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A Study of Climate Change and Meteorological Analysis in Different Ecological Regions of Nepal

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Abstract

Climate change is caused by the increase of greenhouse gas emissions and the associated vulnerability is affecting the whole earth system. The climatic vulnerability has three components; exposure, sensitivity and adaptive capacity. The vulnerability is expressed in term of an index, ranging from 0-1. The inclusion of Climate Risk and Vulnerability (CRV) could be used for the analysis of potential impacts of climate change. CRV is a tool to adapt the climate change impacts in the areas all aspects of environment. Since, it is identified that one of the main component which is severely affected by the climate change is the Water source and water induced extreme events. It is known that when sensitivity is higher, the vulnerability tends to be high unless the adaptive capacity neutralizes the effects; wealth and social factors play a great role in enhancing adaptive capacity. Because of the uneven nature of the climatic factors, the effect of vulnerability also tends to be uneven. Adaptive capacity is an adjustment to reduce the adverse effects of climate change and enhance the benefits of it. The natural system takes its own course, but human intervention such as mitigations measures supports the natural process of adaptation. Nepal's Contribution to Global GHG is minimum, however, the effect of climate change is severe such as increasing, landslide, GLOF, flood, and erosion; all affecting the life of the people. In spite of these, Nepal has not initiated any programs to address the issues, but upon the formulation of Climate Change Policy (2011), some actions were initiated to combat with Climate change hazards through the Ministry of Forest and Environment and related agencies of the government in collaboration with international agencies. Nepal has participated in the different series of COP and integrated provisions of UNFCCC in National Development Plan and in constitution of Nepal, and signed the provisions of UNFCCC in 1994 as a party to it, and prepared initial national communication in 2004 by which CDM implementation was made mandatory for cleaner Production:

Keywords: Words: Climate Risk, Vulnerability, Assessment NepalEtc

INTRODUCTION

Concept of risk and vulnerability

Nepal has witnessed several major natural disasters in the last two centuries. A number of those highlighted are earthquakes, and climate induced disasters including the Koshi floods and the GLOF events in the higher Himalayas. Apart from these major disasters, Nepal also faces frequent landslides during monsoon season, thunder lightning, storms and regular seasonal flooding in terai areas. The combination of these multiple hazard events causes Nepal as a Vulnerable and risk posing country. In this context climate change causing risk and vulnerability is the topic of study.

The following parameters such as sensitivity, exposure, vulnerability, resilience, susceptibility, and adaptive capacity are important in relation to assessing vulnerability and for adaptation purposes and they are the determinants (IPCC 2001).

Figure 1: Showing the Relationship of the Climate Change Threat, Vulnerability and Adaptation (IPCC 2001)

