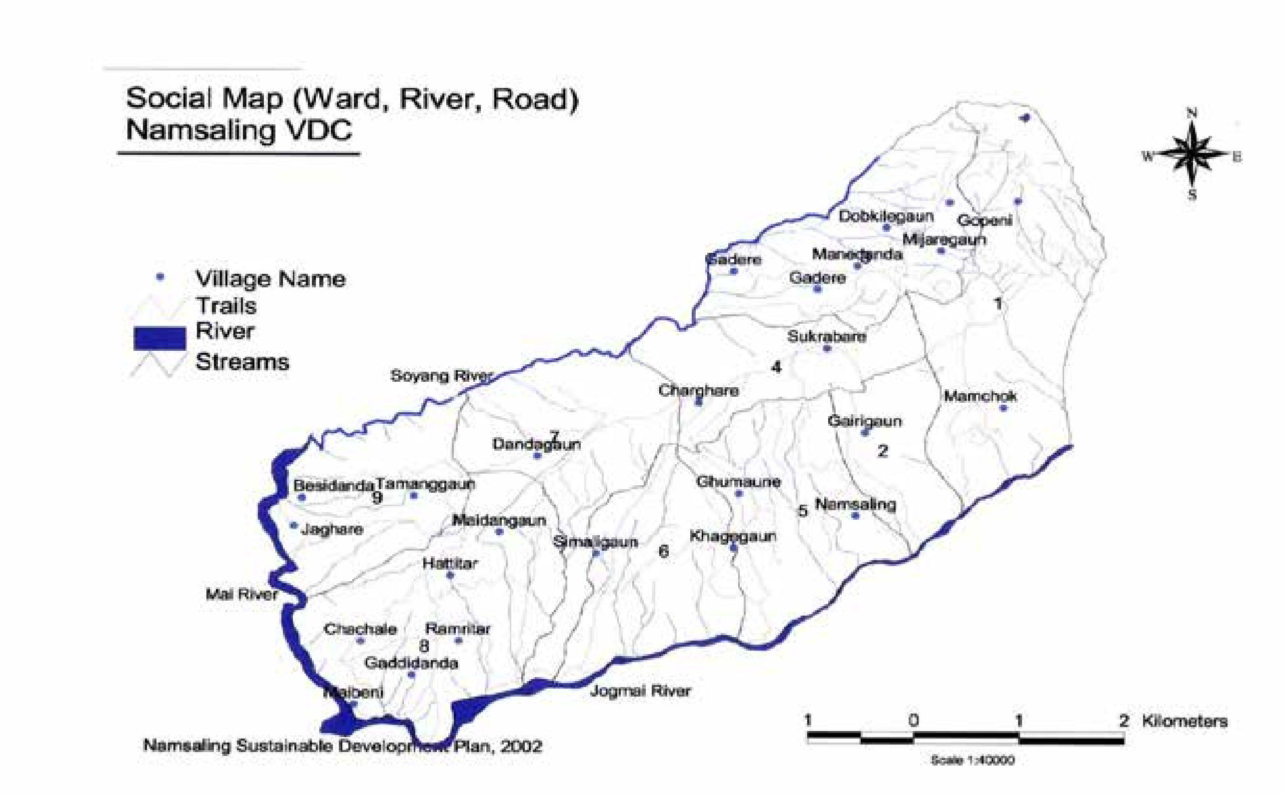

Figure 1: Map of the study area

Ramritar, Khagegaun, Tamanggaun, Dadagaun

Just above the Mai River there is a small village called Ramritar. Just little above the Ramritar there is Khaggun and Tamanggaun. There used to be orange plantation in the Ramritar but now a day there is no any orange plantation in the Ramritar Village. The height of orange plantation is shifted to the villages called Khaggau and Tamanggaun. Geographically Tamanggaun and Khaggaune are in above hight then that of Ramritar. Even in the same hight Khaggaun has stopped giving yield of orange while Tamanggaun still produces the orange. The reason is that Khaggaun is in the sunny slope while, Tamanggaun is in the shady slope. In the past there used not to be any production of oranges in the village called Dadagaun which now-a-days gives good yield of orange. This village is in higher altitude then the all three villages.

3. Discussion

3.1 Experiences on Climate Change

It has been explained the perceptions of the local people on rainfall, temperature and weather in terms of social heterogeneity i.e., class, gender and educational differences. Rural people interact and understand the local climatic phenomena according to the significance of landscape. They are aware about climate fluctuation while doing subsistence practices in their living world. Local people have different perceptions on climate change which is largely based on their lifetime observation of their surrounding by close interaction with environment and local activities. When asked about the change in climate, informants most often began their response by describing the changed pattern in the local climatic condition particularly with respect to the change in rainfall pattern, temperature increase during their lifetimes as well as the impact due climatic related risk and disaster.

Changes in Rainfall Pattern

It was reported that the rainfall has also fluctuated in amount and it has also shifted in time. People compared the frequencies and amount of the rainfall, that they have noticed in their life time. Mr. Bhubhan Limbu of 82 years, a local resident of Namsaling, shared his experience as follows:

"I came here from Dhankuta village and continuously living here since 1960s AD. At my early period, enough rainfall (in winter / summer) used to be prevailing in this place. For ten years, the winter rainfall is almost rare whereas the summer monsoon is also uncertain. Sometimes it falls heavily and sometimes it does not. In addition, due to fluctuated monsoon, the production of rice reduced to half in amount. It directly affected in vegetable and fruits production."

Changes in Temperature

Like change in the rainfall pattern, there are changes in temperature of their area. Namsaling lies at the attitude of 500 meters to 2020 meters above sea level. The informants claimed that the place is getting warmer in comparison to the past days. According to them the days and nights in the winter seasons used to be very cold in the past. But during recent years, they are experiencing less cold winter days and nights. Similarly during summer season, the days and nights are becoming hotter according to them. Mr Chandra Bahadur Rai of 71 years said, “Until 2007, I would use thick woolen blanket in winter night, but now it is not needed.” In Namsaling, Krishna Dahal (52) shared his experiences about change in climate as other informants did according to him: “Generally, in the past the winter season last with the start of March (2nd week of the Falgun), but now-a-days it has become hotter after the second week of February the (end of Magh). It creates difficulty in working in the field. For past ten years, we have changed our working time, we have began to work in the morning and the evening instead of the daytime which we used do in past."

From the above illustrations it is clear that people have their own way of understanding about the phenomena happening in their surroundings. They frame their understanding in relation to the activities they have performed the course of their existence. From the above mentioned narratives, it is clear that people have been observing & knowing the change in their environment. They offer an alternative way to explain the change than scientific explanation.

3.2 Exploring Local Knowledge

The Namsaling area belongs to different communities having rural life ways and cultural practices differently. These community groups have different knowledge and experiences about orange production and climate change. They follow the traditional knowledge and practices in the social world based on class, gender, occupation, education and geographical condition too. In each community female only were involved in domestic activities and caring garden vegetable whereas male were also involved in different activities. But female were found to know more than male because they were much devoted to agriculture production activity for their subsistence life styles. On the basis of their activity they knew well about the seasonal changes in the ground. People think that the rain and temperature play key role for the growth, vegetation production and so on. But the untimely rain has negative changes than positive. The traditional system of rural people is under the challenge of local weather and climate in its natural system. Local knowledge is different because different people have different knowledge, different experience in life. Therefore, local knowledge is different in terms of class, gender and education. Local knowledge on climate change is studied on the basis of these major variables i.e., class, gender and education.

Class and Local Knowledge on Climate Change

The categorization between the classes is often difficult because there are no official guidelines to adhere to. In this paper the categorization between these groups is strictly on the basis of their income sources. Due to the limitations of their income, or lack thereof, there are some patterns that can be discerned, especially in regard to lifestyle and spending. The questions have been asked to job holder who also have orange orchard and lower class people who depend on orange. An informant said that: "My house is in Ilam and I have a job at District Agriculture Office. I also have my home and orange orchard in Namsaling as well. I have kept some people to look after my home and orchard here. What to say orange production is not as before. However it yields enough to sustain my family. The taste of orange is not sweet as that of earlier time." And another respondent who is local resident and teacher of local school said that: "I am a teacher in Namsaling school. I had planted orange trees in about 20-21 *ropani* land. Before (2014 AD) orange used to give good income but now-a-day orange trees hardly give any produce. I am making my mind to replace orange orchard by cardamom. Orange trees now become firewood." One local farmer whose main income is orange production said that: "I am orange farmer the main income of my home is orange farming. This is my ancestral profession. Its income used to sustain all the expenses of family including the study of my children. However from some years now it is difficult to sustain my family from the income of orange. In spite of all good care orange trees have declined to yield good produce. I can't think of replacing it as I have invested a lot of capital and time in an orange. I am in dilemma what to do and what not to do."

Gender and Local Knowledge on Climate Change
In the case of gender local knowledge is also different. This paper revealed a close connection between the ways people perceive the weather and both their tasks of work and modes of travel. Because men and women often engage in different tasks, their perception differs accordingly. Men move more and visit different place, engaged in different seminar, program and also engaged in business. But women spend more time in house, the growth of garden vegetables and well-being of children. A male (aged 50) narrated his experience about the orange production: "The no yielding of orange is due to climate change. Now a day temperature has increased a lot. It is not only with us all over the village you find this change in temperature is still exception. All around it is the same. In the damp area it is little good. But in the sunny area plants have started to die." One woman who always worked on orange orchard (aged 45) said that: "I don't know the reason of not fruitation of orange. I have more care then before, providing fertilizer time, managing irrigation. Even so there is no orange fruitation. In the past it was nice area without much care trees would give full tree yield. I don't know what has happened now."

Education and Local Knowledge on Climate Change
Education is the process of facilitating learning, or the acquisition of knowledge, skills, values, belief, and habits. Education can take place in formal or informal settings and any experience that has a formative effect on the way one thinks, feels, or acts may be considered educational. For this paper education means formal education received from school. This concept has been used because education also affects the local knowledge generating system. Ram Bahadur Dhakal (+2 passed) interpreted that: "My medium knowledge says that it is due to climate change that orange production is decreasing. There is no appropriate environment for orange trees as temperature has increased. This is the reason of reduction of orange production every year". Conscious and educated people are aware of the changing climate and they consult to the concerned authorities as well. And they do have adaptation mechanism to cope with the changing climate. On the other hand less or none educated people are affected by the change of climate. They have unknown that their orange production is declining due to the environmental change. This indicates that in both type of people there is different kind of knowledge generating system. The first category of people have scientific way of generating knowledge while the second category of the people have believed that god has greater role to play in the production of orange.

3.3 Adaptive Strategies of Orange Farmers' in Namsaling

Adoptive capacity is the potential or ability of a system to reason or community to adopt by adjusting to, moderating the potential damages of taking advantage of opportunities by or coping with the effects of global climate change. The changing climate has caused severe impact on their tradition agriculture crops. Therefore in order to cope with such change people have modified their crops. In Namsaling currently, people have changed their growing crops, chayote (*iskus)* and cardamom planted rather than orange in their field. Some of the farmers have cultivated millet in their entire field and have succeeded to make their strong source of income from it. One respondent aged 58 year's resident of the Namsaling shared his planed: "I had done orange farming in 24 *ropani* land. In the beginning it gave very good return. But in the last 2-3 years orange production has dramatically decreased. So, I have planted *salakpuray* cardamom in between the lines of orange trees. I have good income from cardamom." Indeed, the local farmers of Namsaling have taken *salakpuray* cardamom (dry-land cardamom) as an alternative of orange production. It was reported that *salakpuray* cardamom needs less care then orange but gives good income.

Source: Field Visit 2018

4. Conclusion

In sum, climate change in the study area is happening issue. Due to climate change there is change in rainfall pattern and there is also increase in the number of pesticides in the study area. Climate change has several impacts in the livelihood of the local people. The people of the study area are found to have felt significant change in climatic parameters such as temperature, rainfall and weather throughout their life experience. The plantation area, production, local plants species and other available resources are drying and declining. Such Climatic uncertainties bring challenges on the life of people and compel to respond according to the climatic condition; they have changed their living strategies in this area. It is noted that the rainfall has also fluctuated in amount and it has also shifted in time. The ratio of temperature is increasing highly.

Climate change directly hits orange production and local people of Namsaling village follow local adaptive strategies to cope with climate induced risks. Climatic conditions have become more critical for people's livelihood. When orange production declines some farmers have easily shifted their farming, they started to plan cardamom, *Amleso, iskus*, wheat etc. But some farmer could not easily shift over to other crops because of massive start up investment for trees nurtured.

From this study it becomes clear that climate change in this area is occurring. The community is already experiencing the change in temperature and rainfall patterns for past 15 years. This was supported by indicators such as decrease in rainfall, shifting of monsoons, warmer winters, and increasing decreasing rainfall within short duration, long drought, soil erosion, landslides and outbreaks of pests and diseases. The impact of such change in climate condition is seen in the present and may cause severe impact on the livelihood of the community especially on the agriculture production and its income. Though many people of the community have not heard the term 'climate change', they are quite aware of the phenomena. They have felt significant change in climatic parameters such as temperature, rainfall and weather throughout their life experiences over the period. The impact on climatic risk and disasters hits them, their existing socio-cultural and economic system. In addition, it helps to elicit the information on how people observe these phenomena and ultimately help to trace the people's perception on the ongoing climatic events.

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Forestry Practices for Climate Change Adaptation Forestry in Kalikot District, Nepal

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Abstract: Hilly areas of Nepal are highly vulnerable to climate-induced hazards, which further challenges the livelihood withstand. Livelihood of community in hilly areas depends on forest resources where forestry practices are believed to ameliorate climate vulnerability by enhancing the adaptive capacity. This study was conducted in the Pachaljharana Rural Municipality of the Kalikot district to explore the potentiality of forestry practices for climate change adaptation. Interviews, group discussions, and consultations with the local body were conducted for the study. The collected data includes sensitization on climate change and climatic issues, identification of major hazards, pointing out of activities to adapt against climatic hazards and need of forestry practices. Only 30% of the respondents were aware about climate change and its consequences. Drought, landslides, forest fire, diseases and pest on agricultural crops and livestock, hailstorm and soil erosion are major climatic hazards in the study area. Drought is the most problematic one. More than 38% of adaptation activities are forestry-based that includes plantation of bamboos, promoting extension education on control of forest fire, fruits trees (Apple, Walnut) plantation for income generation, bio-engineering techniques, strengthening existing community and leasehold forests, plantation of pines in denuded hills etc. Forestry practices are mostly preferred as they are locally viable (>14%), technically (>9%) and ecologically (>12%) accepted. With very limited knowledge on impacts of climate change and few adaptation options available, practices linked with forestry are mostly preferred where forestry practices will not only reduce vulnerability of communities, but also increase their resilience by diversifying the income sources.

Keywords: *Forest crops, Hazards, Resilience, Vulnerability*

1. Introduction

Climate is changing rapidly; rate of change is unprecedented defying every year with its notorious effects on diverge fields like lives, livelihoods, health, ecosystems and species composition, economic, social and cultural assets and infrastructures globally (IPCC, 2018). Impacts of climate change are more prominent in mountainous countries like Nepal with difficult physiographic locations where communities in mountain area are marginalized, have low adaptive capacity and are more dependent on subsistence agriculture and forest resources economically (Dasgupta et al., 2014; Paudel et al., 2019).

Even with negligible share of global greenhouse gas emission (0.027%; MoPE, 2016a), Nepal is likely to have extensive warming impact on its ecosystem because of highly varying altitudinal range and climatic condition within a short latitudinal extent and species migration is mostly horizontal (Lamsal et al., 2017). As epitomized by rising temperature at the annual rate of 0.04 to 0.06^0 C/yr (K.C., 2017), erratic precipitation, alterations in the pattern of fog, winds, hailstorm, shrinking of glaciers (UN, 2018), Nepal has been at the receiving end of worst climatic scenarios. This can be backed up by the fact that Nepal has been ranked as fourth in terms of relative vulnerability to climate change (MoHA, 2018). Further, the University of Notre Dame Global Adaptation (ND-GAIN) ranked Nepal 120^{th} out of 181 countries on ability to improve resilience and 136^{th} among 192 countries based on the capacity to adapt to climate change impact (UN, 2018).

The marked influences of climate change on pattern of settlements, livelihood and income in hilly areas is presaged to be complex and serious as it depends on intervening factors, which are hard to project (Dasgupta et al., 2014). In hilly areas of Nepal, forests and livelihood are intertwined in terms of forest resources use and dependence on forest for firewood, timber, grass, agricultural tools and other domestic needs as well as medicinal herbs available from non-timber forest products (NTFPs) is inevitable (Chapagain & Banjade, 2009). Increased reliance on forest for livelihood has caused negative impacts on forest area and land use pattern (Pokhrel, 2012). Thus, to reduce vulnerability of forest ecosystem, forestry practices such as reducing exposure (controlled burning, promotion of alternative source of energy), reducing sensitivity to climate change (planting resistant species, increasing water reservoirs), and maintaining resilience (applying reduced impact logging) can be implemented as sustainable forest management practices (Seppälä et al., 2009). Therefore, forest based climate change adaptation and mitigation activities need to be planned and implemented intimately since they are linked with livelihood and resilience of the community (FAO, 2010).

As around 17.4% of annual global emissions are caused by deforestation (Chaudhary et al., 2016), forests have critical role in addressing climate change and halving deforestation by 2020 would prevent the release of 3 billion tons of CO_2 per year (Virgilio & Marshall, 2009) proving forestry practices to be unavoidable in contention to climate change. Despite the fact that forest practices and climate change adaptation in hilly area are interconnected (Chapagain & Banjade, 2009), very limited studies have been conducted in mid-hills of Nepal. According to population census 2011, more than 20.59% of total population residing in hilly areas of Nepal (MoPE, 2016b) depend on forest for livelihood (FAO, 2010). However, potentialities of forestry practices in enhancing climate change resilience and adaptation have not been investigated in western mid-hill region of Nepal. In these regards, this research intends to explore major climatic hazards in the study area and identify major adaptation activities against those hazards. Similarly, this research aims to identify forestry related adaptation activities and assess effectiveness of these activities to highlight the major role of forestry practices in combating climatic stress in the Kalikot district of Nepal.

2. Data and Methods

2.1 Study Area

This study was carried out in Pachaljharana Rural Municipality, ward no. 9 (Former Nanikot VDC ward no. 8 and 9) of Kalikot district in Nepal. Situated in between 29.173° N latitude and 81.430° E longitude, this ward has total population of 1159 residing in a total of 139 households, as provided by the Nepal Census, 2011. Ethnicity of population this area is dominated by the marginalized (Dalits) communities (112 out of 139 HHs).

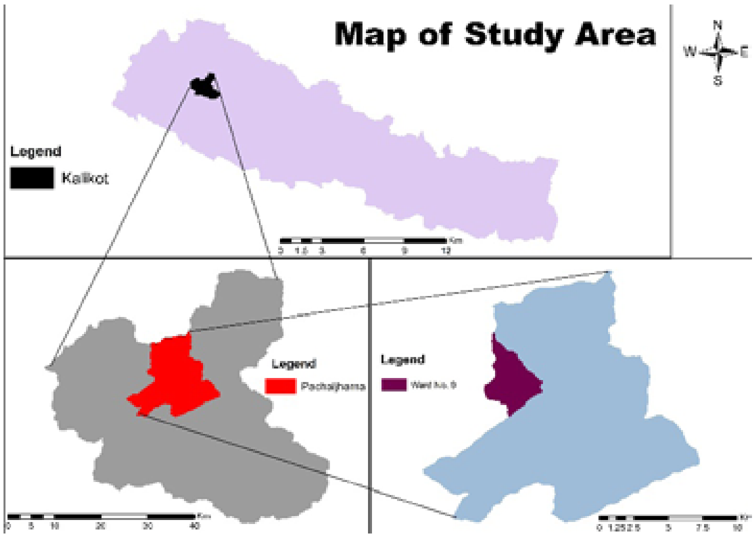


Figure 1. Map of Study Area

2.2 Methods

Precipitation data for the period of 1986 to 2017 A.D. of Pachaljharana-9 was extrapolated from nearby station namely Raskot and Thirpu (two station on either side of ward). Monthly data were estimateded by averaging monthly precipitation from 1986-2017 and temperature data available at www.climate-data.org, and total annual precipitation trend was also analyzed.

Both qualitative and quantitative data for this study were collected in October-November 2018. Major methods employed were key informant interviews (KIIs), focus group discussion (FGD) and meeting and discussion with ward executive committee. 10 Focus group discussion with at least 5 members including representation from females and marginalized group on each focus group was held, 32 key informants from different sectors (agriculture, forest, water supply and management, health and sanitation, schools/colleges, social leaders etc.) were interviewed and extensive meeting with ward executive committee was conducted. Primary data collection was mainly concentrated on sensitization on climate change and climatic issues, identification of major hazards, pointing out of activities to adapt against climatic hazards and need of forestry practices.

Climate Change sensitization involved environment setting for the research with disseminating basic ideas of climate change to local people simply in the way they understand it. This process of sensitization provided foundation for extracting key information regarding change in climatic scenario of the study area over the period of time. Information obtained from KIIs and informal interviews were validated through triangulation during FGDs. Besides, intensive field visits to analyze present situation of study area and climatic diagram were presented to local communities to identify major impacts of climate change and its trends, and adaptation activities adopted in different period of time. Climate induced hazards were measured with level of influences on three pillars of sustainability. Hazards having high impacts were assigned with high value whereas low value was assigned to hazards having least influences. Similarly, changes on the hazard level were also identified and mapped. Finally, effectiveness of forest-based adaptation options were measured in their potentiality to reduce the specific hazards. Information collected through both primary and secondary sources were analyzed and presented in tables, bar charts, pie chart etc.

3. Results and Discussion

In the study area, temperature was observed highest on the month of May and June (Figure 1) whereas average precipitation was found to be 863 mm/yr for 32 years (Figure 2). Precipitation rate was changed drastically from 2008 (Figure 2) and the intensity of rainfall was observed high in one month while low or no rainfall was observed rest of the month (Figure 3). More importantly, forest fire starts in early November and ends in late March, whereas flood/ landslides are recorded in early April to mid-May even though highest precipitation was observed in month of August.

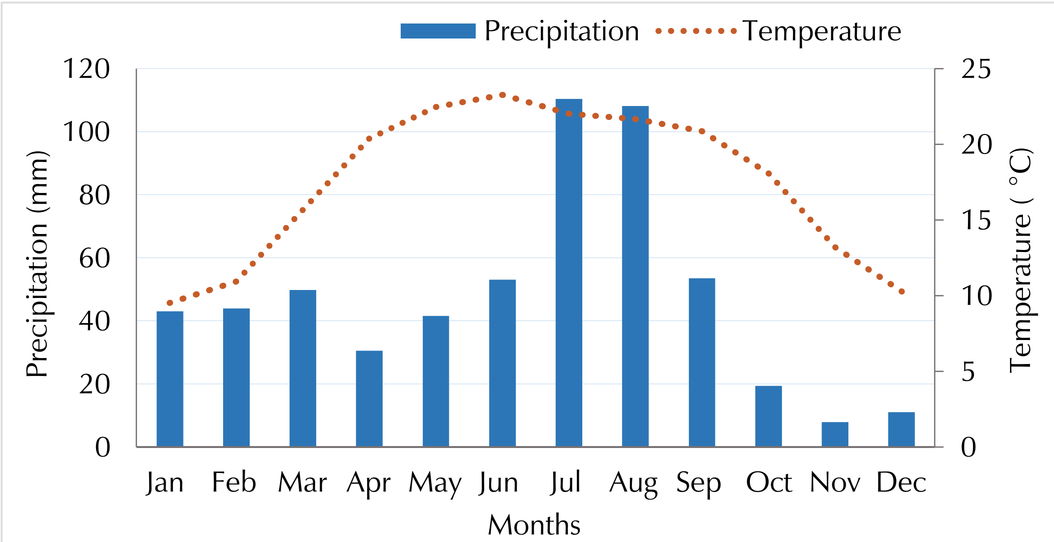
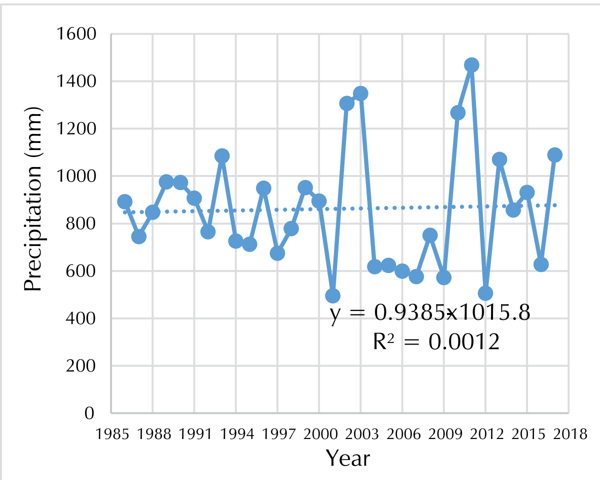


Figure 2. Temperature and precipitation of Pachaljharana (Nanikot).



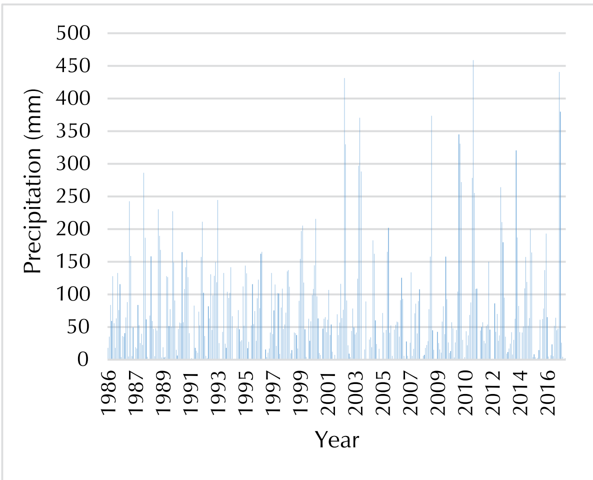


Figure 3. Total Precipitation trend in the study site. **Figure 4.** Monthly precipitation distribution form 1986-2017.

Prior to sensitization, response of local communities about climate change was recorded. The result showed that about 30% of the total respondents were aware about climate change and its impacts while 65% of them were unknown and 5% of them did not respond (Figure 5).