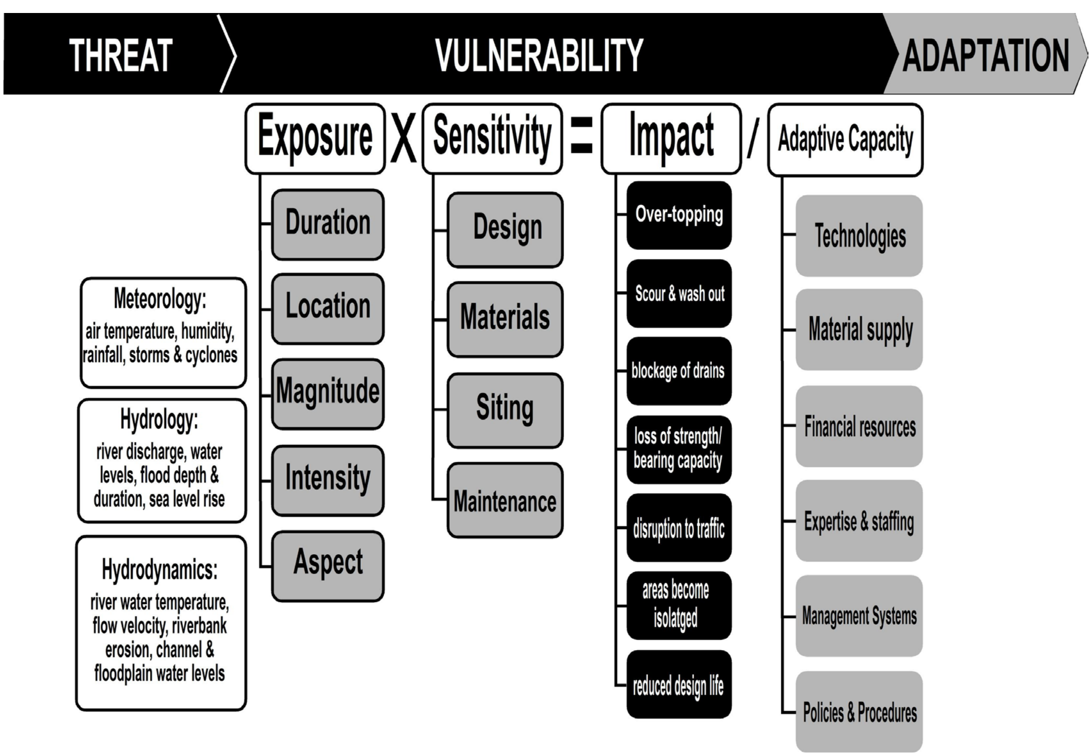


Table 1: Level the table with description

Hazard/ Component	Base Line (Source and time line)	Basis / Quantified Justification		Vulnerability Ranking &Inference Where is this parts in values below	Impact on Water Supply System Correlated to Adaptation Measures
		Climate Projections / Resource Availability			
Change in Temperature (Increase)	Himal 3^0C-10^0C Mountain10^0C-20^0C Terai- 20^0C-25^0C	0.05^0C to 0.06^0C per annum (DHM data, time?? source??) for whole data of Nepal	**Low to Medium** Projected rate of increase in temperature. Increasing trend over mid-century. Sub-project area falls whole Nepal		• Increased evaporation losses at abstraction point, during storage and distribution • Deterioration of water quality and increased treatment requirement (biological activity) • Reduced efficiency of Mech. & Elect. equipment (operating temperature range exceeded) • Increased energy charges. Net higher cost of production
Projected Precipitation Change (Decrease)	Himal :Snow/150mm-200mm Mountain: 275mm-2300mm Terai: 1100mm-3000mm	Baseline (1961-90) to Mid Century (2021-2050) Annual Avg.: -5 to 10% range in summer Monsoon: -10 to 20% range in Rainy season	**Medium** Nominal increase in rainfall over the year projected with higher spatial variation. Decrease in rainfall is projected as very minimal for sub-project region.		• Variation in source availability necessitating demand-side management • Need for additional source diversification & maintenance for tide-over supply during shortfall • Increased energy charges (higher drawdown) during conditions of lowered precipitation & lean flow. • Deterioration of water quality and increased treatment requirement • Increased terminal storage (by beneficiaries) resulting in increased wastage
Drought		Drought Risk in sub-project districts projected for mid-century (2021-2050) Monsoon season: Nil Summer season: 0 to 10%	**Low to Medium** For all the sub project area		• Precipitation decrease coupled with drought can increase salinity intrusion in surface water • Periodic monitoring required to observe change in water quality (salinity or other contaminants) • Need for additional source in areas with lowered availability of surface water.

Hazard/ Component	**Base Line (Source and time line)**	**Basis / Quantified Justification**		**Vulnerability Ranking &Inference Where is this parts in values below**	**Impact on Water Supply System Correlated to Adaptation Measures**
		Climate Projections / Resource Availability			
Floods/ Extreme rainfall events	Historical incidents of flooding in low-lying areas for plain area sub projects	Floods occurring in three project sides area higher there are the annual floods as per the local consultations	**Low to Medium** Low-lying areas near coast and adjoining rivers are at higher risk than inland significantly elevated areas	• Increased turbidity in river intake systems requiring higher pre-treatment / settling rates • Inundation of infrastructure and treatment facilities during storm events - loss of power/ disruption in treatment & service delivery • Additional costs of repairs and replacements	
Earthquakes and induced landslides	Last 2015 Earthquake in Nepal and 1991 Earthquake (Earthquake prone area)		**Medium to high** Medium risk in coastal areas (Z-III).	• Detailed design for infrastructure in coastal areas to consider incorporating Zone III Earthquake Resistant Structures' code provisions into elevated structures (WTP tanks, OHTs) and foundation of large structures (GLR/ CWR).	