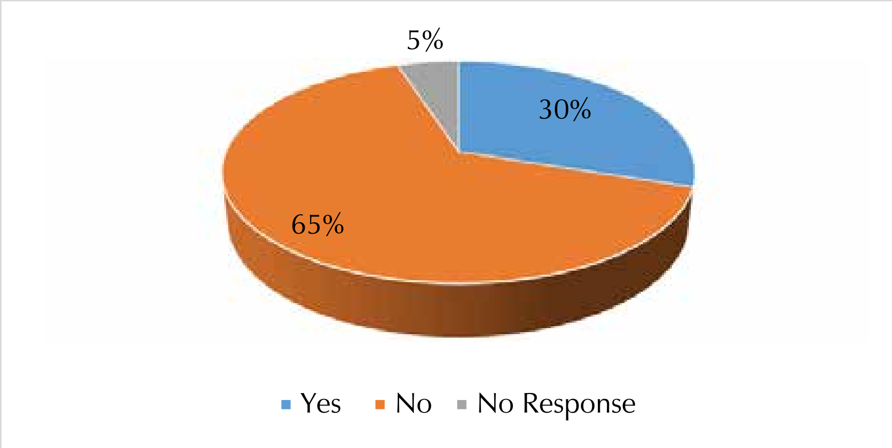


Figure 5. Response on knowledge of climate change and its impacts.

Inadequate information among the professionals both at governmental and non-governmental level is hindering the establishment of relationship between Climate Change and disasters such as droughts, landslides, floods, and cold and heat waves (USAID, 2017). This problem seems to be more conspicuous both at grass roots and at national level and even poor and unclear knowledge is prevailing among poor rural community (Gurung & Bhandari, 2009). In order to invigorate communities and households (HHs) to adjust on ongoing and future climate changes, improved understanding of the ominous risks is urgent (Tiwari et al., 2014). Chaudhary et al. (2011) concluded that majority of local communities in Himalaya regions of Nepal have knowledge on climate change and its impacts, however level of knowledge varies with localities and infrastructure development activities. Kalikot district is one of the least developed and remote districts in Nepal where facilities and services on education are inadequate and concern for food security is pressing hard (MALMC, 2018).

The major climate hazards of the study area were found to be drought, landslide, hailstorm, disease and pest on crops, livestock disease, soil erosion, forest fire and invasive species. By measuring the influences on three pillars of sustainability, drought was found to be most problematic hazard of all followed by disease and pest on crops, livestock disease, landslide, forest fire, soil erosion, and invasive species (Table 1).

Table 1. Ranking of identified hazard in study area.

Hazards	Pillars of sustainability			Value
	Impacts on Environment	Impacts on socio-culture	Impacts on economy	
Drought	I	NC	I	8
Flood/Landslide	I	NC	NC	4
Hailstorm	NC	NC	NC	3
Disease and pest on crop	NC	I	I	7
Disease to livestock	NC	I	I	6
Soil Erosion	I	I	I	3
Forest Fires	I	NC	NC	5
Invasive Species	NC	NC	NC	3
Note	Level of influence: Red-High; Yellow-Medium; Low-Green Value of influence: High-3; Medium-2, low-1 Trend on hazards: I- Increasing; NC- No change			

Natural disasters like drought, forest fires, landslides and floods are very common in highly vulnerable mountain landscape of Nepal (KC, 2017). Drought is most common in Nepal due to irregular rainfall pattern and low water retention capacity of the field. Low amount of rainfall combined with lack of adequate irrigation facilities exacerbates the effects of drought on crop resulting new diseases and pests in the region along with providing ideal condition for forest fire (Singh et al., 2011). Climatic impacts have affected the agriculture production by introduction of new diseases and pests on crops, drying roots of rice, permanent wilting of agriculture crops etc. Prolonged drought and long dry period with high temperature along with dryland and dry air in annual grass dominant area provides ideal condition for forest fire in hilly region of Nepal (Chapagain & Banjade, 2009). In Study site, hills were mainly covered by grass where forest fire was recorded in November. According to local community, main causes of forest fire are minimum rainfall and lack of trees cover in hills (covered by grasses). Complex topography and low livelihood status within this small territory renders it vulnerability to climate change (MoE, 2010). Since impact of Climate Change in a locality is a product of diverse factors including the intensity of climate change, geological conditions, geographical location, socio‐political and economic factors, coping and adaptation strategies demand integrated approaches, both within and between the natural ecosystem and the socioeconomic system (Gurung & Bhandari, 2009).

Possible adaptation options were identified in order to overcome the hazards. Adaptation option for each identified hazard (Table 1) were identified, discussed and selected. Various adaptation options were identified in response to combating the serious effects of Climate Change. Major adaptation options extracted from the field are shown in the tabular form as in Table 2.

Table 2. Major hazards and identified adaptation options.

Hazards	Adaptation Options
Drought	Water source conservation, Water recharge ponds, Irrigation canals, Sprinkle irrigation, Promotion as chilli pocket zone
Flood/Landslide	Bio-Engineering, Retaining walls, Gabion walls, Plantation of species like bamboo, Pinus
Hailstorm	Use of Green-house technique for off-seasonal vegetable production, Training
Disease and Pest on Agricultural Crops	Use of resistant seeds, Crop rotation, Trainings on organic insecticide preparation, Supervision of agricultural technician
Disease to livestock	Shed improvement, Hygiene extension programs, Livestock technician, Livestock health camp
Soil Erosion	Terrace improvement, Plantation of fodder and grass species in the terrace raiser
Forest Fire	Extension education, Firefighting training and equipment
Invasive Species	Conversion to compost manure and charcoal

The need and options available for adaptation depends on frequency and intensity of disasters (Chaudhary et al., 2011), however coupled with poor infrastructure and a weak economy pose a severe threat to implementation of identified infrastructure especially in the Karnali region of Nepal. People in mountain area of Nepal have limited access to the technologies and services, so they choose adaptation activities based on local technologies and indigenous knowledge (Paudel & Kafle, 2012). The linkage between forests and adaptation is two-fold: first, adaptation is needed for forests and forest-dependent people; second, forests play a role in adaptation of the broader society (Locatelli et al., 2010). Support systems and better planning are some of important things to be considered in local preparedness for reducing vulnerability and enhancing resilience (Chaudhary & Aryal, 2009), however selection of adaptation options is sometimes difficult because of uncertainties regarding projections of future climate change (Guariguata et al., 2008).

For the study area, categorization of identified adaptation activities into different thematic area shows majority of the adaptation options were related to the forest and biodiversity (39%) followed by agriculture and food security (28%), water sources and alternative energy (22%) and infrastructures (11%; Figure 6).

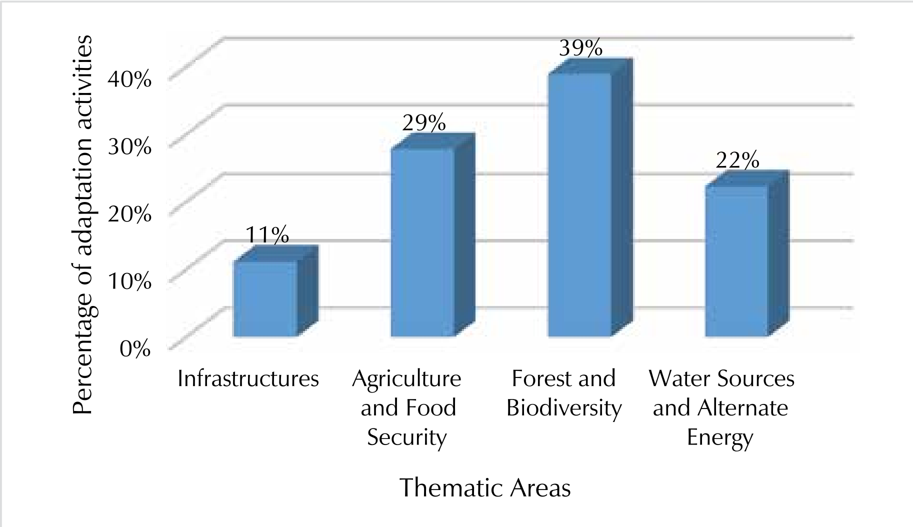


Figure 6. Clustering of identified potential adaptation activities in the study area.

Nepal has an enormous forest resources, which can help in mitigating the adverse impacts of climate change, reducing poverty, and supporting economic development (MoE, 2010). Community forestry has been one of the most successful natural resource management programs in Nepal in terms of restoring degraded land and habitats, conserving biodiversity, increasing supply of forest products, empowering of women, poor and the disadvantaged groups, generating rural income, and developing human resources (Shrestha et al., 2010). Experiences from community forest management have provided enough evidence that forest management in Nepal have the potential to sequester huge amount of carbon and enhance the resilience of community against climatic disasters (MoE, 2010), however other forest based practices such as agroforestry, private forestry are playing crucial role to adapt against climatic hazards in hilly areas of Nepal (Paudel et al., 2019).

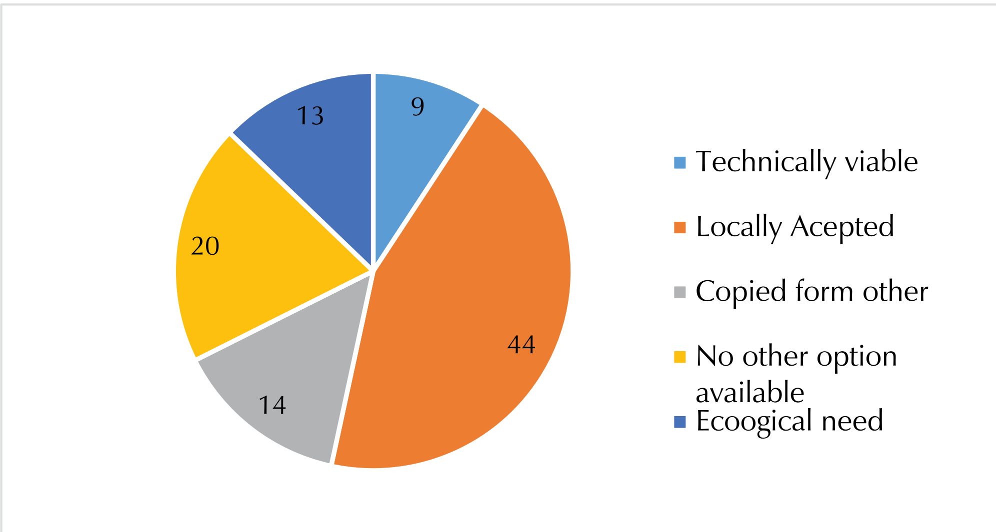


Figure 7. Reasons behind selecting forest-based adaptation activities.

The major forest based adaptation practices that are identified to tackle climate change impacts were discussed and reason behind their selection was documented. Most of the respondents, 44% believed forest practices to be plausible as it is locally accepted. Very few people believed it to be technically viable (9%), however around 20% were selecting forest based adaptation options as they copy form neighbor VDC (Figure 7).

Plantation of bamboo, Pinus etc., promotion of community forest, plantation of fodder and grass species in terrace raiser are in urgent need to be practiced in order to combat drought hazards specifically. To overcome forest fire, which caused havoc situation in the area, forest firefighting equipment along with necessary trainings has to be made available. Further, forest management trainings need to be focused on. To compensate the loss from invasive species, conversion of those species into manure and charcoal has to be done in order to utilize them sustainably. Besides bioengineering, some other extension program needs to be implemented. All these possible forest practices will either directly or indirectly play vital role in climate change adaptation as well as in mitigation. Following figure (Figure 8) shows the effectiveness of identified forest based adaptation measures against identified hazards.

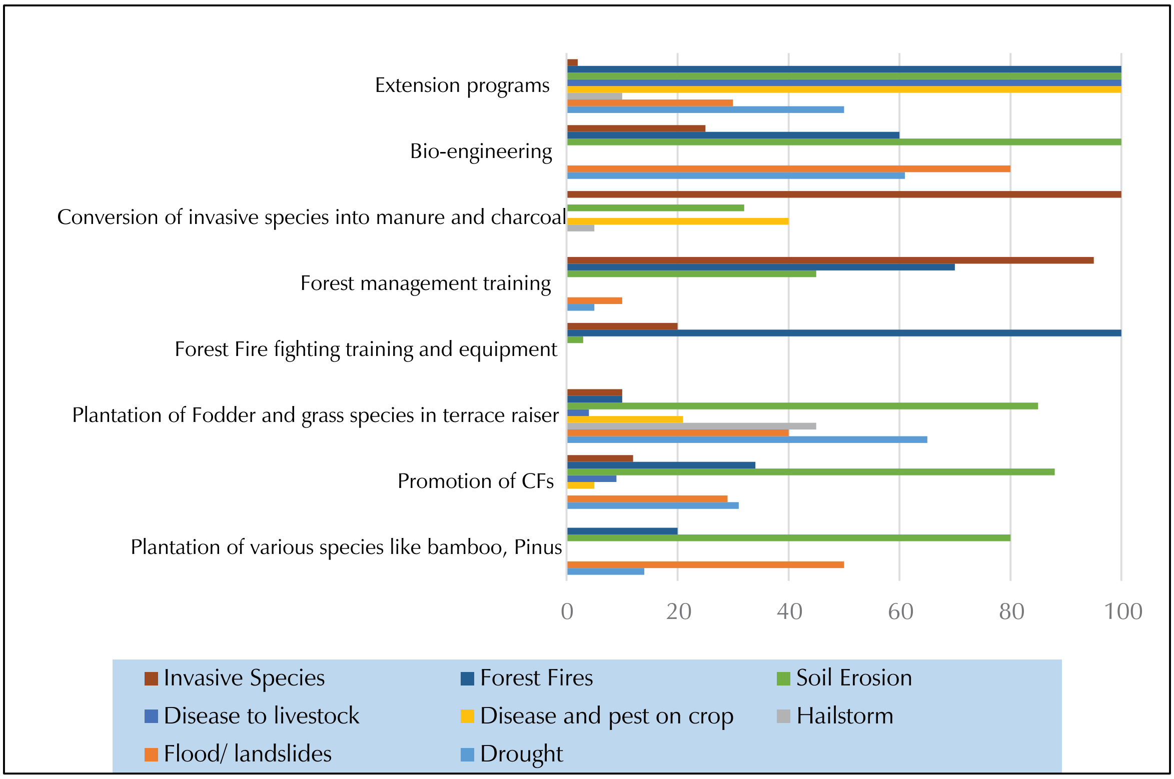


Figure 8. Forest based adaptation activities and their efficiency against hazards (%).

Bamboo is relied on heavily by some of the world's poorest people, and can be a significant pathway out of poverty (Belcher, 1995). It regulates water flows, reduces water erosion on slopes and along riverbanks, can be used to treat wastewater and can act as windbreak in shelterbelts, offering protection against storms (regulating services) and as an alternative can be used as a bio-energy resource and thus utilization for such purposes could provide additional opportunities to mitigate climate change (Yiping et al., 2010). Besides, fire awareness and educational activities are very effective tools in involving community and other groups in a fire management program and engaging the communities as responsible partners (Mathema, 2016) will ultimately help to reduce climate change effects.

Adaptation is mainly about warning people about certain events in advance and preparing them to deal with vulnerability and uncertainty (Chaudhary & Aryal, 2009). Successful adaptation reduces vulnerability to an extent that depends greatly on adaptive capacity: the ability of an affected system, region, or community to cope with the impacts and risks of climate change thus, enhancement of adaptive capacity can reduce vulnerability and promote sustainable development across many dimensions (Lama & Devkota, 2009). Though there are many forest practices that help to minimize climate change impacts, there is need to assess the vulnerability of forest-dependent communities to the changes in forests, as well as determine successful ways of adapting to those changes (Locatelli et al., 2010). Lastly, recognized forestry practices were categorized in terms of their sustainability. Majority of participants (54%) agreed that those actions would be sustainable, while 13% denied on previous facts. About 33% had no clue about the sustainability (Figure 9). Forestry practices are sustainable climate change adaptation options, however their impacts are slow but long lasting (Chapagain & Banjade, 2009).

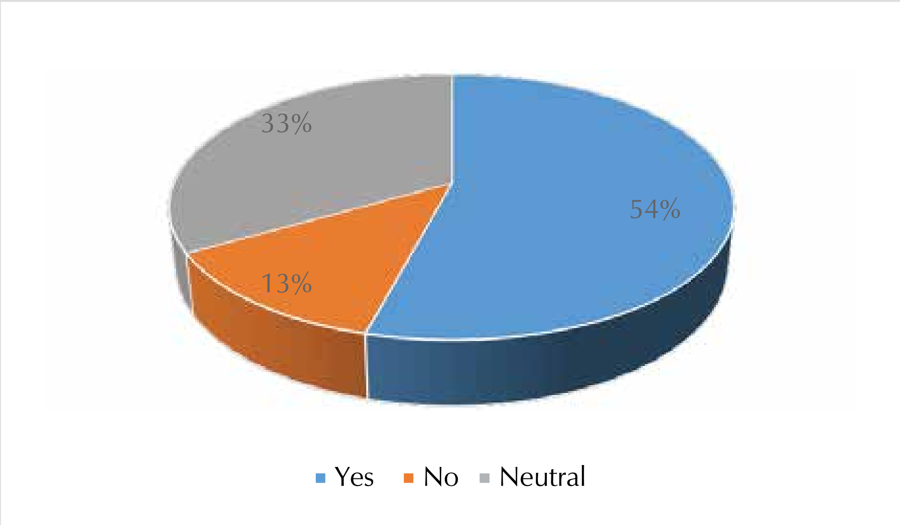


Figure 9. Perception on sustainability of forest-based adaptation practices

4. Conclusions

With emerging climate change impacts on the study area, a very few people were found to be aware on ongoing climatic change situation and a need of climate change knowledge sharing to them seems most inevitable. Major hazards reported in the area were drought, landslide/flood, diseases and pests on crops and livestock, soil erosion etc. Drought is reported as the top serious issues. These hazards can be well addressed through different adaptation activities. We underline that among many of the adaptation practices identified, forestry-related practices are the most effective and sustainable measures to adapt against climate change impacts.

5. Acknowledgement

This study would not have been possible without support from the residents of the study area. We do express our sincere thanks for their time and information without which this paper would have been nothing. We would be remiss if we do not provide vote of thanks to the anonymous reviewers who kept on effort to bring this paper in shape. We are also grateful to the officials of this ward for providing with essential information. At last we express our sincere thanks to Practical Solution Consultancy Nepal Pvt. Ltd. and Birendra B. Shahi for their help during field work.

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Addressing Climate Change and Enriching the Livelihood Through Agroforestry: A Case Study of Chepang Community in Raksirang Rural Municipality, Makwanpur

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Abstract: Agroforestry is the combination of farming practice of agriculture and forestry in the same plot of land. Changes in climate not only distort the farming practices among the Chepang of Makwanpur, who are the 51 indigenous nationalist of Nepal titled as "Praja". Agroforestry practice is the perfect way out to the Chepang of Makwanpur, familiar to farming practice in *khoriya*. This study examine that how agroforestry practices help in adopting and mitigating climate change impact and improve livelihood in Raksirang Rural municipality under newly established federal system of Nepal. Nearly 50 households (12 % of total household) in Raksirang Rural municipality (Ward number-5, Niguretar and Rawang communities) were chosen as agroforestry practioner Chepang community using the purposive sampling method. The study result revealed that due to a number of agroforestry practices such as banana (*Musa paradisiaca*), vegetables, and cereal crops are continuing to improve the livelihood of Chepang, however the overall production in farming is declining due to lack of technical supports, inadequate input support, and change in climate parameters, mainly rainfall patterns and excessive heat. Support services for the farmers in the Pallika level as per new federal structure is somehow fragile as technicians are off, inadequate, limited budget, and remoteness of the locality. The presence of development agencies are also deteriorating due to new federal structure is a challenging to the farmers, who had initiated the farming practice in *khoriya*. The study concludes that agroforestry practice is an option for adaptation and mitigation of the climate change impacts among Chepang. Local indigenous knowledge is somehow, still in practice to maintain the food security situation of the Chepang. Nutrition and dietary diversity is challenging to find out in the proper situation could be next research for Chepang. Agroforestry is less interested in the pallika and it must be on the top for the sustainable development. Bee hives and Chiuri (*Aesandra butyraceae*) practice is high in demand.

Keywords: *Agroforestry, Climate change, Chepang, Livelihood, Khoriya*

1. Introduction

According to Nepal Chepang Association, the Chepang people, also called *Praja,* which are regarded as the most marginalized, and resource poor group in Nepal, they are hunter and gathers (NCA, 2013). Manahari Development Institute stated that the Chepang are one of the 59 groups of indigenous peoples of Nepal have practiced shifting cultivation or *khoriya* for centuries, they are reside and working in the sloping land as rugged and fragile (MDI, 2012). The forest is the ultimate source of food for the Chepang and other indigenous people of

North-western Makwanpur, DADO quoted that the common cereal crop of this groups are maize and millet throughout years and some are engaged in the legumes (DADO, 2015) .

According to Nair (1994), the agroforestry is the traditional practice of growing trees on farms for the benefits of the farm family. It has been in use for at least 1300 years, it not only improve the HHs food security also help in managing environment (Nair, 1993). Agroforestry is the farming practice of agriculture and forestry in the same plot of the land; it can reduce the work effect and improve the HHs food security and Livelihood through its practices (Amatya, 1999). Agroforestry practices in Nepal described in two extensive categories: farm–based and forest-based (Regmi et al., 2008).

According to Carney and Ellis, the term livelihood implies more than a way to earn a living, which goes beyond the concept of basic needs. It involves the improvement of capacity, and assets/ resources required for sustainable living (Ellis, 1999). According to UNHCR (2014), Livelihoods are series of activities that allow people to shelter the necessities of life, such as food, water, shelter and clothing and to engage into the livelihood activity, such as acquiring the knowledge, skills, social network, raw materials, and other resources to meet individual or collective needs on a sustainable basis. According to Piya (2014), through her study which was done in Chitwan district aimed to Chepang in relation to climate change that a change in climate certainly happens as a global phenomenon, the importance is the adaptation, Chepang HHs are also affected with series of Changes from the its effect (Piya et al., 2011). According to USA, Environmental Protection agency, our planet is warming and the climate is changing. People have increased the amount of CO2 in the air by 40 %, since the late 1700 (EPA, 2016).

According to NCA, Makwanpur stated that forest is somehow affected due to heat and fire generated through the effect of climate change, A change and heat in climate noticed through the impact of rainfall and flood patterns in the Makwanpur district, a series of flood in 2009 observed in different section in the district, as a result of which indigenous mainly Chepang were badly affected and many people were shifted from hills to the nearby safe location due to incessant rain and flood occurred (NCA, 2009).

A new constitution of Nepal was promulgated in September 2015, declare the country as federal republic with three autonomous governance level, the federation (National) level, the province and the local level which had an elected assembly (Kiran et al., 2017). Makwanpur district comes under Province number 3 with a total of 8 number of Gaun Pallikas (Rural municipality), 1 municipality and 1 sub metro Politian city exist. Raksirang was the most resource poor RM of the Makwanpur, where the majority of Chepang and other indigenous is high (DCC, 2018).

According to MDI (2008), Makwanpur is located in typical mid hill District in Central Nepal. Occupies the total land area of 242,600 ha with less than 7 % cultivable land. Remaining 93% land are under serious threat. Many research reports shows including (Piya et al 2014) that, climate change, deforestation, slash and burn practice, other unsustainable land use and flood/ landslide as elements that threaten the livelihood of the local. According to Rigendra Kahadka and Ukesh Man Buju, the Northwestern Makawanpur, where Chepang family live are most reliant on Khoriya farming. Earlier, the agriculture period was shorter, followed by a long forestry period (Khadka, 2010)

The vegetation grew during the fallow period was slashed and burnt that provided nutrients to the agricultural crop. Due to climate change the farming practice is little bit differ from the previous practices (MDI, 2012). Through many series of consultation revealed that the local adoptive procedure is changing day by day and farmers are more using traditional practices, seasonal food insecurity noticed (NeKSAP, 2014).

- A study highlights to the Chepang community who do agroforestry practices in the rugged and fragile land.
- Numerous agroforestry studies have been done in relation to indigenous people global and regional level but no such case study was done in case of Makwanpur district.
- North-western sector of the Makwanpur district is introduced by farm based agroforestry practice since last decade, however no such impact study relate to the agroforestry has done yet. Limited Agroforestry and Livelihood related study is done in case of Chepang community.
- Agroforestry and climate change impact study was not done in the study area.
- Majority of Chepang community and most food insecure community of Makwanpur district.
- Year after year, media and other agencies quoted that Chepang are deteriorating food stock in the agroforestry area, although number of Programme and aid was ongoing.

In addition, Raksirang RM is remotely located in the district and majority of indigenous are high following traditional socio economical practices.

The above-mentioned reason and statement brought a big research gap and comes in an action to perform a case study based research within the study area.

Hence, the following research objective were drawn based on the literature mentioned here with:

- To find out the socio economic status of Chepang community.
- To analyse the agroforestry practices and livelihood situation of the Chepang.
- To explore the climate change impact of the Chepang community in the study area.

2. Data and Methods

2.1 Study Area

Makwanpur district located in the central part of Nepal which is under Province number 3, Raksiarng Rural municipality has been selected for the study area, which is located (GPS 27.59 °N 84.86 °E)in the north western part of the district which is 2-3 hrs walking distance from the Manahari market in the Mahendra highway. The Chepang majority is the highest in the RM and agroforestry practioner majority is high in number. Out of 416 agroforestry farmers, which are the universe of the study, 50 HHs (12 %) from the agroforestry Chepang farmers also selected purposively for this study. The study was carried out in between October to November 2018.

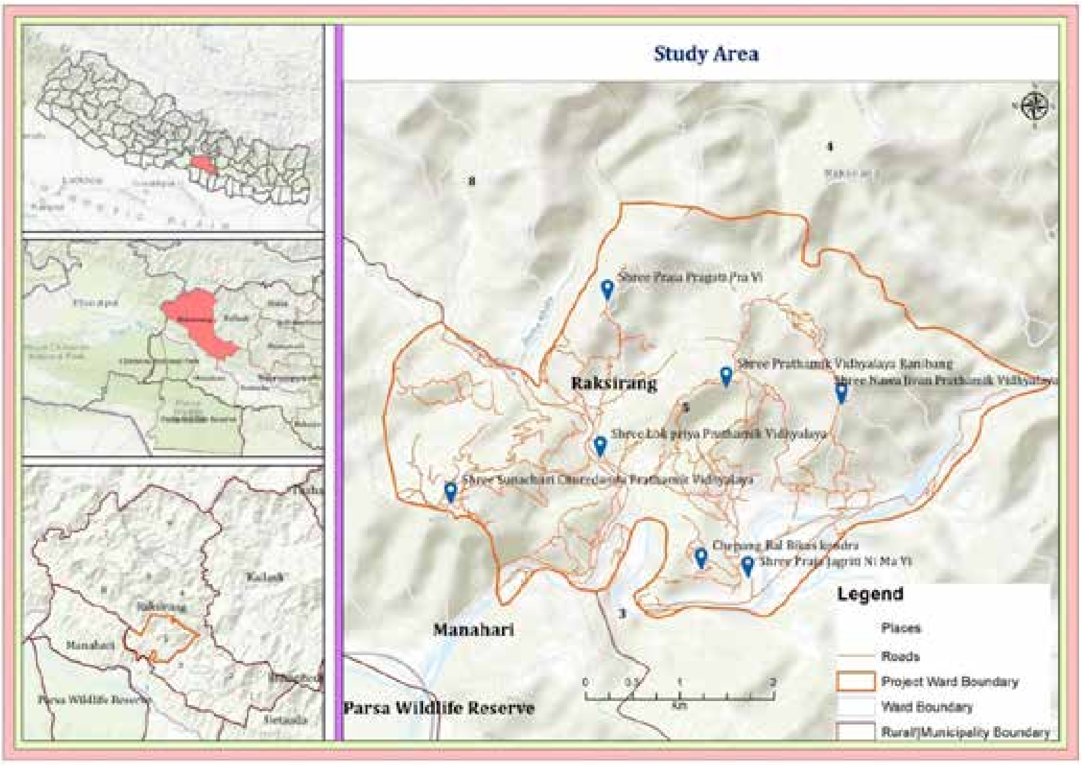

Figure 1. Study area: Raksirang Rural Municipality in Makwanpur district

2.2 Data Collection

Primary survey questionnaire for the respondents were prepared with four major sections. The sections are general information, socio economical, agroforestry, livelihood and climate change.

The observation check list with five major section were designed to analysis the fact of observation, Crop situation, road network, HHs assets including tap, defecation and other visible items were observed, livelihood and food security were cross through observation format such as stock, cloths, availability of inputs, water etc.

In depth, interview and KII (Key Informant Interview) were conducted with various line agencies members such as pallika sectorial officers from agriculture, livestock, health and forest, interview were led with Nepal Chepang Association, MDI and many development agencies to cross-examine the facts for the agroforestry and climate change effects.

A FGD with 8 members in the 4 different locations (2 from Niguretar and 2 from Rawang) were conducted with standard questionnaire of open questions. This also comes in effect to analyse the descriptive description of the study area through a collective mode. The FGD illustrated the market trend, study, food security, livelihood, climate change adaptation, traditional way of living and so on through a systematic manner.

2.3 Data Analysis

The reliability and validity of instruments tested through pilot test, five questionnaires were tested in the nearby community of Raksirang and the validity were verified through Cronbach's Alpha test. The test generated a value of 0.79, which is reliable from the statistical manners.

Similarly, SPSS software was used to analyse and interpreted the data within the data system, later on the value and table were made through the help of excel sheet respectively.

Since, the study is descriptive analysis of Chepang with agroforestry practices not much deals with a series of test, instead, mean, median, mode and Standard Deviation, Frequency with different graphs were used to interpretive the data in simple manners.

3. Results

3.1 Socio economic status

Table 1. Analysis on summary of land and livestock detail of Chepang respondents

Type	N	Minimum	Maximum	Mean	Std. Deviation
a) Land (Kattha)					
Registered	39	1	15	3.5	2.5
Unregistered	47	1	15	4.8	3.8
Lease/ Kabuliyat	9	1	10	3.3	2.6
Khoriya/ Forest	16	1	5	3.2	1.5
b) Livestock (Number)					
Goat	50	2	25	7.2	4.4
Cow/ OX/ Buffalo	47	2	5	3.6	1.1
Pig	25	1	6	1.7	1.3
Poultry	50	1	18	8.3	3.7

The mean value of unregistered land (Table 1) is higher compare to the registered land, lease land respectively, the reason behind the higher number is none other than the uses of uplands which has not registered in papers are Chepang have privilege to do farming on the land, on the other hand khoriya lands are also not legally registered. Many farmers from the study area found that engaged in the lease land through individual and users groups.

In case of livestock, it was found that poultry and goats are found higher in the households because both are generated through a process of agroforestry practices, the number of cattle's increase, due to availability of fodders and green leaves generate through agroforestry practices.

Table 2 Analysis on various production situation of surveyed HHs in the study area.

Production summary (Yearly)	N	Minimum	Maximum	Mean	Std. Deviation
Maize	50	30	3000	419.6	462.6
Potato	6	2	40	12.8	13.7
Millet	47	1	4000	322.4	563.3
Vegetables	8	2	150	30.3	49.1
Paddy	12	2	300	204.3	74.8
Fruits	12	2	100	21.2	26.2
Wheat	1	2	2	2.0	
NTFPs	3	2	5	3.7	1.6

The production summary (Table 2) illustrated that maize mean production is higher compare to the millet and other crop. According to a study by various scholar and agency the overall mean of the study area nearby in Chitwan district is 621.2, which indicate the production is decreased compared to the last few years. Since, the 2 years back the agriculture technical offices such as DADO (District Agriculture Development Office), ASC and various agriculture projects were supporting the farmers in the western area of Makwanpur, which are no longer exist after the federal system runs but after the changing of service delivery mechanism still there are technical support mechanism and many programmes planned for the farmers but the overall production is found drop compare to last few years, The average yield of maize is 2.7 MT/ Hectares recorded from the agriculture office, somehow the production is decline due to lack of water, heat and so on which clearly indicate none other than but a climate change effect on the crop.

The FGD respondent also stated, *"Heat is increasing, water level is decreasing, rainfall pattern is also haphazard, and it is very difficult to assume the rainfall pattern"*.

Maize and millet ate the common cereal crops for the Chepang, Survey result shows that 90 % farmers planted Maize and Millet, 8 % farmers planted Maize, Millet and Paddy, 1 % planted maize, and only 1% planted Wheat. Respondents replied that Cereal: 94 % uses own seeds, 4% uses government seeds, 2 % uses INGOs seed, the vegetables which are planted in the field are Potato (*Solanum melongena L)*, Cauli flowers (*Brassica oleracea)*, reddish (*Raphanus raphanistrum)*, chilli (*Capsicum annum)* and tomato whereas planted fruits are Banana, Pineapple, Aru (Pitch), and lemon (FGD, Observation).

Most of the farmers have noticed with NTFPs plantation such as Chiuri (*Aesandra butyraceae*) , ipil-ipil (*Leucaena leucocephala)*, Bakaino, Tanki, grasses among which Chiuri are most popular and demanded in the field.

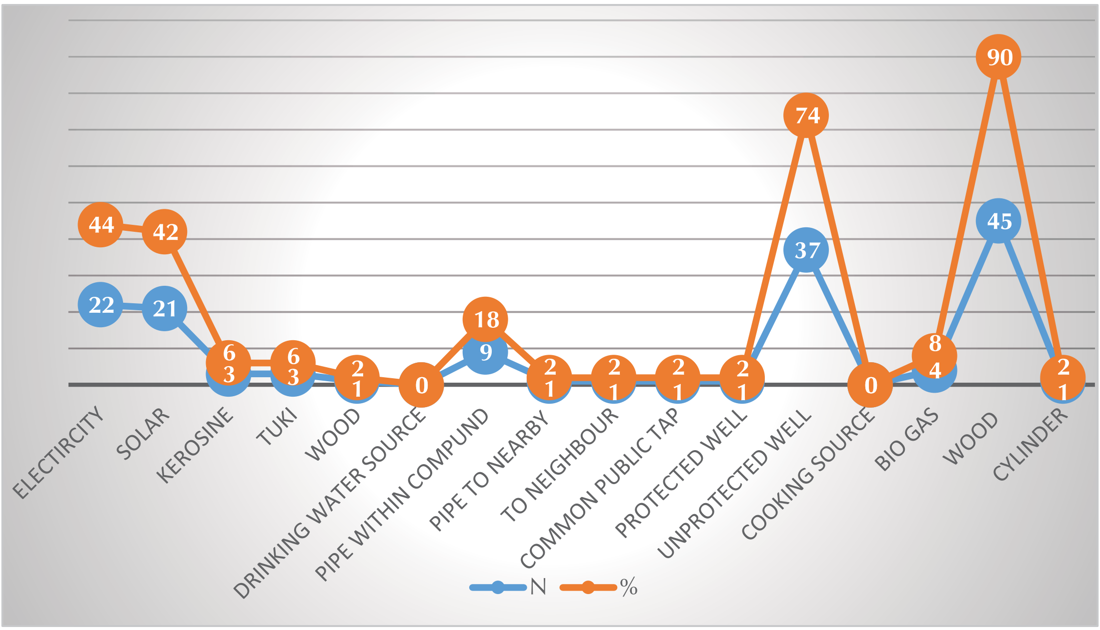

Figure 2. Analysis on summary of different sources of HHs basic needs within the study area

Wood in the highest majority (Figure 2) as a source of cooking fuel in the HHs level, In case of source of Drinking water, majority is higher to the unprotected well. In case of source of energy many solar company through development agencies have initiated the programme because of which some 42% respondents are installed with it. The source of electricity is somehow indicating sound wealth ranking of the HHs for the basic needs, whereas due to remote location, rugged and fragile land the source of water is still not adequate and reliable.

Through primary data analysis it was found that 98 % using temporary toilet with or without slab, 2 % using open defecation, in addition, the source for irrigation is higher for the rainwater as 96% have using rainwater for irrigation, 2 % Surface water and rest 2 % do through river water. A total of 96 % HHs have sale there HHs product to the nearby Manahari market, and 4 % do sale in within the village and 92 % HHs do self-carrying product to the market, only 8 % HHs production collected through traders, the road conditions are too poor and only 4-6 months roads are operation in winter and in rest of the season the road connectivity is poor.

It was also found during the HHS data analysis that more than 90 % women's and children do engaged in water collection; Some 38 % HHs have functional radio, 40 % HHs have operational mobile, 6 % HHs have functional wall clock, 4 % HHs have bench made of wood. In case of HHs assets some, 10 % HHs have sleeping bed made of wood, 2 % HHs have own sofa comes through marriage gift.

The collected data and FGD also well said that the Chepang are now days having good socio economic status however, some of the Indicators are still poor and need to review.

3.2 Relation of agroforestry and Livelihood

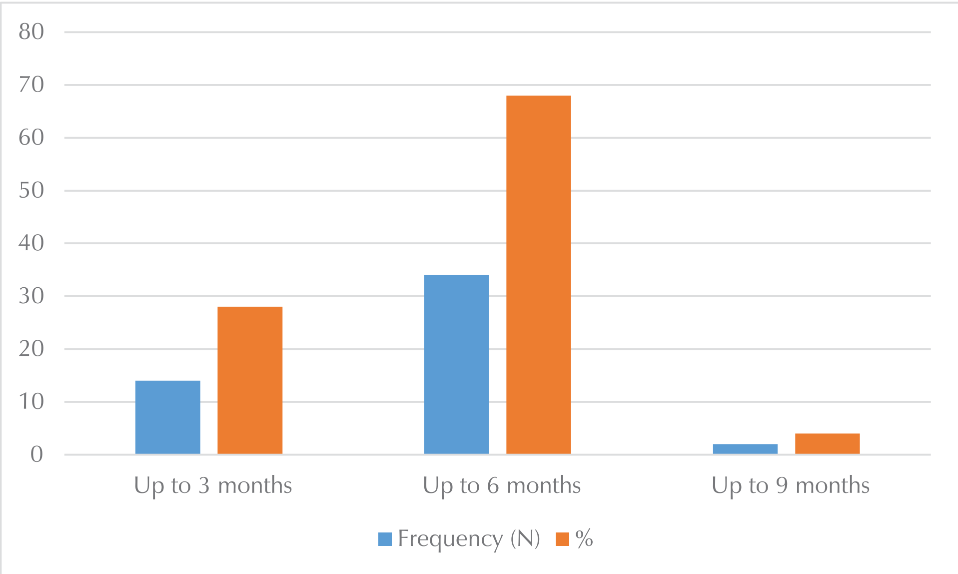

Figure 3. Analysis on status of Food self-sufficiency of the surveyed respondent throughout year.

The highest majority of surveyed HHs are 'own HHs food stock' remain for up to 6 months, the HHs food sufficiency (Figure 3) from the own cereal stock were measured through the questionnaires. It was also analysed through FGD that estimated 60 % HHs food stock self-consumed, 10 % for cattle feeding, 30 % for brewing/ liquor for business and culture (FGD, Key Informant Interview).

Through FGD and many interviews found that on Farm wage rate is 400-500 NRs/ Day whereas Off farm wage is 500-700 NRs/day, mason pay 700-800 Rs/day with food. Chepang are mostly purchased cereals-rice, maize, legumes, spices, veg oils and non-food items from the nearby Manahari markets, which are 3 to 4 hrs walking distance in both way.

In case of food consumption during food scarcity situation, Chepang noticed some local indigenous practices. According to which during a month between Chaitra to Ashad (March/ April to June/July) months show that Chepang uses wild food (Gittha, Bhyakur-Creeper) from locally available as a regular meal. This practice of wild food is more in practice used by every members of the HHs, while asking through interview many respondents have common replied that due to its taste and as part of tradition, they used and maintained their meal during off food. On other hand, it was also noticed that they buy broken rice (Kanika in Nepali) worth 25-30 NRS/kg, which is normally low-grade rice from the market and rely on that as part of traditional practices from many years ago. This is also none other than a part of coping strategy called by many researcher; Agriculture Office also agreed that Chepang do the similar activity during food scarce situation

Table 3. Analysis on status of income expenditure status of Chepang from the various sources.

Sources	N	Minimum	Maximum	Mean	Std. Deviation
Livestock	49	1000	16000	4041	3036
Agriculture	46	500	10000	4100	2709
Agroforestry	27	500	8500	4185	2271
Trade/ Business/ Remittance	41	1000	10000	5000	2156
Expenditure	50	1500	16000	7410	4151

Note:- Livestock:-Milk, goat meat, poultry, egg; Agriculture:- Cereal, legumes, vegetables and Vegetable oil only, Agroforestry:- Tree, grasses, NTFPs, Forest product, roots, tubers, Trade/ Business/ Remittance:- Social grant, brewing, off/ On wage work, shops, salary, Cash or in kind Aid etc.

Overall income from the trade/ Business and remittance (Table-3) is almost on the * higher score. The Chepang are found engaged in brewing business and many programme and interventions are operational which supporting cash and in-kind both, because of this the income is higher. On other hand, the second majority is from the sale of the agroforestry practices, since agroforestry farming has just initiated from a decade ago therefore still the tree are maturing and harvesting of NTFP and other agroforestry practices are emerging. Sale of banana, broom grassed, beehives are higher and getting an utmost income from the sale. From the livestock because poultry and goats are the common product for them to sale and continue livelihood, which also generate through agroforestry cycle, which not only generate plenty of, grassed also give wood to the HHs and manage the HHs food security. In case of agriculture income, only a calculation of legumes and vegetable are include because most of the HHs are not sale there HHs cereal (Figure 3, FGD quotation) – Which they kept for the long-term period as a security during scarcity.

The FGD also enlightened the fact "*We need technical support and continue farming programme for the sustainable development. Bee hives and Chiuri farming is reliable in the community*".

The Beehives and Chiuri are most demanded by the Chepang, which is culturally affiliated with Chepang tradition and used widely in the ritual process.

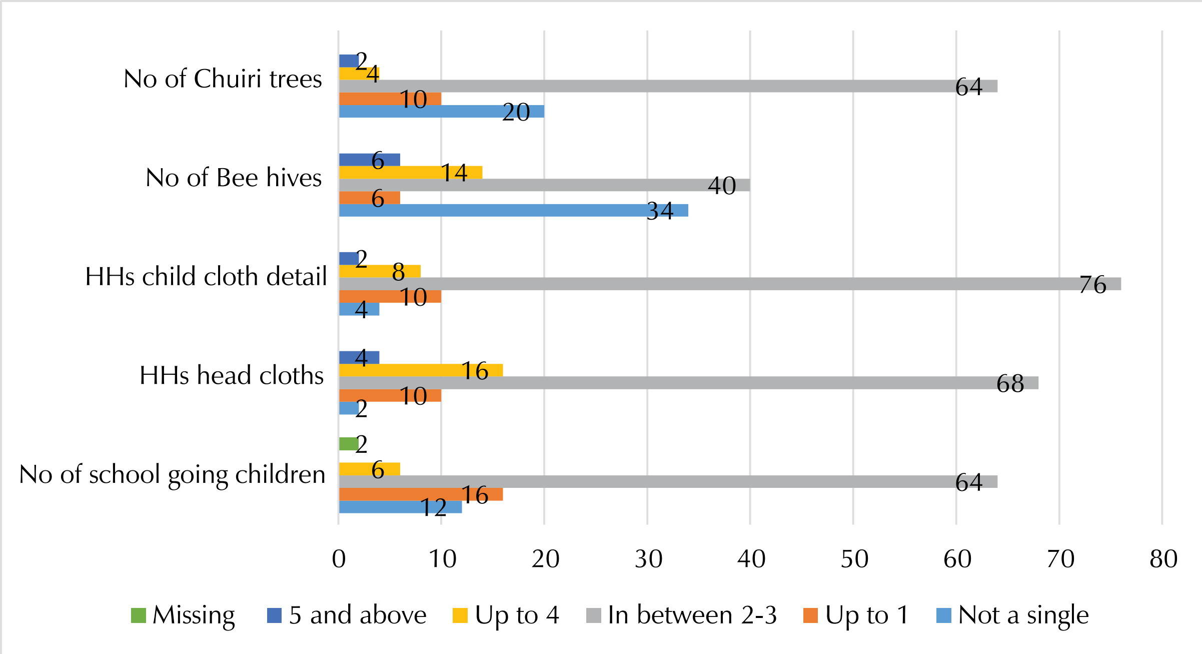

Figure 4. Analysis on livelihood summary of the surveyed Chepang within the study area

The number of Chiuri tree and Beehives (Figure 4) are higher in the field, which prove that both are potential in the context of Chepang, since Chiuri is culturally affiliated with cultural system in Chepang tradition. The Number of school going children is also found higher in the study area because number of agencies and institution have drawn an attention to go for the school, the study importance and Chepang Privilege for the school enrolment such as clothing, study materials are additional attraction in few schools.

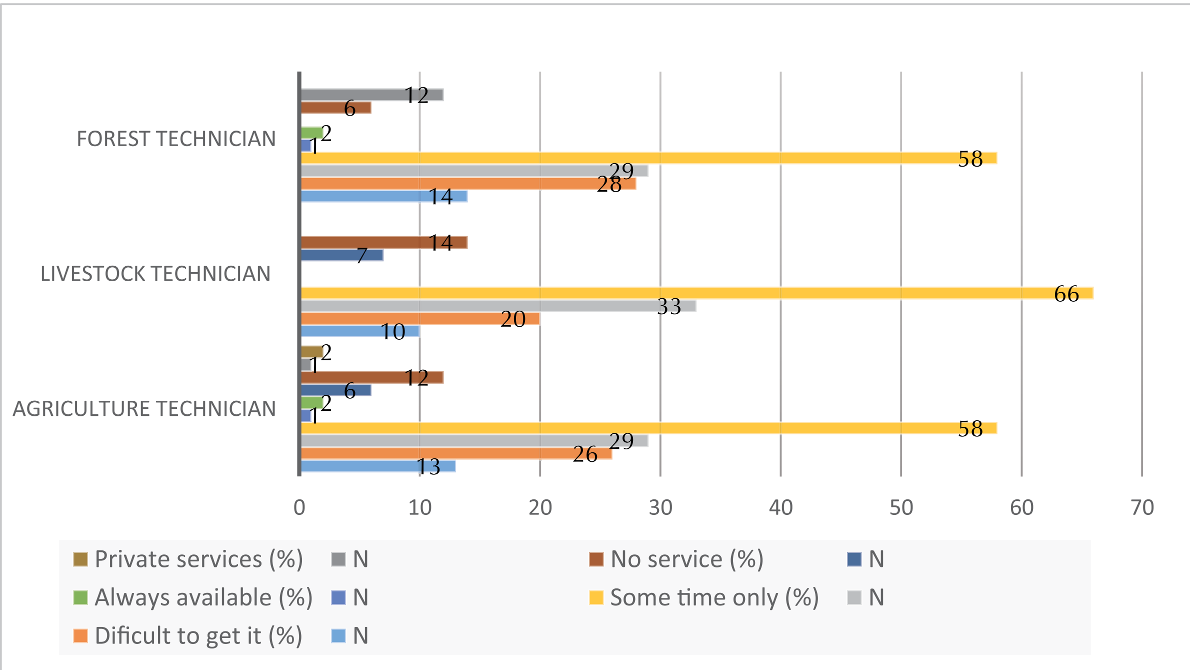

Figure 5. An analysis on responses of Chepang HHs into the status of service delivery situation

The Service delivery situation in Pallika level is not found satisfactory (Figure 5) because the majority has stated "sometimes only" in case of Forest, Livestock and Agriculture service delivery. It was also found that the RM office is located in the Chainpur settlement, which is 1.5 Hrs walking or 30 Minutes off road distance. The situation of human resources are poor due to remoteness, challenging area as well as less interest by both Pallika and technician both. The service delivery situation also not found suitable for the health sector, as an average situation of health facility and nutritional status found.

FGD participants raised the fact that *"For us no new system we have noticed in village level, earlier VDC office and NGO were called for the planning process but now we are no more included into the planning Process in the Pallika level"*.

This also verify that the farmers are no more included in the Pallika activity.

As part of sustainable development, the same group of people suggested that MUAC measurement of under 3 years child was also found in moderate condition as 66 % child's are in moderate condition, In case of Food consumption score based on the calculation of various indicators through Annual HH survey, CBS 2018 and It was also found that 36 % HHs having moderate food consumption and 12 % severe food consumption in the HHs level. The Overall food diversity pattern is also not found suitable in the field, still wild foods are on practice by the Chepang as 68 % are using it frequently and rest 32 % are using some time only, which is a part of culture for them. In scarcity, also FGD respondent stated that it helps in food scarcity situation. However, since practice of agroforestry brought them multiple option for the livelihood.

3.3 Climate Change Impacts

Table 4. Analysis on response of surveyed HHs on climate change in the Chepang area**.**

%	Yes	No	Regular	Irregular	Across the apllika	Few part in the community	Irregular in the area	Increaased	Remain same	Decreased	Low production	Excessive heat	Discontinue rainfall	Change in regular trend	Production increased
Climate Change	**88**	12													
Rainfall pattern			6	**94**											
Types of rainfall					6	**82**	12								
Temperature condition								**68**	30	2					
Water source condition									30	**70**					
Impact of climate change-1											**82**	4	12	2	
Impact of climate change-2											6	**90**	4		
Impact of climate change-3											4		8	**86**	2

The impact of climate change was found through a series of data, (Table 4) revealed that the majority of HHs are know the fact climate change as majority 88 % agreed; The rainfall pattern is somehow affected in the surveyed community, as 94 % respondents agreed in irregular rainfall pattern in the study area. The respondent added that the rainfall pattern is changed as some time partial rainfall and in the same time somewhere heavy rainfall explained by the surveyed respondents. The majority of respondents agree on the increase in temperature. The water source level also found decreased through data, farmers replied that the water level in river, source and in well in decreasing gradually. While asking the reason behind the drop of water level, farmers of FGD replied that mainly due to climate change as well as after the mega earthquake, but the water level was decreasing before earthquake.

While asking in impact, the majority of respondents agree on low production, which is the prime effect of climate change. Table 1 also illustrated the same that the maize production is down causes by one of the important reason is by climate change effect. Excessive heat and change in regular trend are the second and third most majority responses in the study area, the phenomena of excessive heat also recorded through the FGD responses mentioned in Table 1.

From the field visit it was found that farmers are now more engaged in the off/on farming activity and earning a range of 400 to 600 NRs/day, which is a change in regular trend, keeping HHs stock of own production spending amount of non-farm activity are the change trend in the surveyed area.

Through a series of study and fact obtained from the above phenomena, we can explain that the Chepang with agroforestry practices are somehow with improved livelihood. Climate change effect is also noticed in the community through the series of explanation through Table 4, since; this study was limited to the Chepang HHs with agroforestry practices. There are also numbers of other than Chepang ethnics reside in the pallika, such as Tamang, Dalit, and Magar etc. The study further proposed distinct models for the upcoming analysis of climate change or further illustration of agroforestry farming in relation to livelihood situation, a model based on this study was drawn is mentioned below.

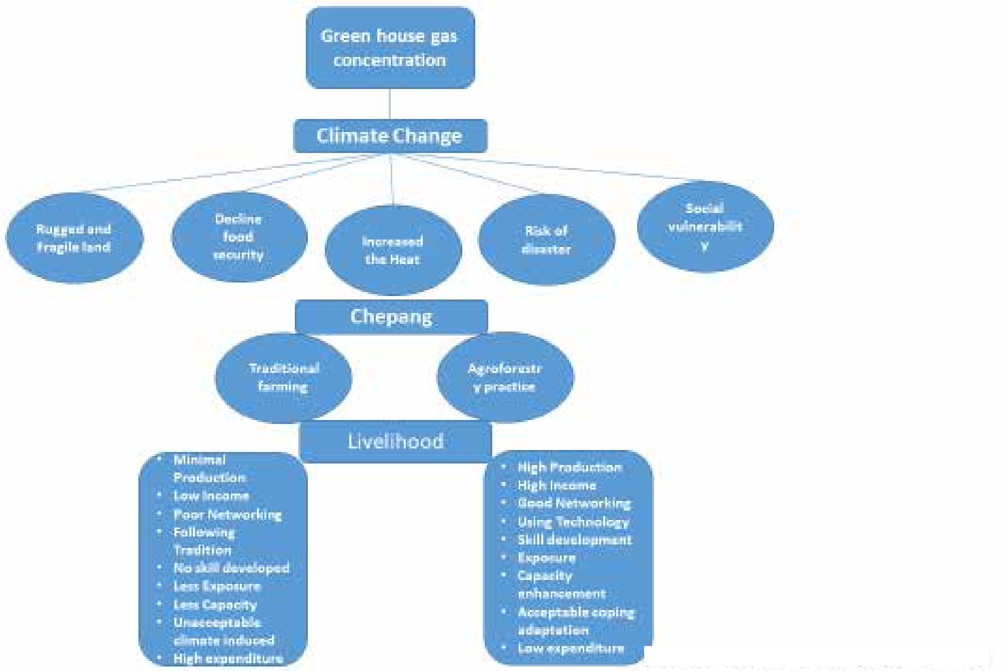

Figure 6. Proposed agroforestry and climate change model of study area in Raksirang Rural municipality.