Source: ADB, Nepal Climate Change Data sheet, 2016

OBJECTIVE/S OF THE STUDY:

The CRVA will assess the potential climate induced risks for the development attention of the Urban Water Sector and Sanitation Project in Nepal and aims to fulfill the following:

(i) Collateorganize, and review available baseline biophysical, environmental, demographic, socioeconomic, and policy data and information relevant to climate risk management within the context of the various ecological zone of Nepal;

(ii) Review existing studies, data, and information on current and projected climate change and disaster risks and vulnerability in the various ecological zone of Nepal;

(iii) Develop detailed scenarios of climate change variables as required for future time horizons pertinent to the project, including documentation of scenario method, data sources, uncertainties, and caveats;

(iv) Identify and discuss the implications of projected climate change impacts and associated uncertainties

METHODOLOGY, SCOPE AND LIMITATIONS

Vulnerability

Climate risk and vulnerability assessment is a cumulative assessment of different climatic and non climatic parameters from and around the particular project. For the quantitative assessment of these heterogeneous parameters were indexed.

Risk Assessment

Risk is the potential of losing or gaining something that has value (lives, livelihoods, infrastructure, health status, economic, social and cultural assets, different services etc.). The assessment of risk can be done in various ways, i.e. quantitatively, qualitatively or using both methods.

Methodological assumptions

The CRVA assessment study has following methodological assumptions during evaluating risk and vulnerabilities of the different subprojects.

- The data analysis in different Study Area has assumed homogenous ecological, socio economic and demographic distribution within particular reference to VDCs.
- The different secondary data were taken from CBS report 2011 and IEES for only four areas which are assumed to be most recent updates.
- The indicators and parameters of assessment were set, here after experts' consultation as individual interview and also on the basis of the available data, therefore it is assumed the parameters and indicators represent all sectors of climate change science and assessment.
- The historical timeline information were not recorded. The whole project is broadly categorized on Hilly and Terai(Plain) area and this assumption is main assumption to be categorized as an ecological division. Based on these two divisions climatic risk and adaptational measures are categorized.
- The vulnerability assessment method is more specific to community; however it was supposed to be equally applicable to urban water supply source and sanitation projects.

Limitations

- The study has been done within a very short time period; the most of data are used from secondary source from Department of Hydrology and Mteorology.
- Based on the ecological region only four locations representating the ecological zones have been taken as a sample.

CLIMATE CHANGE IMPACTS ON THE VARIOUS ECOLOGICAL REGIONS

Unstable steep slopes and fragile geological formation of a young growing mountain range with heavy monsoon rainfall leads to wide range of geological and hydro-meteorological disasters across the country. Nepal is divided into three major ecological region having mountains, hills and terai. Each region is distinct to it characteristics. The variation in geological characteristics together with torrential rain during rainy season result to landslides, debris flows, floods, and earthquakes. Apart from these disasters, there are several other manmade disasters reported in the country. After instatement of peace process in the country, Nepal is leading to the progressive development. In this juncture, there is a dire need to understand the characteristics of existing hazards and establish national disaster risk management plan for sustained development.

Baseline assessment

Topography:

Nepal has more than 6000 rivers that largely drain north to south. The three main rivers systems are the Karnali, Narayani and Saptakoshi. Forests occupy 42 percent of total area. A significant bulk of energy is derived from biomass, mainly fuel wood. Less than a third of the population has access of electricity which comes mainly from hydropower.

Table 2: Climate characteristics in different ecological belts of Nepal

Physiographic Zones	Ecological belt	Climate	Average annual precipitation	Mean annual temperature
High Himal	Mountain	Arctic/alpine	Snow/150mm-200mm	<3^{0}c -10^{0}C
High Mountain				
Middle Mountain	Hill	Cool/Warm	275mm-2300mm	10^{0}C-20^{0}C
Siwalik (Churiya)	Terai	Tropical/Sub tropical	1100mm-3000mm	20^{0}C-25^{0}C
Terai (Plain)				

Source; WECS,2013

Climate: rainfall, temperature, extreme events and observed trends

Nepal's climate is influenced by the Himalayan Mountain range and the South Asian monsoon (NCVST, 2009). The climate predominantly influenced by the monsoon and westerly disturbance is characterized by four distinct seasons, namely: (i)_ Pre-monsoon (March-May), (ii) Monsoon (June- September), (iii) Post-monsoon (October-November); and (iv) Winter (December- February) (Cite).