There are number of models available in relation to the climate change and agroforestry practices globally and in regional level but a prompt model at the Pallika level in relation to agroforestry-climate change and livelihood were described here based on the study conducted above. The model shows that exceed in greenhouse gas concentration (Figure 6) stand a climate change situation. Five basic effect of climate change occurred such as rugged and fragile land, which indicate that the Chepang are more engaged with khoriya land and working in dried area, decline food security, which indicated that the effect in major four dimension of HHs food security which is availability-Stock, crop situation; Access-Market, income etc., Utilization-Nutrition, food diversity and stability means to balance all above three for long time, somehow food security in some dimension adversely affect at the HHS level in Chepang..The third component of Climate change is exceeding the heat, which is a primary reason of drop in production, and increase the pest, human disease. As a result of above three components the fourth and another important fall of climate change is disaster like flood, landslides and so on, The Chepang is affected by flood and hailstone the incidence with disaster will caused due to climate change, and lastly, is social vulnerability which deals with major social events such as life style, rights, culture and so on, so all together this will heavily affected the Chepang social life.

Therefore, the two group of Chepang with agroforestry practices or without agroforestry practices means traditional farming will show the increase or decline in livelihood situation. The agroforestry group of Chepang will have high production with satisfactory income level. Agroforestry practices found good networking and uses a technology in the farming because of which exposure, skill development training opportunity increases. The HHs racticing agroforestry found to maintained a normal or acceptable coping strategy and overall income is found higher and expenditure level is found less, overall it is called a improve in livelihood situation through agroforestry adaptation, whereas on the other hand the Chepang with traditional farming have change in livelihood situation and compare to agroforestry farmers the traditional farmers have difficulties in managing livelihood.

The model is only limited to the Chepang HHs with and without agroforestry farming because the model may work or may not in case of other ethnical groups in the study area and abroad.

4. Conclusions

Through the study and its fact were deeply analysed and the following conclusion were drawn below:

- The findings indicate that Chepang are occupying unregistered land higher than own registered a forest for the agroforestry practices.
- The study result show that overall water level for the domestic use is somehow declining due to numerous reason and climate change is prime factor for that. Overall income of Chepang also shows in favour for the agroforestry practioner.
- Food security mainly HHs foo stock varies in between 3-6 months from the own production, overall cereal production is drop compare to last year cause by numerous reason.
- Khoriya land occupancy is found higher in Chepang than registered land.
- Number of grasses, livestock, woods production has increase due to agroforestry practice this indicated that livelihood also improve compare to previous situation.
- Nutritional and food diversity are interrelated.
- Rainfall pattern is irregular; farmers have realise the change in climate.
- Temperature is increasing year after year, a change in farming practice caused by climate change.
- Respondents agreed in majority that production drop in majority caused by climate change effect. RM does not prioritised agroforestry and climate change effect.

Every study has its significance, this case study cannot be generalised the facts and figure of the entire Chepang or the fact of the entire area, although in recommendation part, three section were prescribed and drawn the recommendation, which is preside and relate with the study findings.

For Development and Policy Implication

- Technical staff are inadequate in the Pallika, Mainly agriculture, health, livestock and forest. The Pallika could hired or manage the human resource from the concern sectoral, provincial institute.
- Chepang are using Khoriya massively with or without knowing its fact, a guideline or policy should be made in local level to organised a farming practice and minimise the climate change effect.
- Land act, seriously need to be revised and make it easier to the farmers who have a knowledge of farming
- Pallika and Provincial government should encourage farmers to intervene crop, tree insurance in order to sustain the development practice.

For the Immediate Effect

- Most of the study findings, recorded that the lack of road/ seasonal network, change in climate is the basic cause of drop in production, road and traders connectivity must be sustainable.
- To lower the climate change impact:-Advanced agriculture and livestock packaging through training is essential; Agroforestry practice such as, banana, pineapple, broom grass, local trees and fruits prove themselves as most emerging in the field. However, without new plantation and continue technical support and personal motivation, livelihood condition in the study area cannot be uplifted for this women must be encouraged and inspired for the promotion of sustainable agroforestry farming in the long run.
- Beehives and Chiuri are emerging in the field since it is culturally related with the Chepang tradition, it should be promote for long term.
- Cooperative function is found less in the area; it should be functional for the farmer.

For the Forthcoming Research

- A future research for the nutritional status and food diversity is essential in the sector to in-depth analysis of nutrition status.
- Capacity and need assessment of functional rural municipality; Also a long term master plan study of Pallika is the future research
- An in-depth study on the economic status of Chepang mainly cause through number of off farm on farm wage activity is the future research.

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Effect of Soil Organic Carbon in Soil Respiration in Different Ecosystems of Annapurna Conservation Area, Nepal

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Abstract: High-resolution information on soil organic carbon from local and regional scale is required to evaluate carbon budget and improve an understanding of soil respiration as its rate across different ecosystems plays vital role in the global carbon budget. A study was conducted to measure soil carbon emission from different types of terrestrial ecosystems in the Annapurna Conservation Area and to study the effect of Soil Organic Carbon (SOM) with respect to soil moisture and soil temperature. Field survey was carried out on 27th October to 7th November 2018 in grassland of Ghandruk, forest and agriculture land of Tadhapani inside the conservation area. Soil carbon emission was measured using closed chamber method (Infrared gas analyzer) and SOM was calculated by Walkley-Black method. Soil respiration was the highest in agriculture land (127 mg $m^{-2} m^{-1}$), medium in grassland (112.10 mg $m^{-2} m^{-1}$) and the lowest in forest ecosystem (47.94 mg $m^{-2} m^{-1}$) which was positively supported by soil organic carbon, the highest in agricultural land (7.42%), medium in grassland (4.48%) and the lowest (3.96%) in forest ecosystem. Soil organic carbon was a major variable influencing CO_2 emission from terrestrial ecosystems. The top layer of 0-10 cm has high organic matter content, which gradually decreased as depth increases. Addition of compost and tillage practice caused higher soil respiration in agriculture land. Among the factors affecting SOM decomposition, temperature and soil moisture are most relevant. The average ST was detected to be lowest in forest i.e., 8.41 ºC, higher in 11.45 ºC in agriculture land and the highest 13.20 ºC in grassland. Moisture is essential for the respiration process, but if the moisture level reaches the saturation level or exceed then it starts to act as carbon sink. Soil moisture is lowest in forest, i.e., 32.8%, higher in agriculture land, i.e., 44.9% and highest in grassland, i.e., 45.7%. Grassland and forest which are natural ecosystems are more preferable in terms of carbon storage than agricultural land due to its relatively permanent soil cover. The study showed the direct correlation between soil organic matter and soil respiration which is highly influenced by soil temperature and soil moisture. Soil organic carbon stock is highly sensitive and varies along different ecosystems types, which could potentially cause release of soil carbon to atmospheric CO_2 through soil respiration.

Key words: *Soil respiration, Soil carbon emission, Terrestrial carbon emission*

1. Introduction

The release of carbon dioxide from soil as the bi-product of the respiration processes occurred within the soil is called soil respiration (R_s) which is an important terrestrial process in carbon cycle (Raich & Schlesinger, 1992). Soil is the second largest carbon sink which is estimated to contribute around 75×10^{15} gC/yr to the global carbon budget (Schlesinger & Andrew, 2000). The transfer of carbon used up the producers for growth of ecosystem to the soil through litter fall, root turnover and death of individual plants. The addition of the carbon to the forest soil is from roots of plants and leaching of dissolved organic matter (Khan, 2013).

Soil respiration relies on a suite of complex processes contributing to CO_2 efflux from soil surface, mainly from plant roots and micro-organisms (Raich & Schlesinger, 1992). Soil respiration also called belowground respiration in contrast with above ground respiration. Soil respiration has been widely simulated using continuous records of temperature, moisture, and other variables. Soil respiration may vary from 10 to 90% depending upon the vegetation type and season of the year (Hansen et al., 2000). Approximately, about 80% of the global terrestrial above ground and 40 % of the below ground carbon is contained by forest (Dixon et al., 1994). Thus, it has the great importance in global carbon budget (Pearce at al., 2003). The amount of carbon during sequestration and emission is not the highest for grasslands compared to forest, but their large land mass plays an important role in global carbon storage and cycling (Franzluebber & Weaver, 1994). Grassland and forests of high altitude protected areas also contribute in maintaining CO_2 balance in atmosphere (Grand et al., 2016). Radiative forcing of climate refers to a change in the Earth's energy balance, leading to either a warming or cooling effect. The dominant factor in the radiative forcing of climate in the industrial era is the increasing concentration of various greenhouse gases in the atmosphere (IPCC, 2007). An increase in the atmospheric concentration of carbon dioxide (CO_2) (from 280 parts per million in the pre-industrial era to 390 ppm in 2010) may attenuate radiative forcing and alter the Earth's mean temperature and precipitation (IPCC, 2007).

Improved understanding of soil respiration and its sensitivity with variables is very important to potentially mitigate the climate change by understanding global carbon cycle (Magnani et al., 2007) and enhancing soil carbon sequestration (sierra, Martinez, Verde, Martin, & Macias, 2013). Thus, high resolution information from local and regional scale is important to evaluate the soil carbon budget on global scale (TRS, 2001). The study was conducted in three different ecosystem types from Annapurna Conservation Area (ACAP) to study the impact of different variable such as soil organic carbon, soil temperature and soil moisture in soil respiration. Research work was directed with the objective to measure the soil carbon dioxide emission from grassland, forest and agriculture land with respect to its dependent variables soil moisture, soil temperature and soil organic matter; in order to predict the impact of global warming on soil respiration.

2. Data and Methods

2.1 Study Area

Annapurna Conservation Area is Nepal's largest conservation area, located in west central Nepal. It features an outstanding variety of wildlife habitats and vegetation, stretching from sub-tropical lowlands and lush temperate rhododendron forest in south to dry alpine steppe in north. It covers around 7,629 km^2, which is 5% of the total protected area i.e., 21,051 km^2 (ICIMOD, 1995). The study area lies in Kaski district, province no. 4-Gandaki, Nepal. Grassland area was selected from Ghandruk, on the east side of the Ghandruk village. There were several small patches of grasslands, which are not natural but cleared for grazing purpose by local people long time back. A local from Ghandruk has seen that place as it is in this state from his childhood which is around 35 years back however, no fix date recorded on clearing of ground, yet the area has been continuously grown as a grassland for donkeys, buffalos, surrounded by rhododendron forest. Forest and Agriculture land are from Tadhapani, which is around 13.35 km. north from Ghandruk. Figure 1 shows the study area in points at elevation ranging from 2155 m to 2662 m asl.

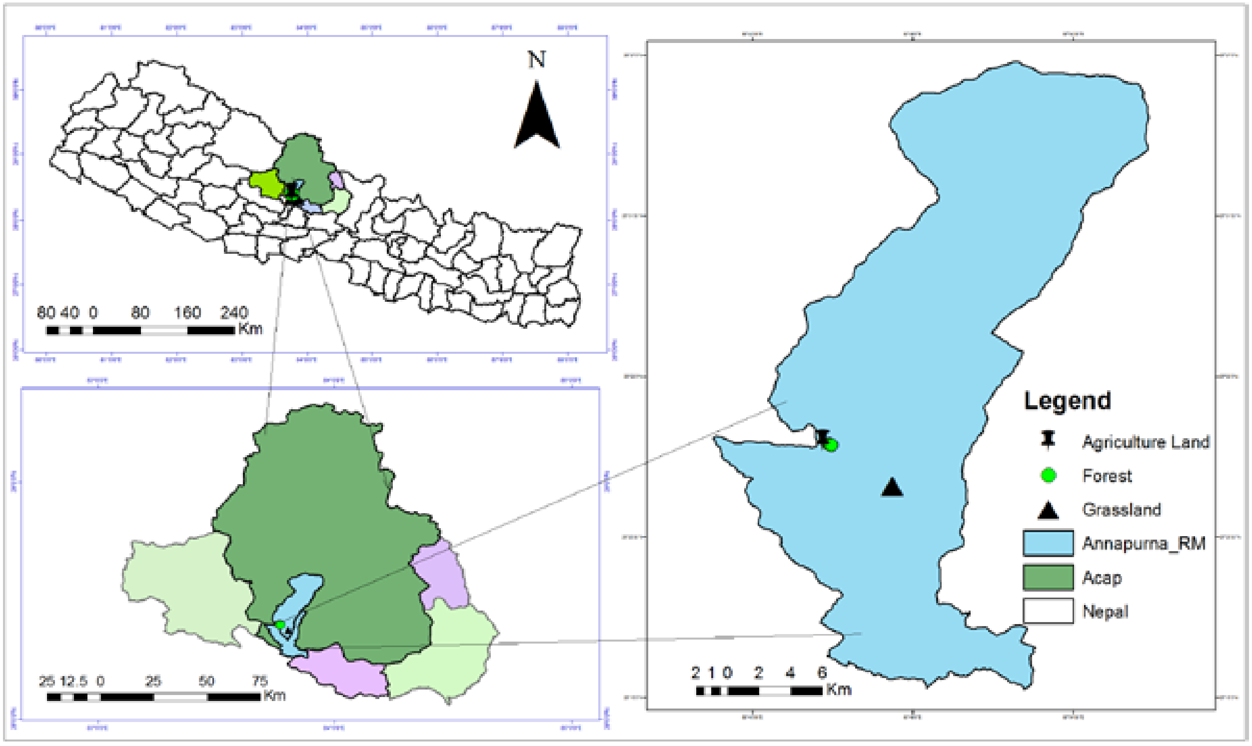


Figure 10. Study Area with Different Ecosystem Types in ACAP

Climate varies with altitudinal aspect, where 6 ºC drops in every 1000 m rise in elevation (DUHM, 1977). The seasonal climate is dominated by southern monsoon. Rainfall type is mainly related to aspect, altitude and the presence of rain shadow effect. The average rainfall ranges from 2,987 mm at Ghandruk, which lies in the cis-Himalayan region (BCDP, 1994). This area is much disturbed by human settlement with trees being looped for different purposes. Other dominant species are, *Rhododendron arboretum, Quercus lamelossa, Q. semicarpifolia, Mahonia nepaulensis, michelia spectabilis, Acer sp.,* and *Shorea cuspidate*. The study area lies between 2000 to 3000 m, with temperate deciduous forest dominated by rhododendron forest. Three study sites are of different ecosystem types, grassland, agriculture and forest found at that elevation. Grassland is very low and sparse that is not visible through google earth, surrounded by dense Rhododendron forest. As the study the study area is inside the conservation area, agriculture land is also vey less, small agricultural patches are kitchen gardens of hotels in trekking route for cultivating vegetables enough for hotel own business only.

2.2 Selection of Site

Study area was already identified and demarked research area by National Academy of Science and Technology (NAST) for continuous seasonal, annual and time series study of the same objective of soil respiration. These areas represent the ecosystems at elevation 2000-3000 m.a.s.l. inside conservation area which are closely connected with human area and are prone to be target for developmental purpose. This study is done in natural state which differentiate the impact of variable and human interference in soil respiration process. All the study sites are south facing. For this subject, 200 m long transect line of width 50 m. was laid along the trail. Chambers were placed avoiding foot trails and possibly low human interference. 10 chambers were fixed in every 20 m. distant by placing alternately on each side. Chambers were fixed 24 hours before study to avoid/minimize the disturbance effect in the specific point of study. Very less ploughing was done during chamber fitting and let it set in natural state, then the following measurements data were collected.

2.3 Soil Carbon dioxide Emission

Soil CO_2 emission was measured in the field by using closed chamber method (Bekku et al., 1995; Koizumi et al., 1999) with an infrared gas analyzer (IRGA). Vaisala CARBOCAP CO_2 probe GMP343 and the cylindrical chambers made of polyvinyl chloride with diameter of 18 cm and height of 16 cm. was used for measurement of CO_2. This method involves placing a closed chamber over the soil surface and the increase in the concentration of CO_2 within the chamber is measured as a function of time. An Infrared Gas Analyzer (IRGA) was fitted in the chambers to measure CO_2 and gas temperature. Soil carbon emission was measured one day after the chamber placement on the study point. The soil carbon emission was calculated from the following equation (Koizumi et al., 1999):

$$F=\left(\frac{V}{A}\right)\left(\frac{\Delta C}{\Delta t}\right)$$

Where, F= Soil respiration (mg $CO_2 m^{-2}$ h^{-1}), V= Volume of air within the chamber (m^3), A= Area of the soil surface within the chamber (m^2), $\Delta c/\Delta t$ is the time rate of change of the CO_2 concentration in the air within the chamber (mg CO_2 m^{-2} h^{-1}).

2.4 Soil Temperature and Soil Water Content

Soil temperatures at 5 cm depth were measured at the time of soil CO_2 emission measurement using the digital lab stem thermometer (AD-5622, A&D, Japan). Similarly, a measurement of soil water content (SWC) was obtained by using soil moisture sensor TRIME-FM (Imko, Germany) at 5 cm depth near the chamber.

2.5 Soil Organic Carbon

The soil sample arrived at laboratory was first labelled permanently on the sample. The sample container (tray) was also marked with same number. The soil sample was then spread on tray, the stones and undecomposed organic matter were discarded and large aggregates are broken. Sample tray was left in the room or shade to air dry the soil.After air drying, soil sample was crushed gently with a wooden pestle and mortar and sieved through 2mm sieve. Part of 2mm soil is again sieved through 0.2mm sieve for organic matter determination and packed for analysis.

For SOC (soil organic carbon) determination, a Rod ring of 3.5 cm diameter was used instead of the soil corer in the field. By clearing all the residue, Rod ring was drilled straightly up to the depth of 0-10 cm with the block of wood cap and hammer. Likewise, depth of 0-20 cm i.e., (10-20) cm soil sample and to the depth of 0-30 cm i.e., 20-30 cm soil sample was obtained by adopting same process mentioned above (Aryal et al., 2018). Walkley-Black method was used for the chemical analysis of soil organic carbon (O.M).

$$\text{O.M.\%} = \frac{(B-S)*N*3*100*100*100}{wt\ of\ soil*1000*77*58} = \frac{(B-S)N}{wt\ of\ soil} * 0.67$$

Where, B = Volume of FAS used up for blank titration, S = Volume of FAS sample for blank titration, N = Normality of FAS from blank titration and wt =weight (Pradhan, 1996).

3. Results and Discussion

3.1 Distribution of Soil organic Carbon

Soil organic carbon (SOC) stocks amount to an estimated 1500 ± 230 GtC (IPCC, 2001) in the first meter of soil, nearly twice (Lloyd & Taylor, 1994) as much as atmospheric carbon i.e. 828GtC as CO_2. Soil have been a global net source of GHGs (Hall, 1998). These processes and emissions are strongly affected by land use, land use change, vegetation cover and soil management. Depth-wise soil sampling is important for accurate account of soil organic carbon sequestration, storage, retention and los (Olson & Al-Kaisi, 2014). SOC stocks in the upper soil layers (0-30cm) are especially sensitive and responsive to such changes in land use and management, which provides an opportunity to influence the amount of CO_2 in the atmosphere.

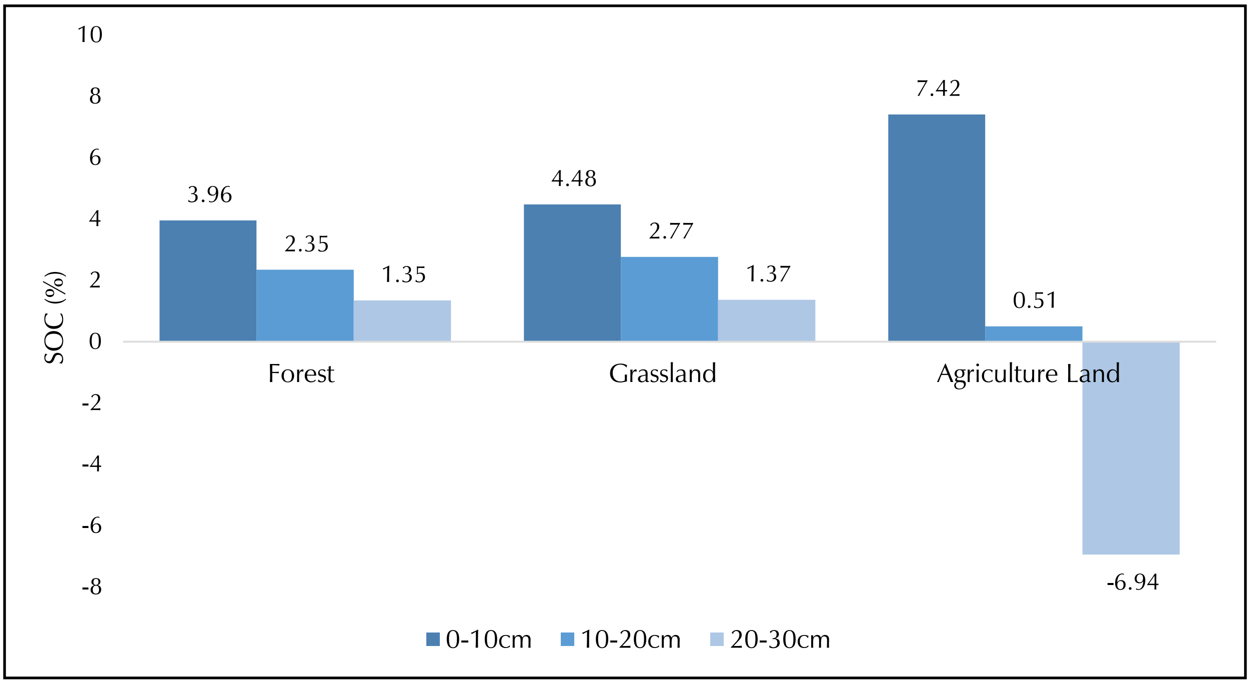
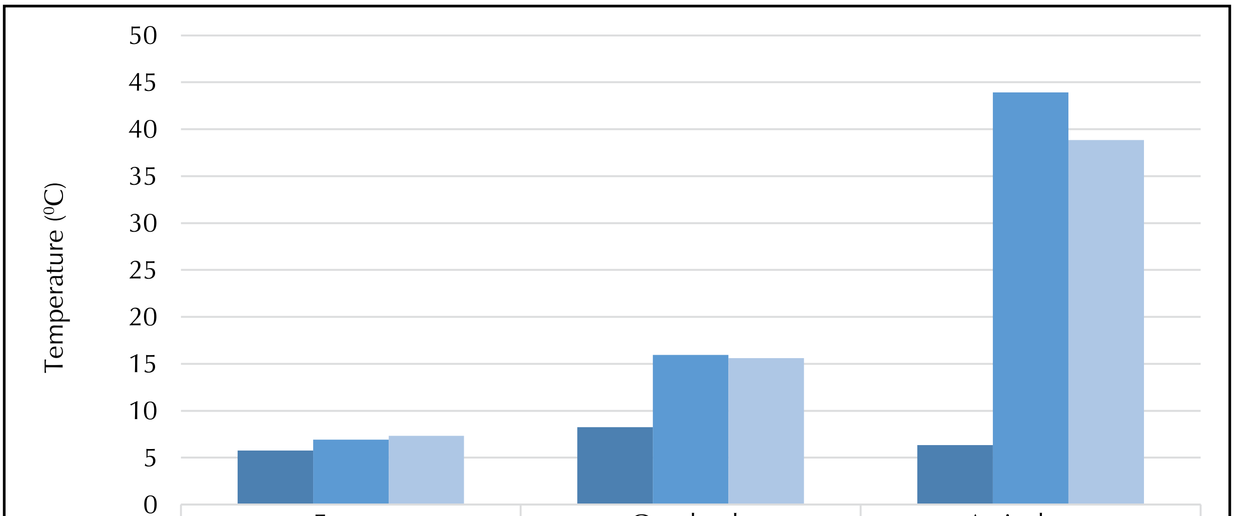


Figure 11. Depth wise Distribution of Soil Organic Carbon in Different Ecosystem

Soil sample collected from upper three layer 0-10, 10-20 and 20-30 cm shows a very distinct difference in SOC in these layers. Figure 2 reflects this clearly as top soil 0-10cm has maximum SOC which gradually gets decreased as depth increases. In Forest, SOC on top layer is 3.96% which was decreased by 41.92% in second layer 10-20 cm i.e., 2.35% and final layer had SOC almost half of second i.e. 1.35%. Likewise, SOC has been decreased from 4.48% to 2.77% followed by 1.37% in grassland ecosystem. This case is similar yet very distinct in agricultural land where SOC is very high in top layer i.e., 7.42% and found dramatically decreased to 0.51% in 10-20cm and went -6.94% in 20-30 cm. Forest and grassland are natural system where depth wise SOC distribution is even and gradual. Whereas, agriculture land is disturbed site with continuous addition of cow dung and food waste as manure in top layer which cause high deposition of organic matter in soil.

3.2 Diurnal variation in Soil Temperature and Soil Water Content

Soil temperature (ST) affects the rate of decomposition of organic matter in soil. It is directly linked with the atmospheric temperature as soil acts as an insulator for heat flow between the solid earth and atmosphere (Onwuka, 2016). On sunny day soil will absorb energy from the sun and its temperature will rise. At night, the soil will release the heat to the atmosphere that cools the soil. This process is correlated with soil albedo, which is determined by many soil dependent and independent variables. Absorbed energy by soil allows the rise or fall in soil temperature (Dobos, 2003).

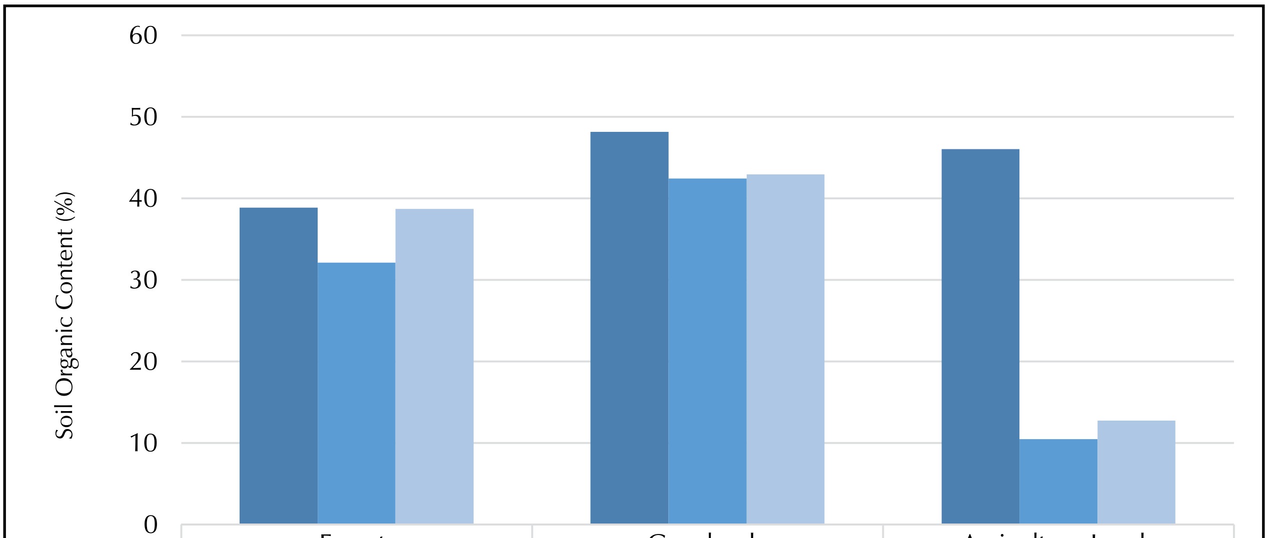


	Forest	Grassland	Agriculture
Morning	5.75	8.26	6.355
Day	6.927	15.94	43.936
Evening	7.329	15.6275	38.834

Figure 12. Difference in Soil Temperature in Morning, Afternoon and Evening.

Temperature variation is very less in forest ranging from 5.75 to 7.329^{0}C. It was October, beginning of winter season. Leaves were turned yellow yet thick due to mixed type of temperate forest with dominating species *Rhododendron rboretum* and *Acer sp.,* which provides continuous shade to the forest by blocking the sunlight and limiting the increase in soil temperature. In case of grassland, ST was less in morning i.e. 8.26^{0}C which increases as rise. ST reaches maximum at afternoon and again start decreasing smoothly with sunset. Likewise, ST is low in morning time in agriculture land which is increased rapidly in day time due to very sparse vegetation and direct exposure of soil to sunlight. ST highly fluctuates in agriculture land from 6.355^{0}C at morning to 43.936^{0}C at day time and again decrease to 38.834^{0}C at evening.

Source of water in soil of study area is either rain or morning dew, snow melt or nearby water canals causing ground water flow and activity of capillary action. Supporting the processes to maintain water balance in soil which keeps fluctuating due to ST variation at different time.



	Forest	Grassland	Agriculture Land
Morning	38.838	48.164	46.038
Day	32.104	42.411	10.465
Evening	38.677	42.923	12.744

Figure 13. Diurnal Variation of Soil Water Content in Different Ecosystem.

Soil water content (SWC) is high in forest in morning and evening time i.e. 38.838% and 38.677% while it is decreased to 32.104% due to increase in temperature. Similarly, in grassland SWC is high in morning i.e. 48.164% due to melting of dew as sunrises. Due to evaporation of surface soil moisture it decreases to 42.411% at day time and gradually again it will balance it moisture level when sun sets at evening. SWC 46.038% in agriculture land due to dew melting as well as external application of water for vegetables. Exposer of soil to sunlight at day time rapidly decreases it up to 10.465% at day and slowly increases at evening.

4. Discussion

4.1 Soil Organic Carbon Distribution Across Different Ecosystems

Soil organic matter contains a large reservoir of carbon, recently estimated at 1500 PgC (IPCC, 2001), about twice of the atmospheric CO_2-C pool. Changes in the size of the soil C pool therefore can significantly affect atmospheric CO_2 concentrations (Raich and Potter,1995). SOC is the major variable affecting the response of soil in carbon release (Onti & Schulte, 2012). Figure 5 demonstrates the SOC is lowest in Forest i.e. 3.95%, medium in Grassland i.e. 4.48% and maximum in case of agriculture land i.e., 7.42%.

Forest soil is the large carbon pool (IPCC, 2000). Soil carbon is present in soil as organic and inorganic carbo. Inorganic carbon consists of mineral forms of C which could be from weathering of mineral or reaction of soil minerals with atmospheric CO_2. Soil organic carbon is available from organic matter present in soil (Lal, 2007). Any disturbance factor such as deforestation has potential to cause release of forest carbon to atmosphere which may amplify the concentration of atmospheric greenhouse gas (IPCC, 2000). Liter deposition from trees are major source for forest soil carbon. These plant remains are decomposed by microbes, which contributes in soil respiration and not-respired carbon is retained in soil as humus (Bird, 2015). As temperature and moisture content of forest is less, the decomposition of organic matter to organic carbon is also gets slow contributing gradual yet less carbon to the soil. Soil carbon tends to be concentrated in the topsoil, which ranges from 0.5 to 3.0% organic carbon (Skjemstad, 2002). The study site demonstrated average 3.95% of soil organic carbon. The value differs from vegetation type, photosynthesis rate, decomposition and transformation organic matter to organic carbon (Xiao et al., 2010).

Input for grassland soil organic matter is from above and below ground plant tissues. (Rumpel, 2010). Grasslands contain about 20% of the global carbon stock (FAOSTAT, 2009), characterized by average 333 $Mg1.ha^{-1}$. (Schlesinger , 1977). The study site is the pasture land with soil organic matter content of average 4.48%. It's major sources of soil carbon is abscission, lodging and trampling of aerial plant parts and its decomposition (Hoorens, Hackler , & Lawrence, 2003). In temperate grassland, more than 80% of the NPP is through root production which adds the organic matter to soil (Swift, Heal, & Anderson, 1979). Root carbon input into soil may contribute greatly in soil organic carbon flux (Rasse, Rumpel, & Dignac, 2005) due to rhizosphere processes which is extremely important in stabilization and destabilization of soil carbon (Cheng & Kuzyakov, 2005). The organic carbon has been found greater in grassland than forest due to addition of dung in great amount from domesticated animals from Ghandruk. Dung constitute an important organic matter source in grassland ecosystems (Jarvis et al., 1996).

Agricultural lands are transformed land pattern to feed growing world population (Powlson et al., 2011). SOC is calculated to be highest 7.42% in agricultural land sue to addition of manure, dung, charcoal and food waste from hotels as compost. Agriculture is considered as a potentially powerful tool in carbon balance as approximately 12% of the soil carbon is present in cultivated soil (Schlesinger , 1977) and agricultural soil occupies 35% of global land surface (Betts et al., 2007).

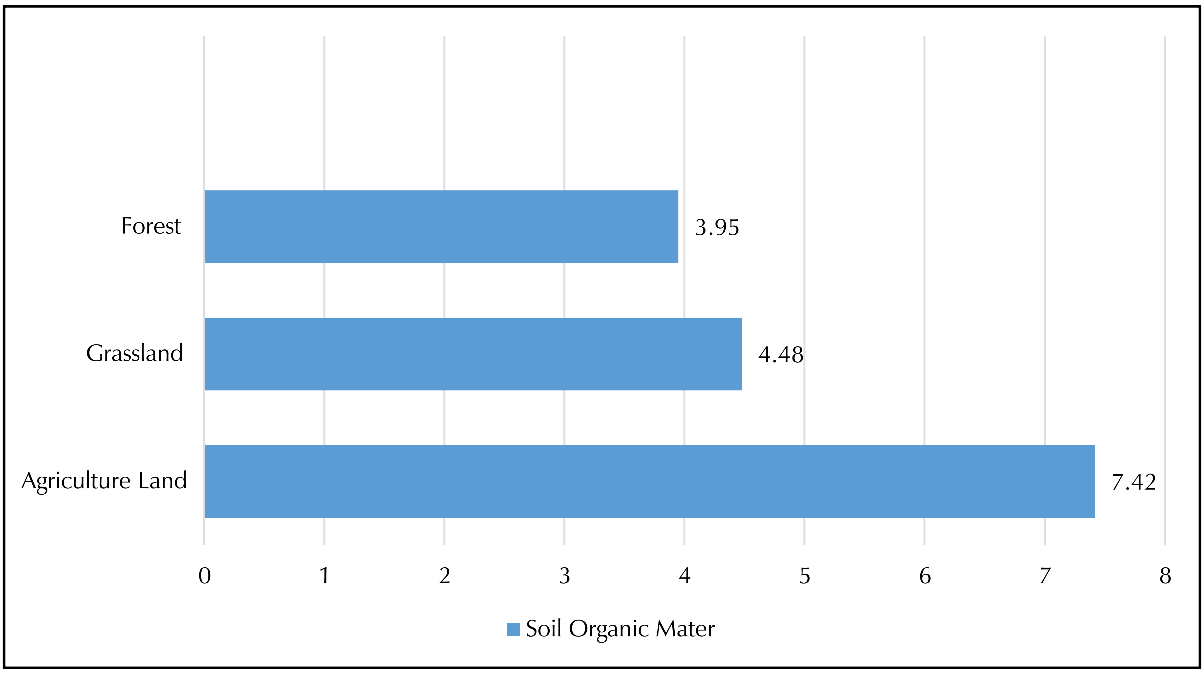


Figure 14. Distribution of Soil Organic Carbon in Different Types of Terrestrial Ecosystems Found in ACAP

Among the factors affecting SOM decomposition, temperature and soil moisture are most relevant. The average ST was detected to be lowest in forest i.e., 8.41 ºC, higher in 11.45 ºC in agriculture land and highest 13.2 ºC in grassland. Forest is a large area covered chiefly with trees and undergrowth, which limits the penetration of sunlight and lowers the atmospheric temperature inside forest (Marc, 2001). In agriculture land, ST increases as more part of the soil could directly get exposed to the sunlight in sparse vegetation areas. In ACAP, they maintain distance in vegetable growth and time by time removal of weed increases the chance of soil to get more sunlight (Norremark & Griepentrog, 2004). While in case of grassland, the vegetation is very low with high maximum up to 1 inch as it was starting of the winter season. Thus, average ST reaches highest in grassland.

Moisture is essential for the respiration process but if the moisture level reaches the saturation level or exceed then it starts to act as carbon sink (Lee et al., 2004). Soil moisture is lowest in forest i.e. 32.81%, higher in agriculture land i.e., 44.93% and highest in grassland i.e. 45.74%. Soil water content is important variable for predicting organic matter decomposition and soil CO_2 efflux (Fang & Moncrieff, 2001).

Globally 40% of the soil organic carbon is found in the upper 20 cm of topsoil (Jobbagy & Jackson, 2000). Over the last 50 years, the terrestrial ecosystems have been acting as the carbon sink for atmospheric $CO_{2,}$ reducing up to 30% of the global atmospheric $CO_{2'}$, however this pool is vulnerable to reverse the process in future (Cox, Betts, Jones, Spall , & Totterdell, 2000). Soil is the center of all global issues with the fact that it contains ¾ of the global terrestrial carbon stock (Eglin, et al., 2010) Human activities are major root for unprecedented rise in greenhouse gases in atmosphere which is likely to modify rainfall pattern (IPCC -C. C., 2013). Long term land-use change can easily convert soil organic matter pool as carbon source (Houghton, Hackler, & Lawrence , 1999). Therefore, land management is most important in determining soil quality and its act as carbon source or sink. Grassland and forest which are natural ecosystems are more preferable in terms of carbon storage than agricultural land due to its relatively permanent soil cover (Conant, Paustian , & Elliott, 2001).

5. Conclusions

Soil organic carbon, highest in agricultural land i.e., 7.42% medium in grassland i.e. 4.48% and lowest 3.96% in forest ecosystem which is highly influenced by soil moisture and soil temperature. Soil organic carbon stock is highly sensitive and varies along different ecosystems types, which could potentially cause release of soil carbon to atmospheric CO_2 through soil respiration.

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Rainfall and Temperature Trend: A Case Study of Spring Water in Chandragiri Municipality, Kathmandu, Nepal

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Abstract: Nepal is facing several water issues. There is currently a demand of around 320 million litres per day of water in Kathmandu and only 120 litres has been supplied. This indicates a large gap between the water demand and supply. In developing countries, like Nepal, water resources are often focused on use, rather than protection and conservation. Climate change possess a significant challenges to water resources in the form of high variability and seasonal scarcity, which directly affect the stream water. Hence, this study aims to identify the volume of stream water. The study was based on the primary data collection from spring and link with observed rainfall data by calculating water balance model and potential evapo-transpiration, and surface runoff was determined by using Throne model (2010). Finally, water availability was calculated in annual, seasonal and monthly basis from the output of Thorn model. The output was inspired of number of challenges; local government is providing the certain amount of water and tries to minimize the scarcity of water. In this study, we measure the volume of spring water and calculate the Monthly water availability and runoff by using Thornth waite model. This study helps to support regional water planning and policy level for sustainable management of water resources in urban area. Also, wind up that proper management of local resource is important otherwise sooner or later the result could be devastation.

Keywords: *PET, Water balance, Spring discharge, Water surplus, Water-deficit,Thorne model*

1. Introduction

Given the numerous uncertainties the topic of climate change, the impact that the process could potentially have on our lifestyle are not completely known (Reilly et al., 2003).The global average surface temperature has increased by 0.6±0.2ºC since the late 19th century and it is project. The updated 100–year's trend (1906–2005) of 0.76ºC is higher than the 100-year warming trend (1901–2000) of 0.6ºC at the time of the TAR- Third Assessment Report due to additional warmth years (IPCC, 2007). The year 2010 was likely to be the world's warmest year on record, the British Met Office has predicted. According to the Met Office, man-made climate change will be a factor and natural weather patterns was contributed less to 2010's temperature than they did in 1998, the current warmest year in the 160-year record (Times of India, 2010) .The World Meteorological Organization (WMO) concluded that the year 2010 was 0.53ºC warmer than the average for the period 1961–1990, a period commonly used as a baseline. Regions of the world experiencing particularly warm conditions during 2010 included Africa, southern and western Asia, and the northern extremities of North America, including Greenland (BBC News, 2011).The global mean surface temperature has increased by 0.6ºC during the 20th century (IPCC, 2001a) and estimated to rise by 1.4–5.8ºC by 2100 (IPCC 2001).

The year 2010 was 0.53ºC warmer than the average for the period 1961–1990(WMO). Studies show that developing countries are more vulnerable to climate change and are expected to suffer more from the adverse climatic impacts than the developed countries (IPCC, 2001a)South Asian countries are especially vulnerable to its effects due to their poor resilience of most sectors in Asia (IPCC, 2000).

The global mean surface temperature has increased by 0.6ºC during the 20thcentury (IPCC, 2001a). Population growth and urbanization are leading to a sharp raise in global demand for freshwater for drinking,sanitation, agriculture, energy production, industry, and environmental protection (FAO, 2011; WWAP, 2015). But the sussustainability of the freshwater supply is seriously threatened because of widespreaddepletion of groundwater, surface water pollution and climate change impact (IPCC 2007; Gleeson et al., 2012; WWAP, 2012). The magnitude of warming was rapid in the 19thcentury than in the 17thand 18thcenturies in Nepal (Doglo et al., 1995).

2. Study Area

Chandragiri municipality is the largest municipality in the Kathmandu district with the area of 43.91527km^2. Chandragiri municipality in the province no. 3, established on 2 December 2014by merging the 11 different village development committee. The urban administration is located in the old-Balambu. The municipality has 87,553 total population with 44,835 male and 42,718 female population. The city main attraction includes Chandragiri hills.

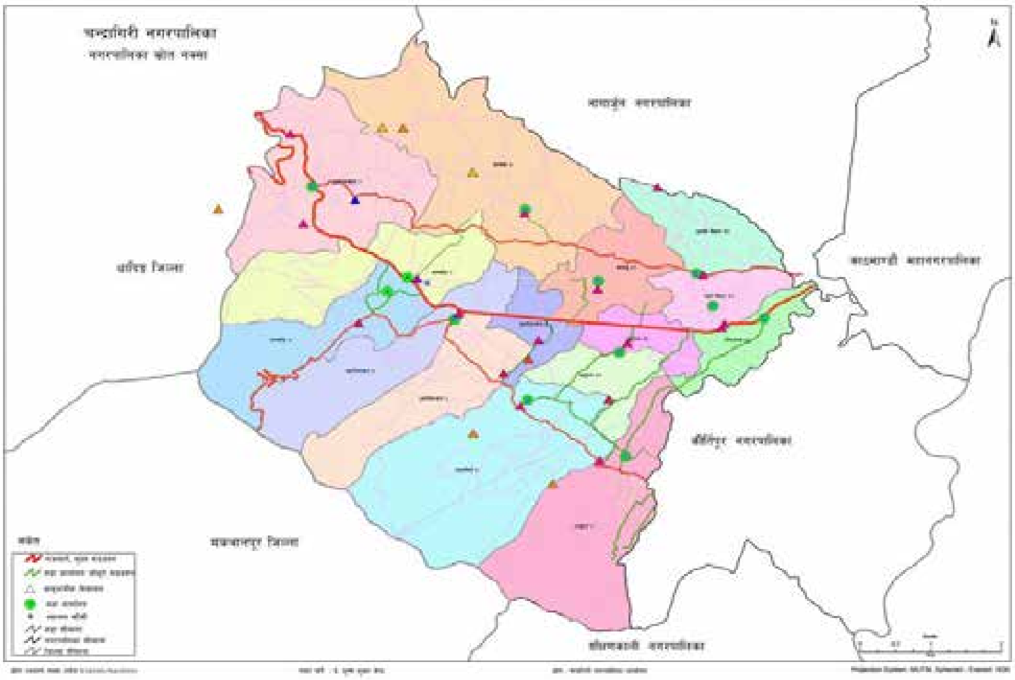

Figure1. Map of Chandragiri Municipality (Source:Chandragiri municipality, 2019)

Chandragiri Municipality is one of the rapidly growing cities (Figure 1). Thousands of people migrate yearly for the better opportunity and education. During the visit one can see number of land planning project. Agriculture land has turn to the big building. The price of land has increased unexpectedly. This also indicates the rapid urbanization in area with demand of water for different household activities. With the increase in population, the municipality is unable to provide the basic requirement like pure drinking water to people. Drinking water is the main problem created by crowd.. But recent year, maximum spring water dried up or become seasonal. This has created great problem in area.

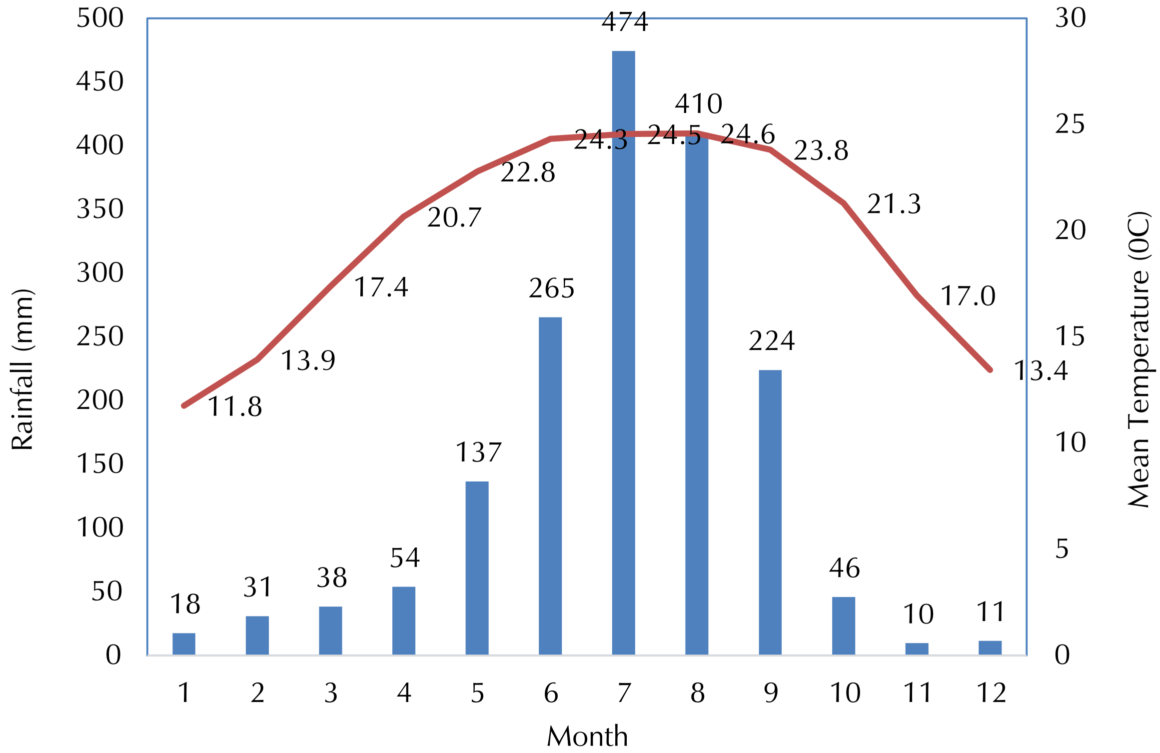

Figure 2. Mean temperature and average rainfall of Chandragiri Municipality

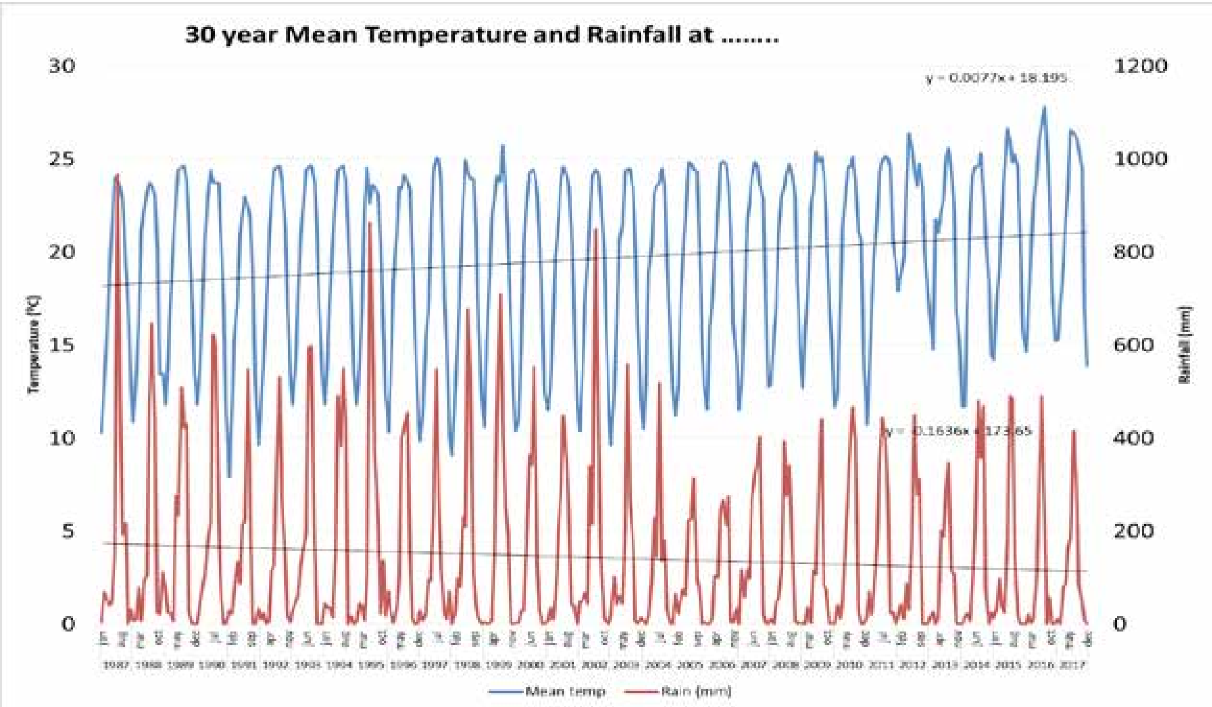

Figure3. Mean temperature and rainfall of 30 years

Precipitation data was taken from Thankot station located in Kathmandu district. Station index of the Thankotstation is 1015 (latitude 27°412′N, longitude 85°12′ E,elevation 1630 m).Thisstation doesn't have the temperature data. So temperature data was taken from near station, Panipokhari. Mean temperature and rainfall status of 30 years (Figure 2). July month has the highest rainfall i.e., 474 mm followed by month august, June and September with rainfall 410mm, 265mm, and 224mm respectively. Minimum temperature is observe in the month of January with11.8^{0}C and maximum temperature 24.6 °C in the month of August. Rainfall and temperature relation is directly proportional. First four months and last three month have less rainfall and minimum temperature. May, June, July, August, and September records maximum rainfall and temperature. A total of474mm rainfall calculated in July and maximum temperature 24.6 °C on month August.

Mean temperature and rainfall of Thankot station from the year 1987 to 2017(Figure 3). The minimum temperature is measured in 1990 A.D. whereas maximum recorded in 2016 A.D. Rainfall pattern is observed in decreasing trend. Maximum rainfall recoded in 1987 and minimum rainfall recorded in 2006. Rainfall shows the decreasing trend and temperature is in gradual increase order. Mean temperature shows the reverse trend.

3. Data and Methods

3.1. Primary data collection

Primary and secondary source of data were used for study. Primary data is dependent upon the data collected in the month of February. . The field visit was conducted in the month of February. A total of 34 different spring sources were recorded with their GPS location and discharge and total volume of water recorded accordingly.

Primary method includes GPS Survey, key information interview (KII) and measure discharge of springwater. Detailed GPS survey of all springwas conducted in the month of February,2019. An inventory sheet designed. The sheet contained information of spring such as name of spring, altitude; GPS coordinate and change in water volume within the last decade. Springs weresurveyed for their GPS location and discharge on the month Feburary. The discharge was measured by taking known volume of bucket and total time recorded by digital watched. All 15 ward of municipality visited in the month of February. The whole study was conducted for February month due to time limitation. Local people who age was above 50 year were selected for the questionnaire survey and asked about their experience in natural spring.

Apart from the field Survey, GPS data were imported into the GIS system. The spring inventory data were plotted in Microsoft excels and later integrated into GIS database of spring.

3.2. Secondary data collection

Secondary data rainfall and precipitation collected from the Department of Hydrology and Meteorology (DHM), Government of Nepal, from year 1987 to 2017.Data are collected from two different stations. Rainfall data from Thankot station, temperature data from the Panipokhari station, which is located to the nearest point.Temperature data was taken from the Panipokhari Station because Thankot Station doesn't have temperature data. So for the accuracy nearest station data was taken. Monthly water-balance model have been used as a means to examine the various components of the hydrologic cycle (for example, precipitation, evapotranspiration, and runoff). Such models have been used to estimate the global water balance (Mather, 1969; Legates and Mather, 1992; Legates and McCabe, 2005); to develop climate classifications (Thornthwaite, 1948); to estimate soil-moisture storage (Alley, 1984; Mintz and Serafini, 1992), runoff (Alley et al., 1984, 1985; Yates, 1996; Wolock and McCabe, 1999), and irrigation demand (McCabe and Wolock et al., 1992); and to evaluate the hydrologic effects of climate change (McCabe and Ayers, 1989; Yates et al., 1996; Strzepek and Yates, 1997; Wolock and McCabe, 1999).