Average annual rainfall is approximately 1800 mm but there are marked spatial and temporal variations both north-south and east-west.
Temperature varies with altitude and season. It increases from north to south and decreases with altitude. The winter season is coldest, with the highest temperature during the pre-monsoon period.

Temperature and rainfall analysis

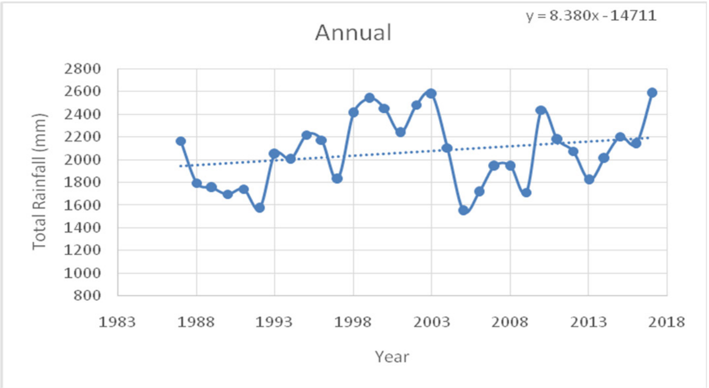
To identify the Climatic pattern of the Nepal , it is assumed that four different ecological sites to represent the whole Study area. Four study site have been chosen as :
Hilly area : Charikot and Kathmandu
Churiya Area : Pragatinagar Dang
Terai (Plain Area) : Mirchaiya , Siraha
To represents these sub projects, it is analyzed the following climatic analysis:

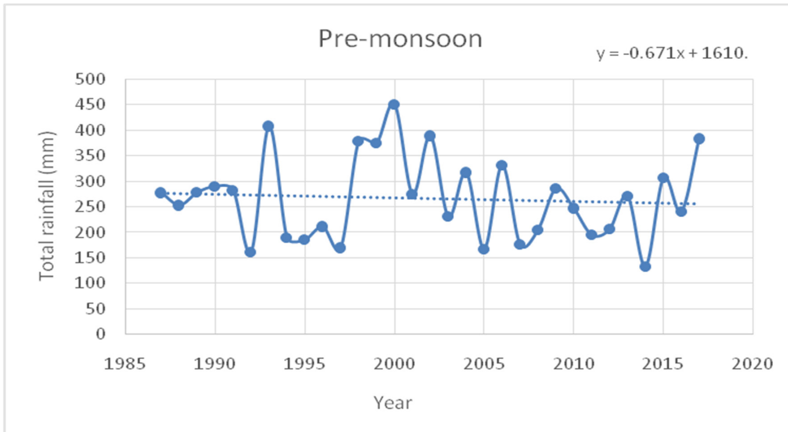
a. Charikot
b. Kathmandu
c. Dang
d. Lahan (Plain Terai)