The water-balance model analyses the allocation of water among various components of the hydrologic system using a monthly accounting procedure based on the Markstrommethodology originally presented by Thornthwaite (Thornthwaite, 1948; Mather, 1978, 1979; McCabe and Wolock, 1999; Wolock and McCabe, 1999). Inputs to the model are mean monthly temperature (*T*, in degrees Celsius), monthly total precipitation (*P*, in millimeters), and the latitude (in decimal degrees) of the location of interest. The latitude of the location is used for the computation of day length, which is needed for the computation of potential evapotranspiration (*PET*). The model is referred to as the Thornthwaite model. A discussion of the individual components of the water balance follows.

The first computation of the water-balance model is the estimation of the amount of monthly precipitation (*P*) that is rain (*Prain*) in millimeters. If temperature is greater than an additional threshold (*Train*), then all precipitation is considered to be rain. Within the range defined by *Train*, the amount of precipitation that is snow decreases linearly from 0 to 100 %of total precipitation. This relation is expressed as:

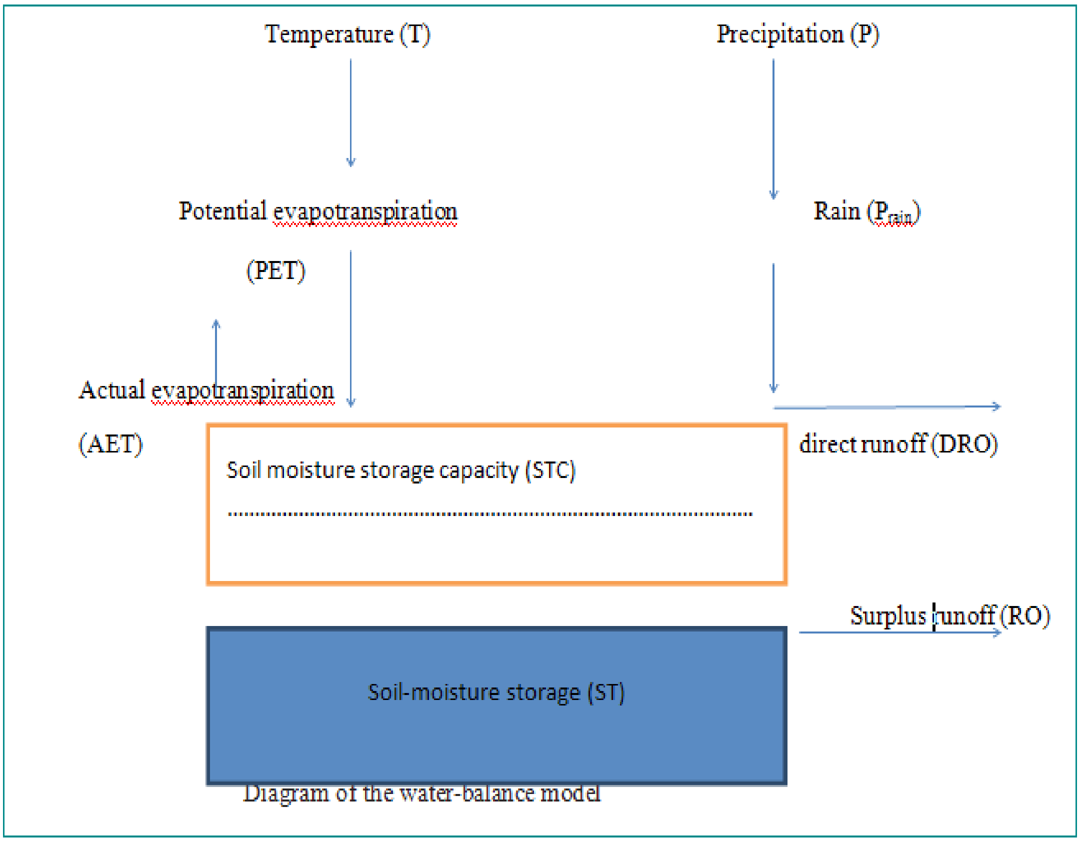

Figure 4. Diagram of the water balance model

Direct runoff (*DRO*) is runoff, in millimeters, from impervious surfaces or runoff resulting from infiltration-excess overflow.The fraction (*drofrac*) of *Prain*that becomes *DRO* is specified; based on previous water-balance analyses, 5%is a typical value to use (Wolock and McCabe, 1999).

The expression for *DRO* is:

$DRO = Prain \times drofrac$……..(3)

Direct runoff (*DRO*) is subtracted from *Prain*to compute the amount of remaining precipitation (*Premain*):$Premain = \text{Prain} - DRO$ ………(4)

Actual evapotranspiration (*AET*) is derived from potential evapotranspiration (*PET*), *Ptotal*, soil-moisture storage (*ST*), and soil-moisture storage withdrawal (*STW*). Monthly *PET* is estimated from mean monthly temperature (*T*) and is defined as the water loss from a large, homogeneous, vegetation-covered area that never lacks water (Thornthwaite, 1948; Mather, 1978). Thus, *PET* represents the climatic demand for water relative to the available energy. In this water balance, *PET* is calculated by using the Hamon equation (Hamon, 1961): and soil-moisture storage withdrawal (*STW*). Monthly *PET* is estimated from mean monthly temperature (*T*) and is defined as the water loss from a large, homogeneous, vegetation-covered area that never lacks water (Thornthwaite, 1948; Mather, 1978). Thus, *PET* represents the climatic demand for water relative to the available energy. In this water balance, *PET* is calculated by using the Hamon equation (Hamon, 1961).

$PETHamon = 13.97 \times d \times D2 \times Wt$........(7)

where *PETHamon*is *PET* in millimeters per month, *d* is the number of days in a month, *D* is the mean monthly hours of daylight in units of 12 hrs, and *Wt*is a saturated water vapor density term, in grams per cubic meter, calculated by:*STW*

$Wt = 4.95 \times e0.062 \times T100$..........(8)

Where *T* is the mean monthly temperature in degrees Celsius (Hamon, 1961).

When *Ptotal*for a month is less then *PET*, then *AET* is equal to *Ptotal*plus the amount of soil moisture that can be withdrawn from storage in the soil. Soil-moisture storage withdrawal linearly decreases with decreasing *ST* such that as the soil becomes drier, water becomes more difficult to remove from the soil and less is available for *AET*. *STW* is computed as follows;

$STW = STi\text{-}1 - abs(Ptotal - \mathrm{PET}) \times STi\text{-}1STC\ (e0.062 \times T100)$........(9)

where *STi*-1 is the soil-moisture storage for the previous month and *STC* is the soil moisture storage capacity. An *STC* of 150 mm works for most locations (McCabe and Wolock, 1999; Wolock and McCabe, 1999).

If the sum of *Ptotal*and *STW* is less than *PET*, then a water deficit is calculated as *PET–AET*. If *Ptotal*exceeds *PET*, then *AET* is equal to *PET* and the water in excess of*PET* replenishes *ST*. When *ST* is greater than *STC*, the excess water becomes surplus (*S*) and is eventually available for runoff.

Runoff (*RO*) is generated from the surplus, *S*, at a specified rate (*rfactor*). An*rfactor*value of 0.5 is commonly used (Wolock and McCabe, 1999). The *rfactor*parameter determines the fraction of surplus that becomes runoff in a month. The remaining surplus is carried over to the following month to compute total *S* for that month. Direct runoff (*DRO*), in millimeters, is added directly to the runoff generated from surplus (*RO*) to compute total monthly runoff (*ROtotal*), in millimeters

$STW = STi\text{-}1 - abs(Ptotal - \mathrm{PET}) \times STi\text{-}1STC$

$Wt = 4.95 \times e0.062 \times T100$

$PETHamon = 13.97 \times d \times D2 \times Wt$

3.3 Running the Water-Balance Program

The window for the Thornthwaite monthly water-balance program will behave like any other window on the desktop. Resize, iconify, or close it like any other application by dragging the borders and clicking on the window controllers in the upper corners of the frame. Figure 2 is a screen image of the program's graphical user interface.

The water-balance model has seven input parameters (runoff factor, direct runoff factor, soil-moisture storage capacity, and latitude of location, rain temperature threshold, snow temperature threshold, and maximum snow-melt rate of the snow storage) that are modified through the graphical user interface (Figure 2). The range and default values for these parameters are set by the model. These values are changed by clicking on the corresponding slider bar and dragging the value. The system will not allow invalid values to be entered.

The model requires a simple input data file. To select the input file, click on the button corresponding to the file ("Input file") and a file browser will appear. The input file must be a file on the user's local file system that contains monthly water-balance input data. A sample data file (input.file) is provided with the model and is located in the USGS_Thornthwaite installation folder. The data file must be organized into four columns with one or more space characters between the columns. The first column is the year, the second is the numeric month of the year, the third is mean monthly temperature in degrees Celsius, and the last is monthly total precipitation in millimeters.

When the model runs, tabular output is written to a popup window (Figure 3). The columns of the output are date, *PET*, *P*, *P–PET*, soil-moisture storage, *AET*, *PET–AET* (also known as moisture deficit), snow storage, surplus, and *ROtotal*. The contents of this window can be saved to a file by clicking on the Save button at the bottom of the window and specifying the name (and directory) of an output file in the file browser.

At the bottom of the main program window (Figure 2), the user can select the specific variables to be plotted by clicking on the corresponding circle. After the model runs, a window will open with the plotted time series (Figure 4). The model can be run any number of times, each time selecting a different set of variables to plot(McCabe et al., 2007).

The output plot snowmelt and snow storage were not selected. Snow in not available in the area. So, remaining 10-output plots were selected for the result. And runoff was taken for analysis of data.

The water budget is input and output of water within a given hydrological boundary taking into account of net change in storage (Patra, 2002). Water as an inexhaustible substance maintains its balance through hydrological cycle in terms of standard continuity equation:
Input- Output = Change in Storage

4. Results

The discharge of spring water varied. There is no uniform pattern of distribution of springs in terms of discharge rate and altitude but eastern part of municipality has more spring source.

Table 6. GPS location of spring water with the discharge volume

S.N.	Latitude	Longitude	Elevation (ft)	Discharge (liter/day)	Discharge (m^3/s)
1	3064003	328922	4427	1500	0.0005
2	3063874	328946	4410	1000	0.0003
3	3064321	328272	4419	1000	0.0003
4	3062488	325955	4916	3456	0.0011
5	3062293	326156	4863	21600	0.007
6	3063448	328621	4398	500	0.0002
7	3066460	324102	5184	2000	0.0006
8	3064770	326026	4447	16038	0.0052

S.N.	Latitude	Longitude	Elevation (ft)	Discharge (liter/day)	Discharge (m^3/s)
9	3065611	325983	4560	4872	0.0016
10	3066194	325462	4918	3240	0.0011
11	3066391	325895	4905	1800	0.0006
12	3065887	326521	4825	16817	0.0055
13	3065714	326519	4690	7331	0.0024
14	3065666	326244	4592	9964	0.0032
15	3062945	325542	4925	20000	0.0065
16	3065315	328190	4574	1500	0.0005
17	3065057	328175	4636	3000	0.001
18	3064865	328679	4454	500	0.0002
19	3065063	328384	4567	1200	0.0004
20	3064716	323356	4879	1728	0.0006
21	3065339	327387	4718	15037	0.0049

34 sources of water recorded. Out of which 13 were dried up or were seasonal.

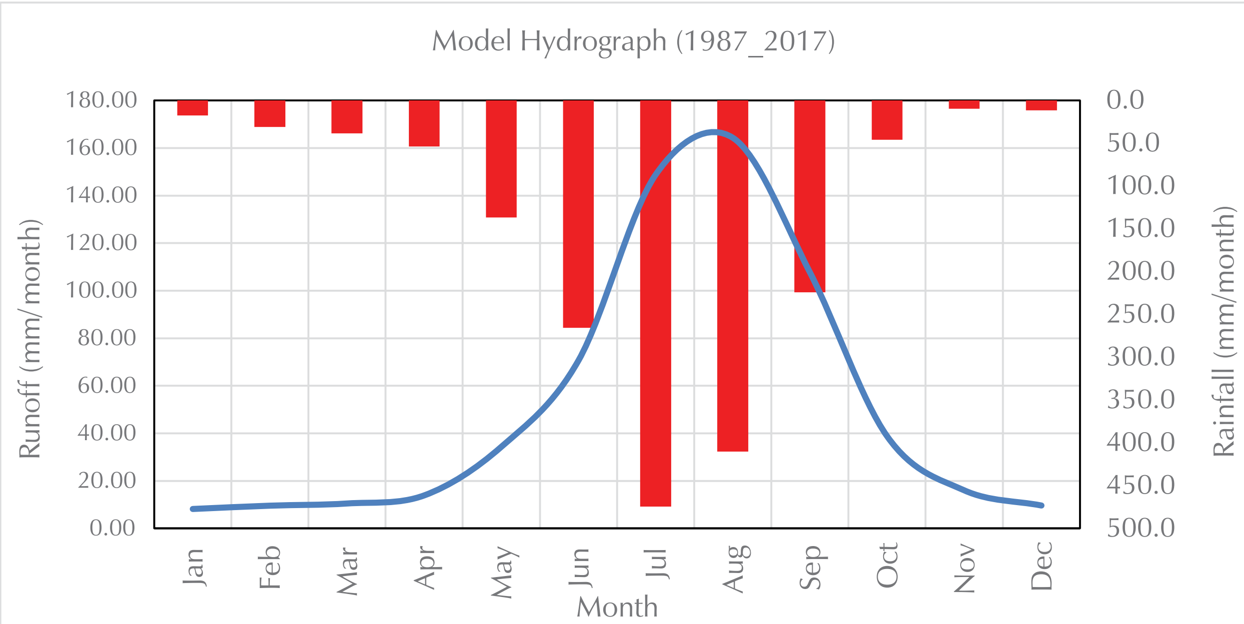

Figure 5. Runoff and rainfall from1987 to 2017.

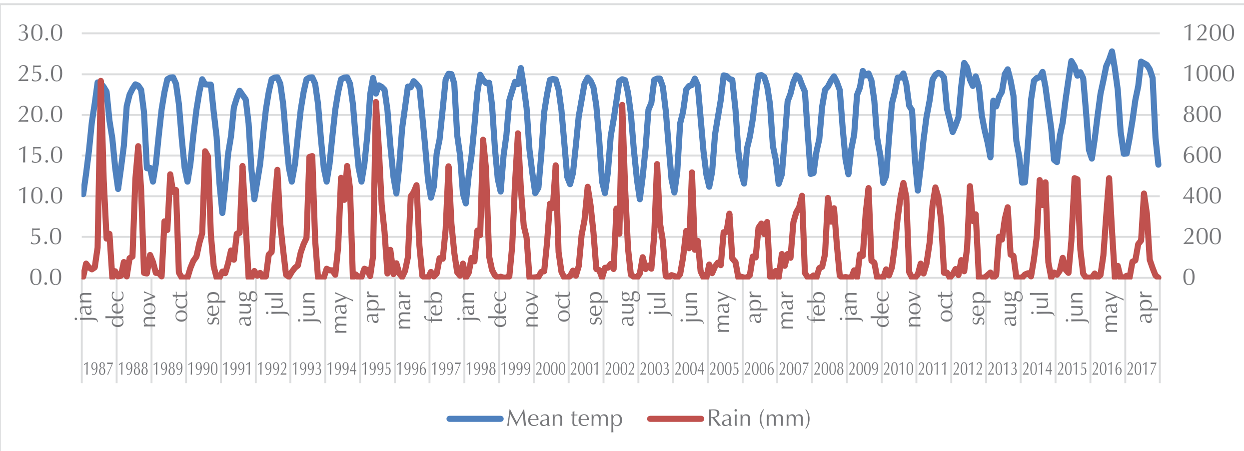

Figure 6. Mean temperature and rainfall from 1987 to 2017.

Figure 5 shows relation between runoff and rainfall status (1987 t 2017). Rainfall plays great role in total runoff. Runoff is generated by rainstorms and its occurrence and quantity are dependent on the characteristics of the rainfall event, i.e. intensity, duration and distribution. There are, in addition, other important factors which influence the runoff generating process.Apart from rainfall characteristics such as intensity, duration and distribution, there are a number of site (or catchment) specific factors which have a direct bearing on the occurrence and volume of runoff.The specific factor is soil type, Vegetation, slope and catchment size. Runoff found more (i.e.170mm/month) in the month of August. Maximum rainfall in July (figure 5). Minimum runoffs observe on first three month and last month December. Harvesting water and its proper management can help to reduce Municipality water supply issue. This can greatly reduce the water scarcity in the area and help in the development activities.

Figure 7. Output result of Thornwhaite model (2010).

Eight output plots are selected. Output plot are direct runoff, actual ET, Runoff, Potential ET-Actual E, oil moisture storage, precipitation, surplus and temperature. Thornwhaite model (2010) was used to calculate the runoff. As runoff station is not available in area in the thankot stations and nearby station.

The chart shows gradual increase in average temperature in last two decade. The maximum mean temperature was in year 2016, with 28 °C. Rainfall was maximum in 1987 with1000mm. The pattern also results in decrease in rainfall (as shown in figure 7).

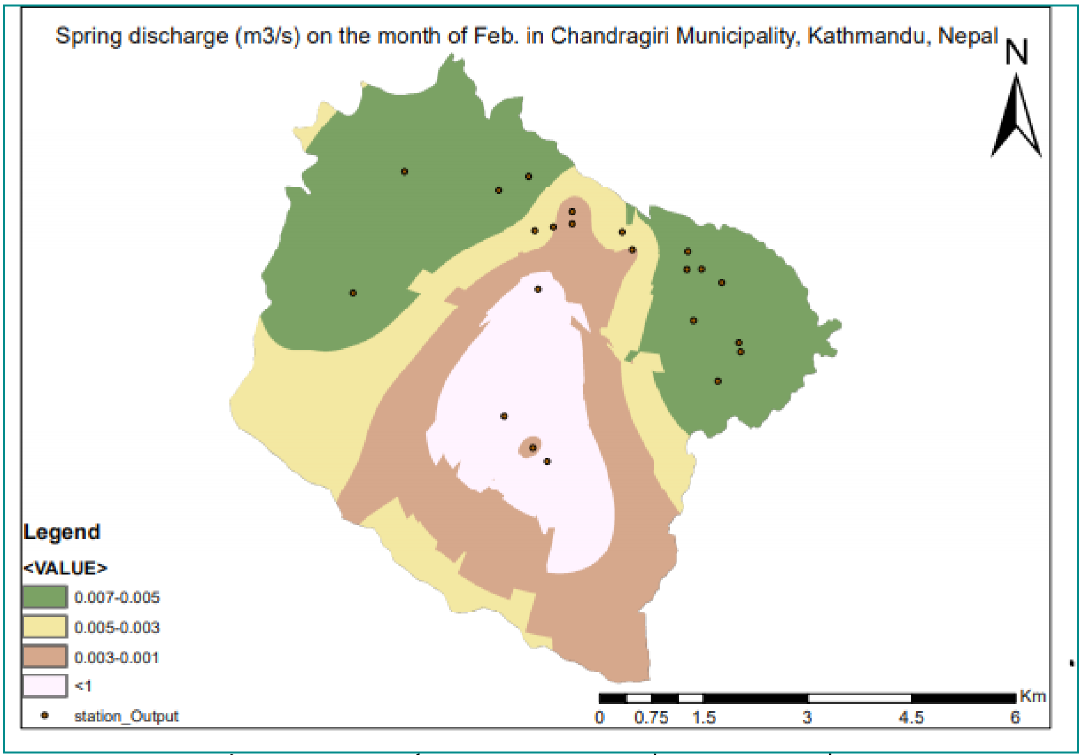

Figure 8. Status of spring water in Candragiri Municipality.

Spring water was found maximum in the northern part of the municipality. The discharge range from 0.007-0.005mm/s is dominant in the area.North-East and North-West portion has maximum water source whereas southern part has less to minimum spring. 12 sources of water found from range 0.005 to 0.007 m^3/s. 4 spring from the range of 0.003 to 0.005,4 springs from range 0.001 to 0.003 and remaining less than 1.

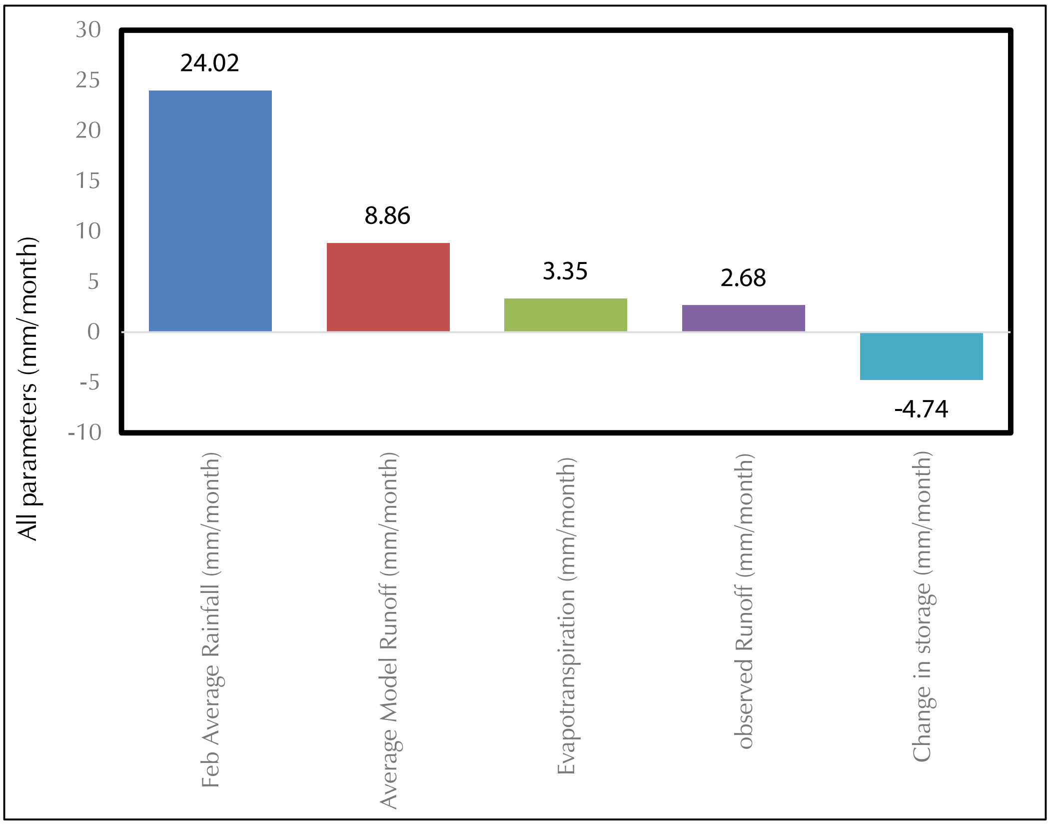

Figure 9: Monthly rainfall, runoff and evapotranspiration of February (2019)

Table 7: Runoff in T_max, T_min, T_average and observed discharge

Month/ year	Runoff T_Max (mm/ month)	Runoff T_Min (mm/ month)	Runoff T Mean (mm/month)	Average Model Runoff (mm/ month)	Observed Discharge (m^3/s)	Runoff (mm/ month)	Average Feb, Rainfall (1987_2017) (mm/month)
02/2019	9.61	8.95	8.02	8.86	0.05	2.68	30.76

The average rainfall (mm/month) of February is 24.0mm/month, average model runoffis 8.9 mm/month, Evapotranspiration 3.4 mm/month, and runoff obtained 2.7 mm/month. Change in sstorage is negative (i.e., -4.7mm/month)

Runoff is found 9.61in maximum temperature, 8.95 when temperature is minimum. Runoff is calculated 2.68 mm where observed discharge is 0.05 the average rainfall of study month (February) from 1987 to 2017 is calculated 30.8mm.

5. Discussion

The average annual precipitation of Kathmandu valley recorded to be from 1365mm to 1872 mm from 1890 to 2009. They found a higher number of springs in the altitude from 975 to 1600 m with similar characteristics. Furthermore, studies from the Koshi River Basin of Nepal in the Central Himalayas showed that steep slopes impact springs at higher altitudes, limited recharge area, and decreased winter rainfall (Dixit et al., 2009, ICIMOD 2009).

Most of the spring found in the upper part of human settlement and just below the forest. People are found aware about the protection of spring water. Rapid urbanization has increased the scarcity of drinking water making people aware of its importance. The minimum range of spring water is from 4398 to 5184 ft.

Monthly water-balance models have been used as a means to examine the various components of the hydrologic cycle (for example, precipitation, evapotranspiration, and runoff). Such models have been used to estimate the global water balance (Mather, 1969; Legates and Mather, 1992; Legates and McCabe, 2005); to develop climate classifications (Thornthwaite, 1948); to estimate soil-moisture storage (Alley et al., 1984; Mintz and Serafini, 1992), runoff (Alley etal., 1984, 1985; Yates et al., 1996; Wolock and McCabe, 1999), and irrigation demand (McCabe and Wolock, 1992); and to evaluate the hydrologic effects of climate change (McCabe and Ayers, 1989; Yates et al., 1996; Strzepek and Yates, 1997; Wolock and McCabe, 1999). The model, referred to as the Thornthwaite water-balance program, can be used as a research tool, an assessment tool, and as a tool for classroom instruction. Thornwhaite model (2010) was to calculate the average runoff of February month. Storage annually increases temperature and decrease rainfall pattern could be due to climate change. According to (Jha and Shrestha, 2013), the average annual precipitation pattern of Thankot has decreased trend.

Climate change is a global phenomenon. The Hindu Kush Himalaya (HKH) region has been experiencing consistent warming (Shrestha and Aryal, 2011), and the local weather has become unpredictable and erratic (Sharma et al., 2009; Chaudhary et al., 2011). Nepal is highly vulnerable to climate change and variability (MoE 2010).The average annual temperature from 1971 to 1994 has increased by 0.06 °C in Nepal (Shrestha et al., 1999) and the changes are greater in Middle Hill and High Mountain with frequent drought and erratic rainfall (Xu et al., 2009). Based on future climate change projections (higher temperature and more frequent and prolonged drought), there is likely to be an increase in water scarcity and expressed uncertainty and variability in the Asian monsoon (Vaidya et al., 2014)

There are only a few Himalayan based studies on the characteristics of natural springs. It is claimed that spring distribution is controlled by topography (Mahamuni and Kulkarni, 2012), rainfall, and characteristic of recharge area (Tambe et al. 2012; Negi and Joshi 2002, 2004). Tiwari and Joshi (2013) study in Nainital District in Uttarakhand, India, showed that the dry and seasonal springs are higher in lower altitude (below 1000 m) compared to mid-altitude (1500–2500 m) and at high altitude (above 2500 m). Tambe et al. (2012) study from Sikkim Himalayas also revealed similar characteristics with respect to the distribution of springs at various altitudes. Furthermore, studies from the Koshi River Basin of Nepal in the Central Himalayas showed that springs at higher altitudes are impacted by steep slopes, limited recharge area, and decreased winter rainfall (Dixit et al., 2009; ICIMOD, 2009)

Monthly water-balance models have been used to examine the various components of the hydrologic cycle (for example, precipitation, evapotranspiration, and runoff). This report presents a description of a monthly water-balance model, the Thornthwaite monthly water-balance program, which includes computations of monthly water-balance components for a specified location driven by a graphical user interface. The program can be downloaded from the internet and run on any computer platform. The program can be used for research, assessment purposes, and classroom instruction.

The discharge volume of spring was total runoff of Chandragiri Municipality (i.e.2.68 mm). Runoff is found more in month of August. Whereas maximum rainfall in July. Infiltration rate is high at beginning of July and saturated level of soil leads to maximum runoff in August. Precipitation rate is very low in February which finally leads to 31mm runoff. Rainfall in February month is very important for spring vegetable and wheat. Change in storage is negative in month of February; this signifies less rainfall in the month and can slowly disapear the spring water.

"Mahadevsthan-Matatirtha drinking water and cleanness Committee" is one of the leading committee to provide water in the ward no. of 5, 6, and 7 of Chandragiri Municipality. Before decade matatirtha spring water used to be main source of water. Recent year, muchspring source dried out including Matatirtha spring. Since then, dip boring hasbeen alternative source of water. The committee provide water to 2342 household in the area. This indicates majority people are dependent upon groundwater.

Some part of Aquifers filled by natural recharge from rainwater (especially during monsoon season). The major natural Recharge areas in the valley are located towards northern part and some areas towards southern part in the valley (Figure 1) where thickness of the clay layer is expected to be minimal. The annual recharge to the aquifers estimated by several earlier studies (Binnie and Partners, 1988; JICA, 1990; Gautam and Rao, 1991) using various approaches varies widely. Considering an average of them (as discussed on Pandey et al., 2010b) as a representative one, annual recharge to the aquifers in the valley is 9.6 MCM/year. The groundwater availability could further be increased by artificial and/or managed aquifer recharge, which of course, is resource-intensive and needs further investigation of the aquifer systems to understand the flow paths and flow velocity; however, would help understand the artificial recharge potentials (location, recharge volume, etc). The Nepal Water Supply Corporation (NWSC) also introduced groundwater into its water supply system from mid-eighties (Metcalf and Eddy, 2000). Depletion in groundwater levels and decline in design yield of wells have become a common phenomenon. Groundwater aquifers in the Kathmandu Valley are already under stress (Pandey et al., 2012).

Improvements in groundwater monitoring by increasing spatial and temporal coverage, further research to enhance understanding of groundwater dynamics and its recharge system, management of existing data/information/knowledge and its disseminations and policies and strategies for public participation in groundwater management and conservation activities could be the immediate next steps in the direction of achieving 'groundwater sustainability'

Different study shows decrease status of spring water. This can create great problem in the coming days. The total annual average rainfall in calculated 1718mm. Water harvesting could be the alternative option to overcome the demand of rapid urbanization. Water harvesting can be easy, economical method to meet the needs of growing population in Chandragiri Municipality (Pandey etal., 2012).

6. Conclusions

Natural springs are the source of drinking water. Among 34 different natural springs observed, 13 are seasonal or dried up after the earthquake in 2015 A.D.. . Spring water is controlled by the nature of topography, rainfall amount and pattern, and the characteristic of the recharge area. Recent year groundwater is major source of water in the chandragiri Municipality. Groundwater aquifers in the Kathmandu Valley are already under stress (Pandey et al., 2012). The availability of groundwater resources has been reduced as a consequence of excessive withdrawal of groundwater resources. They are reflected in terms of depletion in groundwater level, decline in design yield of wells, degradation in groundwater quality and shrinking aquifer volume due to land subsidence.

21 different springs observed in area which provide drinking to the local people. Monthly rainfall and runoff calculated by using data from DHM. 30 years of rainfall and precipitation data is analysed Result shows increase in temperature and decrease in rainfall pattern. This could be the result of many factors, one major reason can be changing climate. February month has negative change in storage i.e., rainfall is less than discharge which can lead to dried out of spring water in coming days

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Climate Change Impact on Water Resources: A Case Study of Dhulikhel Municipality, Kavre District, Nepal

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Abstract: Climate change has significant impacts on water resources since climatic factors, such as rainfall and temperature cause a change in water and water resources. Dhulikhel Municipality has a problem regarding reliable water supply for over three decades. This study aims to identify the impact of climate change on water resources of the study area based on household survey and a linear trend analysis of meteorological data (temperature and precipitation) from Dhulikhel station of Kavre district. Furthermore, key informant interviews were also conducted to support the results from the household survey and climatic data analysis. Based on climatic data analysis, the mean annual temperature of past 25 years of the study area is in increasing trend while the precipitation patterns show the decreasing trend. Both the temperature and rainfall tread were supported by people's perception. Dhulikhel has Dhulikhel Drinking Water User Committees which is water supply by the supported of the German Government and also several small user committees, however, there is still problem regarding water supply. The increase in geographical size in 2014/2015 resulting increase in population has ultimately created increased water stress in the study area and also the earthquake in Nepal 2015 has caused decrease in source of water resources as per many respondents. In order to cope with scarcity of water, local people has adopted several strategies such as storage of water on tank or gallon, rely on distant water sources, pumping of water from the rivers/streams/any sources of water, construction of plastic pond, sharing of same irrigation water, plantation of drought resistant plants, construct storage reservoir for dry season.

Keywords: *Climate change, Water resources, Temperature, Precipitation, Adaptation*

1. Introduction

Climate change has caused serious impacts on the hydrological, biological and ecological system along with economy and its future effect on the sustainable development in regional, national, and global level (Guo-yu et al., 2008). Overall, climate change affects the life supporting system including atmosphere, hydrosphere and lithosphere and biosphere (Dhimal & Bhusal, 2009). Among the different factors like as Agriculture, forestry, water and energy, health, urban and infrastructures, tourism, industry that the climate change has adverse impact, water resource and hydropower are the highly affected sectors (OECD, 2013). Climatic factors like rainfall and temperatures has caused change in water and water quality, ultimately causing impact in water resources (Nan et al., 2011) and the increasing global temperature has severely affect the availability of water resources and the water demand across the world (IPCC, 2014). Dhulikhel municipality has struggled with water stress and reliable water supply for over three decades due to variable rainfall patterns and increasing water demand (Pandey & Bajracharya, 2017). As Dhulikhel is one of the famous tourist areas of Nepal, huge amount of water availability is required.

The main objective of this study is to identify the impact of climate change on water resources in Dhulikhel Municipality, Kavre distict. In specific, this study a) identify the different sources of water in Dhulikhel Municipality, b) generate the list of water resources affected by climate change, and identify the impact of climate change on water availability, c) analyze the temperature and precipitation trend of the study area and d) to assess peoples' coping strategy or adoptive measures to deal with the climatic impact on the water resources.

2. Data and Methods

2.1 Study Area

The study was conducted in Dhulikhel municipality which is located in Kavrepalanchok district. It is 32 km east of Kathmandu Valley. One of the three major urban centers in the Kavre Valley, Dhulikhel, lies in province No 3 of Central Nepal. The new municipality constitutes of 12 wards covers a total of 55 km^2.

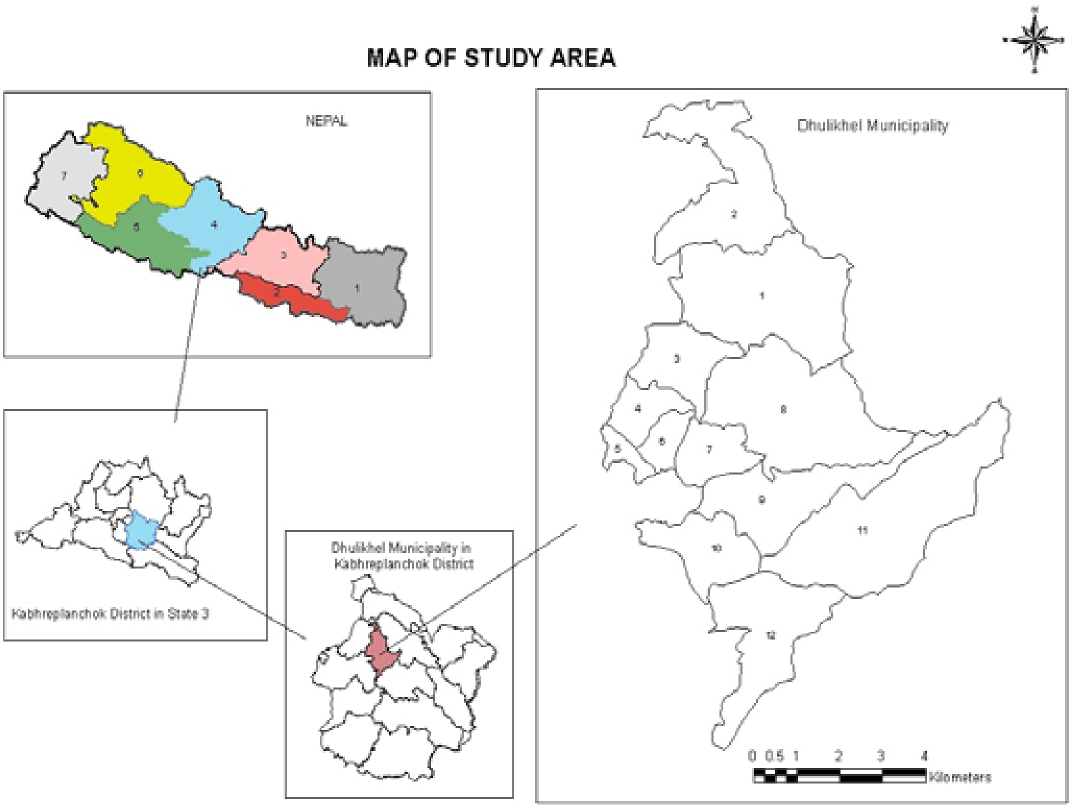

Figure 1. Study Area

2.2 Methods

The research adopted primary data from filed visit and secondary data from literature review and temperature and precipitation data from the Department of Hydrology and Meteorology (DHM). Primary data were collected from household survey and key informant interview. A set of questionnaire which includes several question about climate change, and its impacts on several factors especially water resources was developed and total of 238 households were chosen for household survey by using purposive sampling method. 1 key informant interviews (total 12 KII interview) were taken in each wards of the study area. For secondary data, several published and unpublished research reports, journals and papers related to climate change and its impacts and regarding to the study area were collected and reviewed. Also, temperature and rainfall data since last 25 years (1993-2017) were collected from the DHM and analyzed to understand the change in climate. Similarly, GPS coordinate of various water resources was taken from GPS device during field visit and the coordinates are later plotted in the GIS map.

2.3 Data analysis

Data collected from household survey and KII during field visit was analyzed and also compared using MS Excel 2013. The trend of rainfall pattern and temperature was analyzed -by comparing past and present data. Quantitative and Qualitative information gained from household survey and rainfall and temperature data collected from DEM were analyzed using bar graph and pie charts.

2.4 Sampling method and sampling size distribution

A total of 238 households were taken for the household survey from 12 wards of the study area. The number of household to be interviewed was identified by using statistical method of sample size determination formula (Daniel, 1999):

$$n_o = \frac{z^2 P(1-P)}{d^2}$$

where, n_o = sample size, Z = Z statistic for a level of confidence=1.96, P = expected prevalence or proportion =0.2, and, d = precision = 0.05).

3. Results and Discussion

3.1 Temperature

The interpolated mean annual temperature from 1993 to 2017 has increasing trend which is increasing with an annual rate of +0.004 °C per year which is supported by people's perception as most of the respondents felt increase in summer and winter temperature.

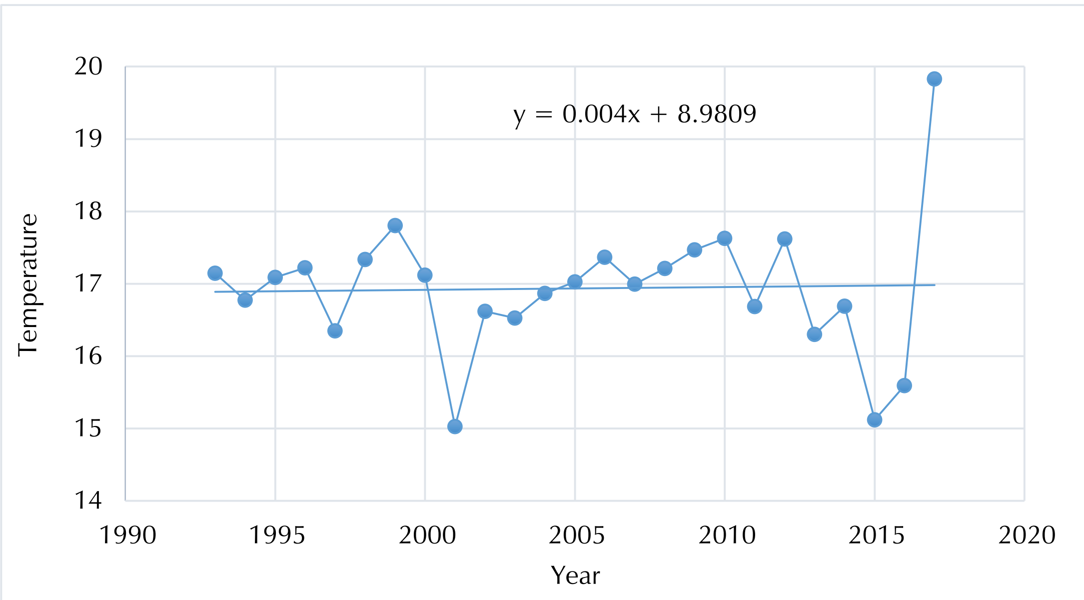

Figure 2. Annual mean temperature

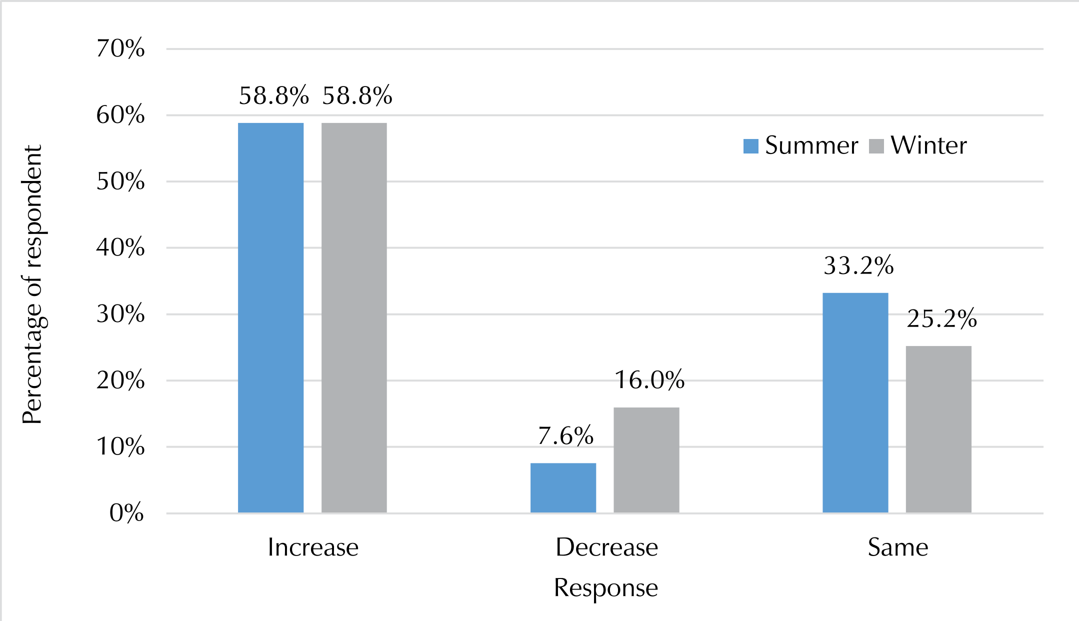

Figure 3. People's perception on change in temperature

3.2 Precipitation

The analysis of the mean annual precipitation has shown that the mean annual rainfall has been decreasing at the rate of -2.231 mm/year which is also supported by people's perception as most of the respondents replied there is decrease in rainfall pattern in both monsoon and winter rainfall.

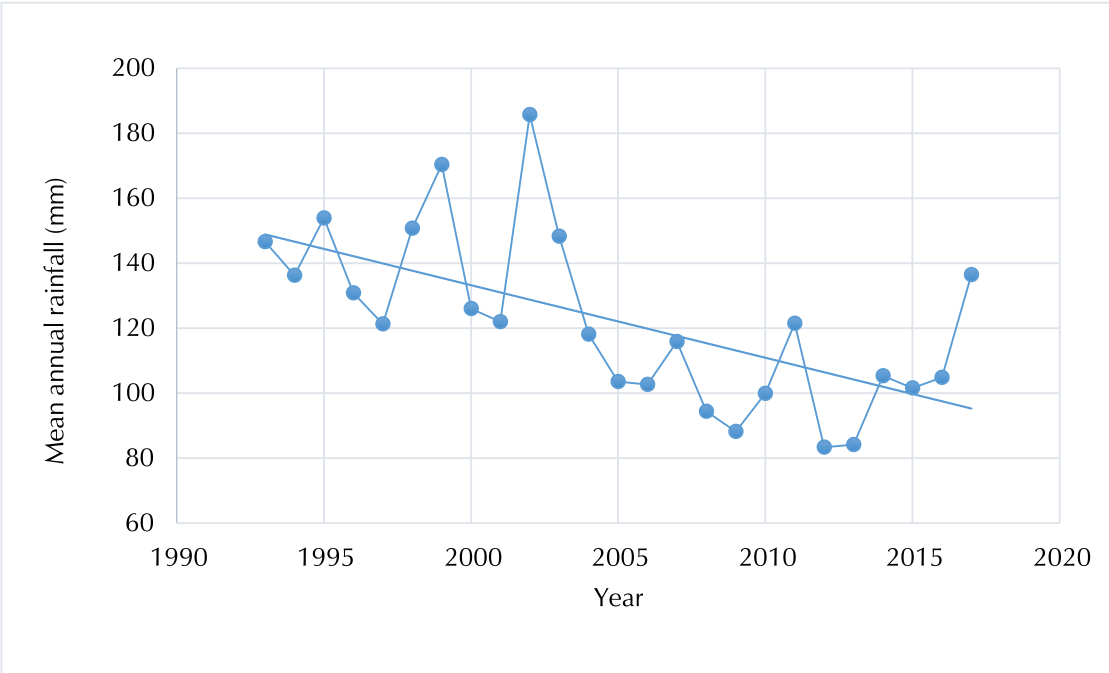

Figure 4. Annual Mean Rainfall

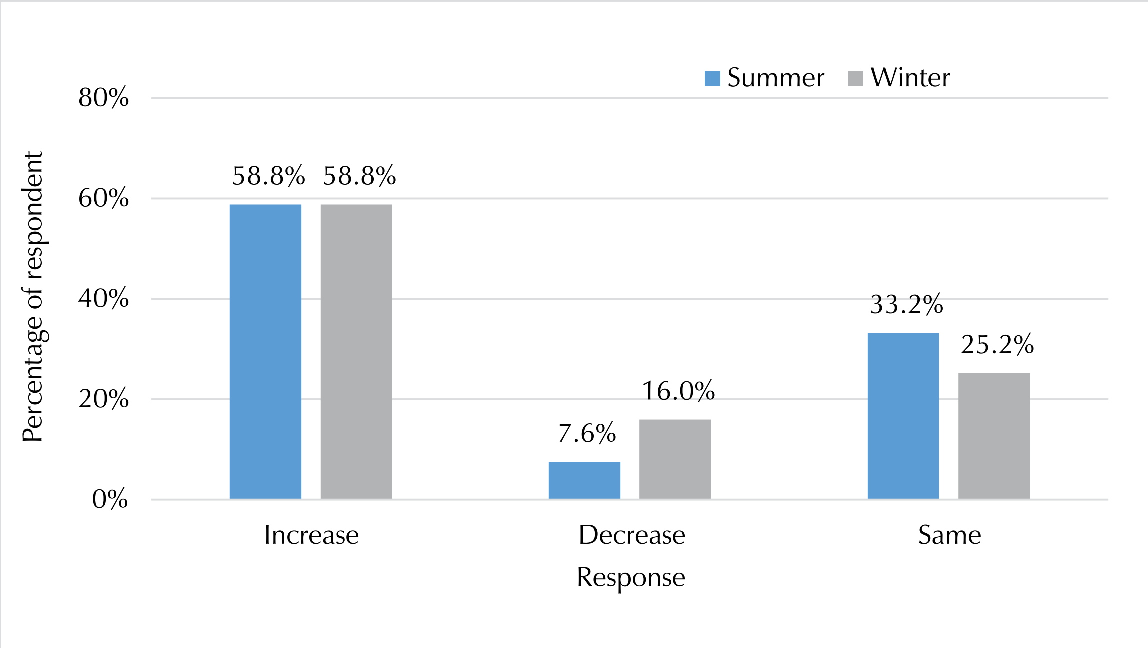

Figure 5. People's perception on change in rainfall pattern

3.3 Source of water resources

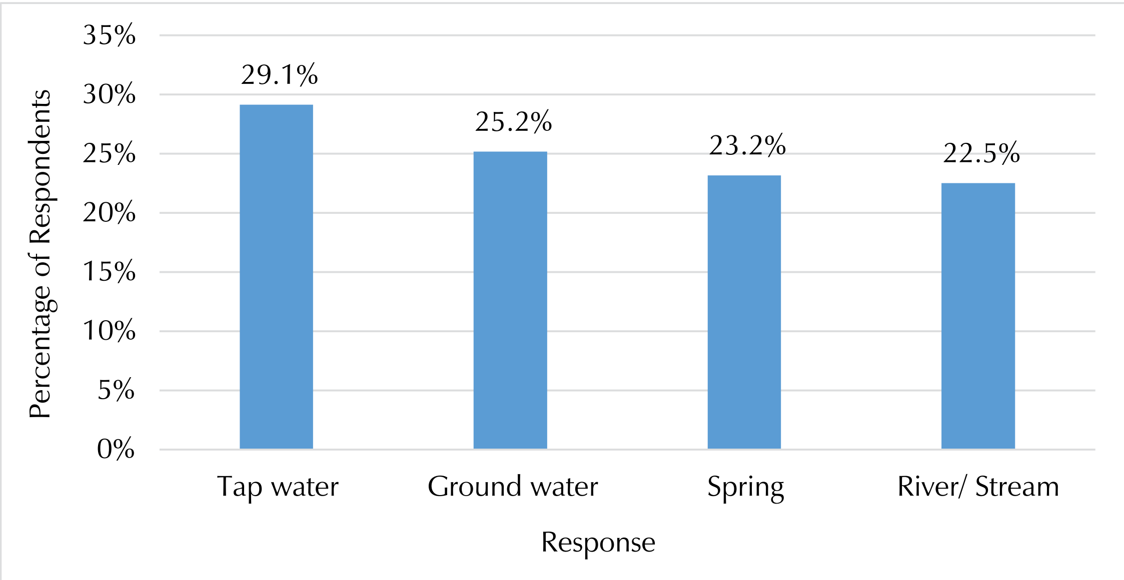

Figure 6. Source of water resources

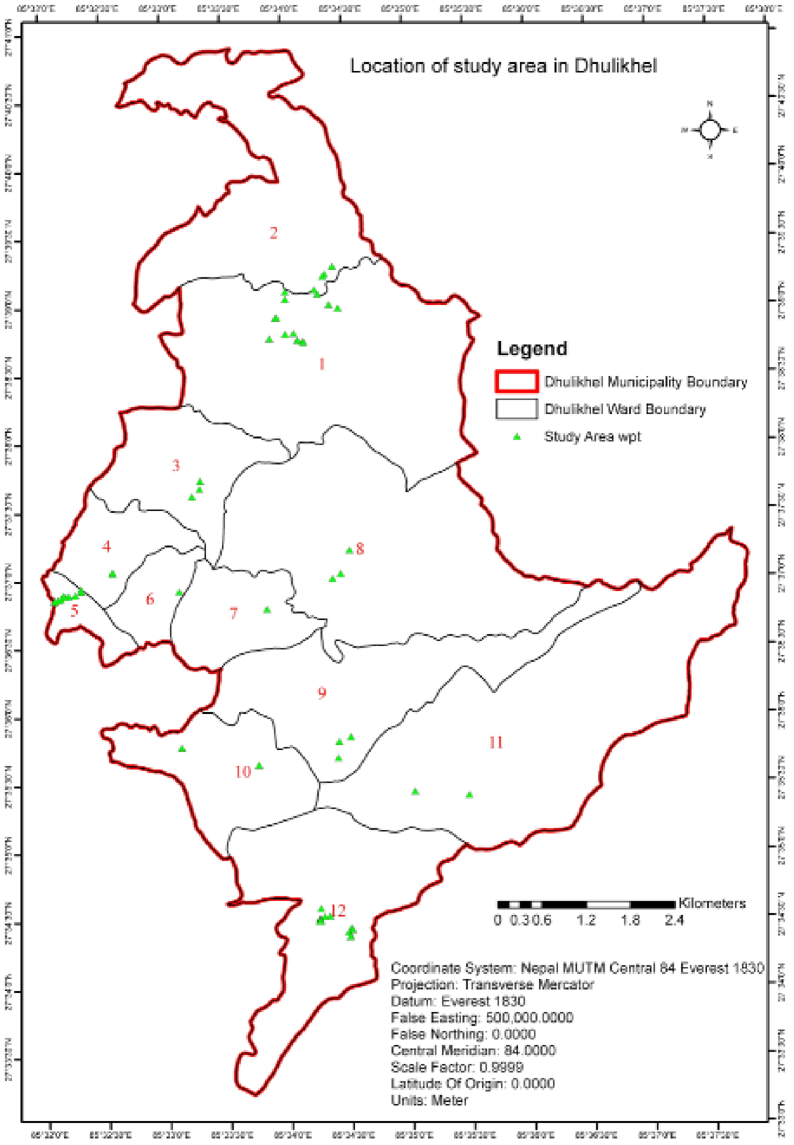

Figure 7. Natural water resources in Dhulikhel municipality

During the field visit, it was found that the main source of water for most of the respondents (29.14%) is tap water provided by managed drinking water supply organization known as Dhulikhel Drinking Water User Committee (DDWUC). The main source of DDWUC is Kharkhola, which a tributary of Roshi River, is 14 km far from Dhulikhel. The facility of tap water isn't available is overall area of the study area. DDWUC is able to provide tap water facilities in ward no. 3, 4, 5, 6, 7, 8, and 11 while other remaining wards aren't provided with the tap water, people on these wards depends on natural sources of water such as spring, ground water, river, stream and well. As per to Dhulikhel municipality, the majority of supply of water pipes in available in ward no 11 whereas ward no 3 has the least facilities of water supply.

About 81.1% of the HH have facility of tap water in their house whereas there are also other natural resources of water; boring 1.9%, ground water (kuwa) 2.7%, and spring (12%) (Dhulikhel municipality). But Pandey and Bajracharya discussed that only 48% of HH have get facility of water pipes in their house, however, the supply is insufficient for their daily use. The user committee has been able to supply 13.8 million liters of water per day out of 23 million liters per day of demand (Pandey & Bajracharya, 2017). The demand of the water supply is fulfilled by natural source of water from local seasonal springs, well, ground water, buying through jars and tankers. Besides DDWUC, there are also other many other small user committees in the study area, which are the formal user committees that are formed as per the act, and some informal institutions formed by local people like Sthaniya Sarokar Samiti (Local Concern Committee), Sangharsha Samiti (Struggle Committee) and Roshi Khola Sarokar Samuha (Roshi Khola Concern Group) (Devkota & Neupane, 2018). In addition, there is another water supply system, which was built in support of the Indian embassy as early as 1982 (Tiwari, 2008).

3.4 Status of water resources

During the household survey, about most of respondents replied that there is decrease in the amount of water in water resources.

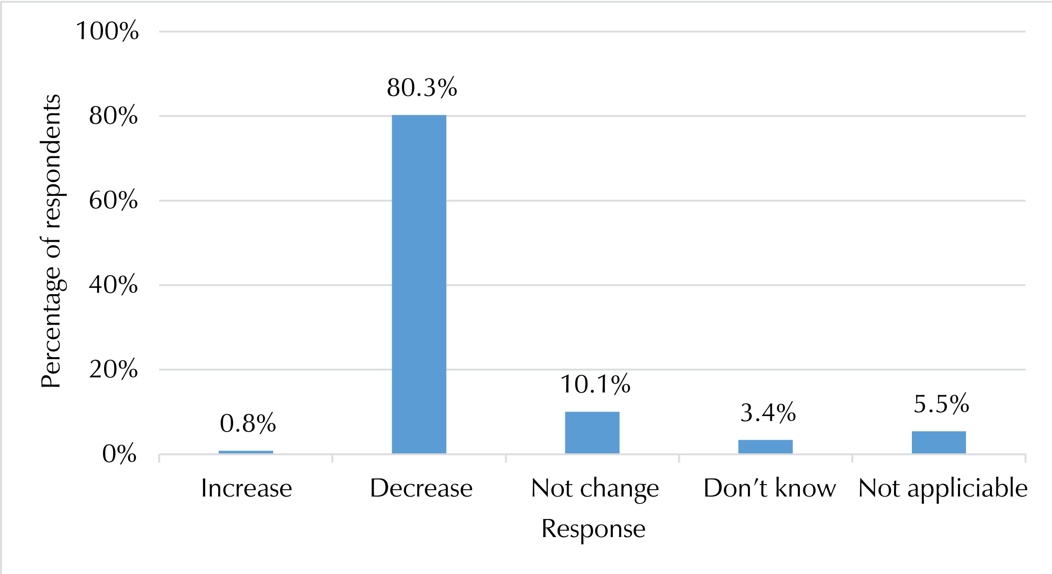

Figure 8. Change observed in water resources

Similarly, most of the respondents also responded that streams, rivers, rivulets or springs and well, tube wells or ponds have already dried up which is explained in Figures 9 and 10, respectively.

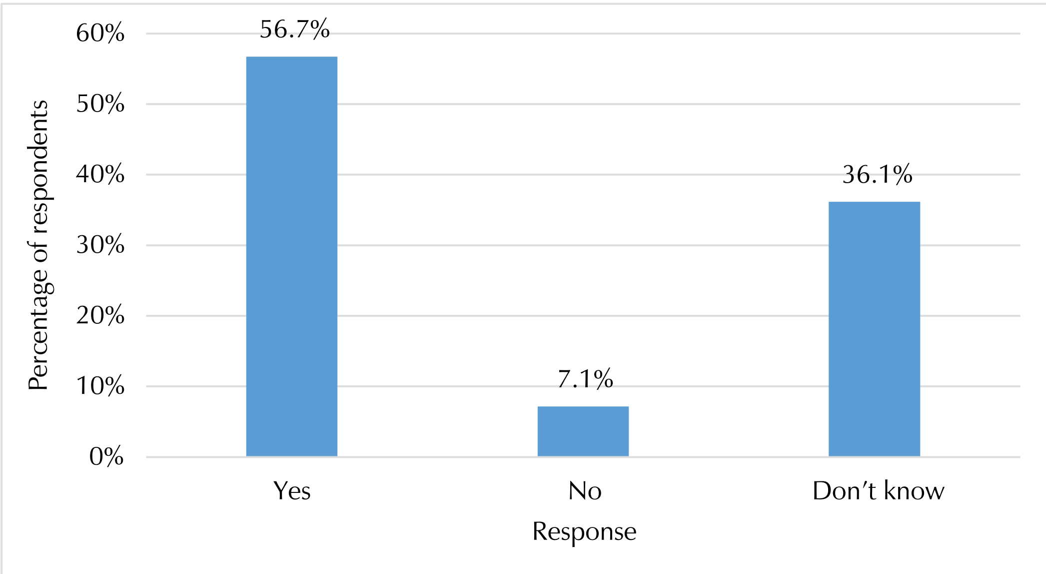

Figure 9. Streams, rivers, rivulets or springs dried up

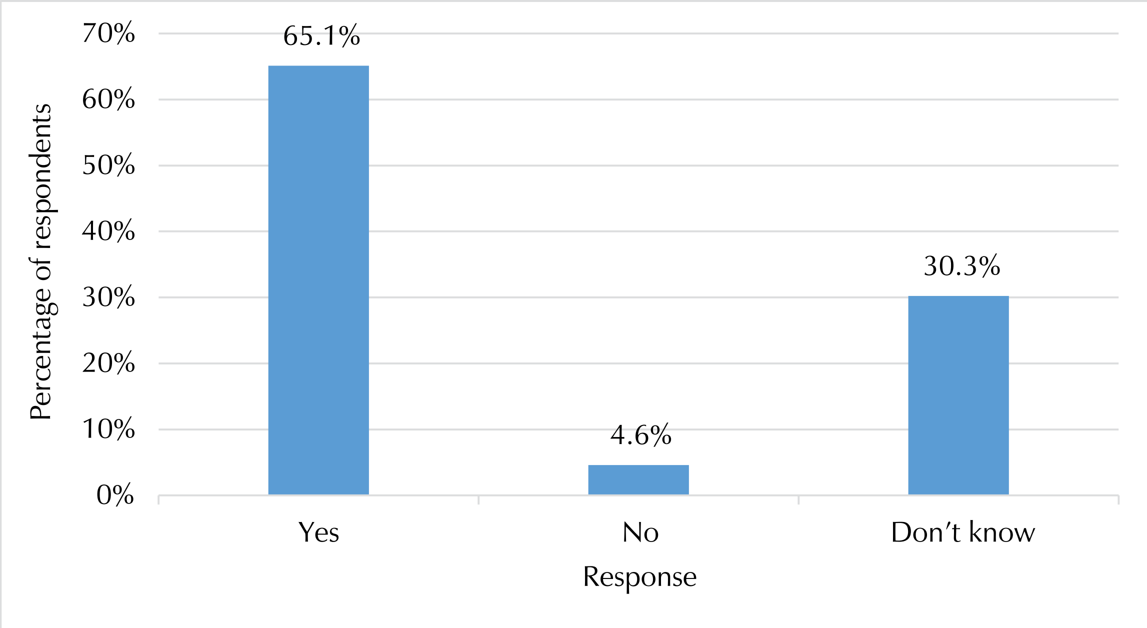

Figure 10. Well, tube wells or ponds already dried up

3.5 People's perception on water availability

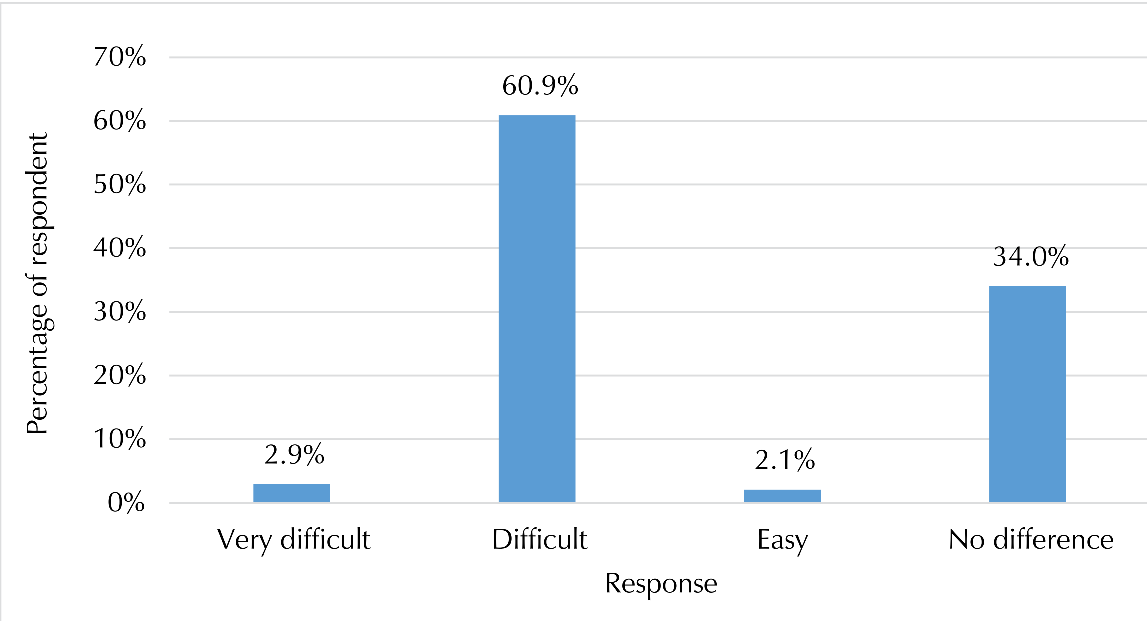

Figure 11. Access to water resources than previous days

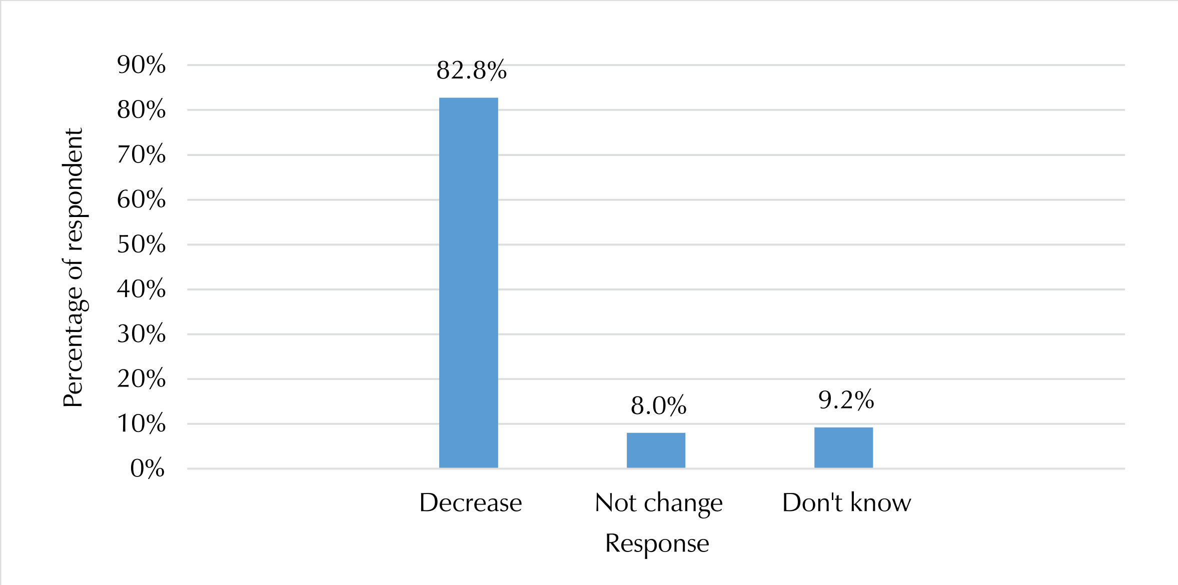

Figure 12. Change in the duration of water flow in piped water on daily basis

During the household survey, 60.9% respondents replied that there is difficult to access to water resources than previous days and also most of the respondents (82.8%) experienced decrease in change in the duration of water flow in piped water on daily basis. A previous study had shown that the supply of water gradually decreased and became insufficient in Dhulikhel, and had concluded that 24 hrs water supply reduced to less than 2 hr/day (Devkota & Neupane, 2018).

3.6 Locally adopted coping and adaptive strategy

To adopt with scarcity of water during dry season for domestic use, local people have adopted several strategies. On the basis of the field survey, most of the local people (35.5%) store water on tank or gallon to cope with scarcity of water during dry season. About 21.3% respondents rely on distant water sources. While about 18% respondents depend on ground water extraction. Likewise, around 17.4% use less water for drinking/washing and other purpose and 7.9% buy water tank to cope with scarcity of water during dry season, which is described in Figure 13.

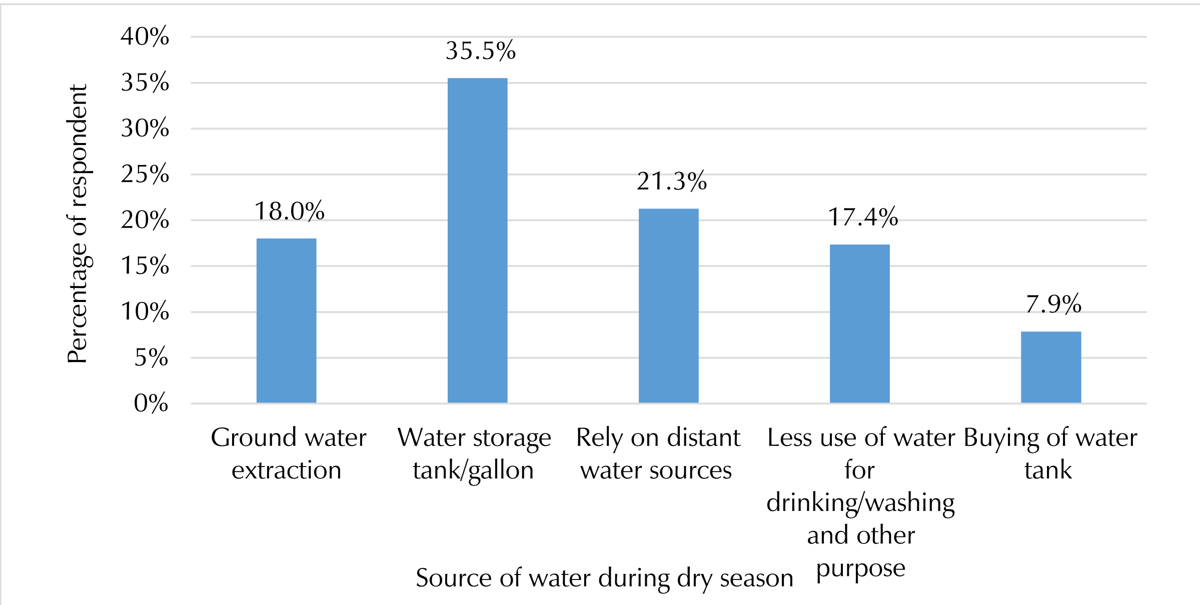

Figure 13. Source of water during dry season

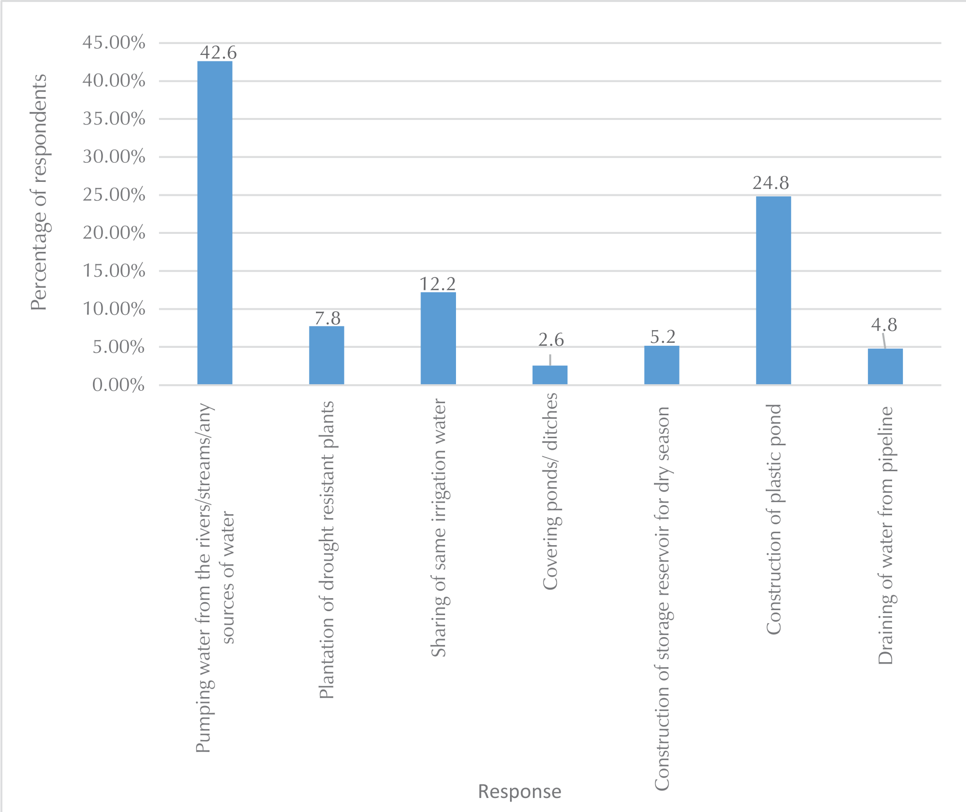

Figure 14. Coping strategy adopted for crop production in dry days

To cope for crop production in dry days, about 42.6% of respondents reported that pumping water from the rivers/streams/any sources of water while 24.8% of respondents construct plastic pond. Similarly, about 12.2% respondents informed that they share same irrigation water. Furthermore, 7.8% respondents do plantation of drought resistant plants, 5.2% construct storage reservoir for dry season, 4.8% of respondents use draining of water from pipeline and 2.6% respondents use covering ponds/ ditches.

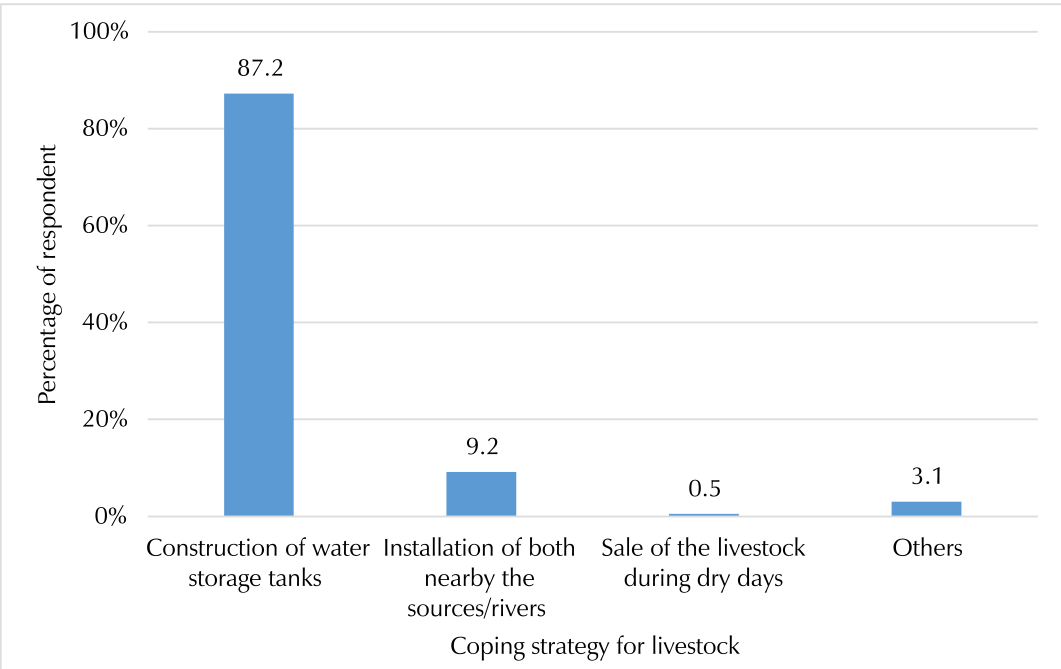

Figure 15. Coping strategy for livestock

Local people also adopted several coping strategy for livestock due to water shortage. Majority of respondents adopt (87.2%) construction of water storage tanks. About 9.8% and 0.5% response installation of both nearby the sources/rivers and shifting from high water consuming animals to low consuming animals. About 3.1% respondents adopt other strategy like pumping water from spring, stream and ground water.

4. Conclusions

The district headquarter of Kavre district, Dhulikhel has the problem regarding reliable water supply for over three decades and the water stress has increased more after the increase in geographical size resulting increasing population in 2014/15. The study area has struggled with water stress and reliable water supply for over three decades as it experiences variable rainfall patterns and increasing water demand (Pandey, 2017). During field visit, 93% of respondents answered that there was change in water availability and 83% experienced decrease in change in the duration of water flow in piped water on daily basis. The supply of water gradually has decreased and became insufficient in Dhulikhel and 24 hours water supply is reduced to less than 2 hr/day (Devkota & Neupane, 2018). The HH survey also shows that the most of the natural water resources such as streams, rivers, rivulets, springs, ponds, and well are already dried up and are also in the state of dying. The earthquake can also be the reason of drying water resources and most of the respondents had revealed that water resources has dried up after earth quake of Nepal in 2015, however, the study of the earthquake is limitation of the study. To cope with scarcity of water, local people has adopted several strategies such as storage of water on tank or gallon, rely on distant water sources, ground water extraction, less use water for drinking/washing and other purpose, and buy water tank. Furthermore, they also adopt coping strategies like pumping of water from the rivers/streams/any sources of water, construction of plastic pond, sharing of same irrigation water, plantation of drought resistant plants, construct storage reservoir for dry season, and drains of water from pipeline for crop production and construction of water storage tanks, installation of both nearby the sources/rivers and shifting from high water consuming animals to low consuming animals are the coping strategy for livestock.

5. References

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Annexes I: Program Agenda

Research Seminar on Climate Change
24 Falgun 2075 (8th March 2019)
Hetauda, Province No. 3

Time	PROGRAM
8:00 – 9:00	Registration and Breakfast
9:00 – 10:00	Opening (MC: Ms. Sanju Shrestha, Program Associate, Clean Energy Nepal) Welcome: Prof. Basudev Pokhrel, PhD. Assistant Dean, Faculty of Forestry, Agriculture and Forestry University (AFU) **Keynote Presentation on Status and Scenario of Climate Change Research and Key policy initiative in climate change sector in Nepal:** Mr. Manjeet Dhakal, Board Member, CEN Speaker: • Prof. Nabaraj Devkota, PhD. Director, Vice Chancellor, Agriculture and Forestry University • Prof. Balram Bhatta, PhD., Dean, Faculty of Forestry, AFU • Prof Sanjay Nath Khanal, PhD., SchEMS-Pokhara University • Mr. Shiva Kumar Wagle, Secretary, Ministry of Industry, Tourism, Forestry and Environment, Province No. 3 • Assoc. Prof. Sudeep Thakuri, PhD. CDES, TU
10:00 – 10:10	Break
10:10 – 12:00	**Oral Presentation: Chair of the session Prof. Dr. Sanjay Nath Khanal** Entailment of climatic factors on human health due to Malaria (case of
10:10-10:30	Bharatpur, Chitwan) Presenter: **Lata Neupane**
10:30-10:50	Agroforestry is the Best Way to Diminish the Climate Change Effect and to Uplift the Livelihood Among Chepang Under New Federal Structure of Nepal: A Case Study of Raksirang Rural Municipality Under Province 3
10:50-11:10	Presenter: **Raju Chhetri** Forestry Practices for Climate Change Adaptation in Mid-hills of Nepal Presenter: **Prashant Paudel**
11:10-11:30	Impact of climate change on water availability: A case study of Chandragiri Municipality, Kathmandu, Nepal
11:30-11-50	Presenter: **Shristi Bantha Magar** Understanding the nexus of climate change and migration: A case of Dhye people from Upper Mustang Presenter: **Pragya Serchan**
11:50 – 1:00	Lunch
1:00 – 2:00	**Poster Presentation, Chair of the session Assoc. Prof. Dr. Sudeep Thakuri** 6 poster presentation and discussion
2:00 – 3:00	Conclusion and Closing

Annex II: Photos of the Program

Group photo of the participants

Participants of the program

Mr. Manjeet Dhakal delivering presentation in the program

Participants of the program

Prof. Nabaraj Devkota, Director of DoREX, AFU sharing his remark in the program

Prof. Dr. Sanjay Nath Khanal sharing his remark on the program

Secretary of the Ministry of Industry, Tourism, Forest and Environment of Province No. 3, Mr. Shiva Kumar Wagle Sharing his remark on the program

Assoc. Prof. Dr. Sudeep Thakuri from CDES delivering his remark on the programme

Dean of Faculty of Forestry, Agriculture and Forestry University, Sharing his remarks.

Participants of the program

Sanju Shrestha from CEN facilitating the program

Participants of the program sharing their remarks and queries in the program

Researcher presenting their poster in the program

Researcher presenting their paper in the program

Researcher presenting their poster in the program

Researcher presenting their poster in the program

Researcher receiving the certificate from the organizer

Mr. Lalmani Wagle, SPO-CEN, delivering vote of thanks in the program

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