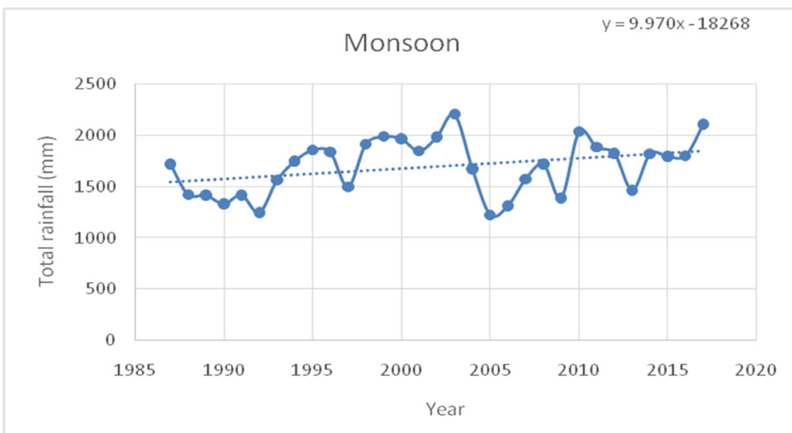
Charikot

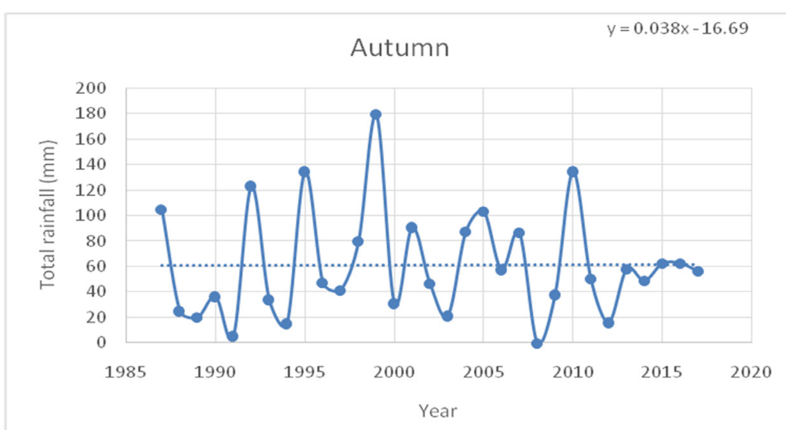
The annual rainfall of the Charikot station showed increasing pattern. The rate of increment was observed to be 8.38mm per year with maximum average annual rainfall in 2017 (2985.02 mm) and minimum rainfall in 1992 (1569.8 mm). The overall trend of pre-monsoon and winter season were observed to be decreasing whereas that of monsoon and autumn season were increasing with time.

Rainfall




Pre-monsoon
y = -0.671x + 1610.
500
450
400
350
300
250
200
150
100
50
0
Total rainfall (mm)
1985
1990
1995
2000
2005
2010
2015
2020
Year


y = 9.970x - 18268
Monsoon
2500
2000
1500
1000
500
0
Total rainfall (mm)
1985
1990
1995
2000
2005
2010
2015
2020
Year


y = 0.038x - 16.69
Autumn
200
180
160
140
120
100
80
60
40
20
0
Total rainfall (mm)
1985
1990
1995
2000
2005
2010
2015
2020
Year

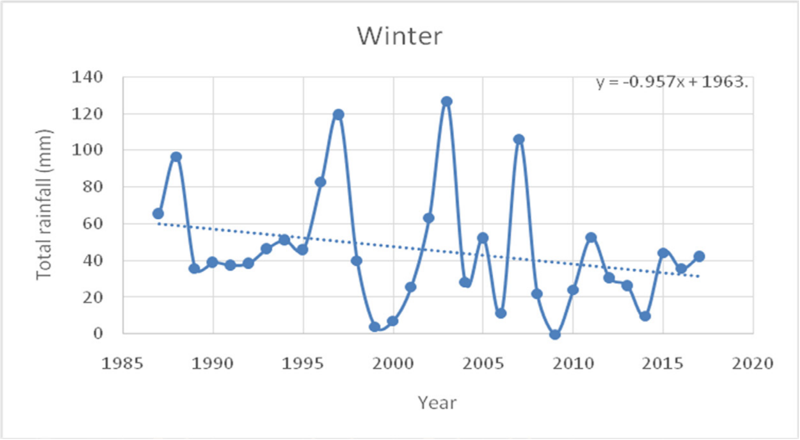
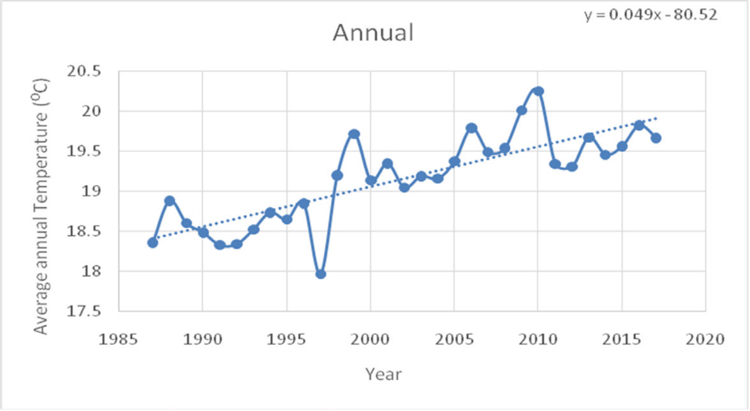
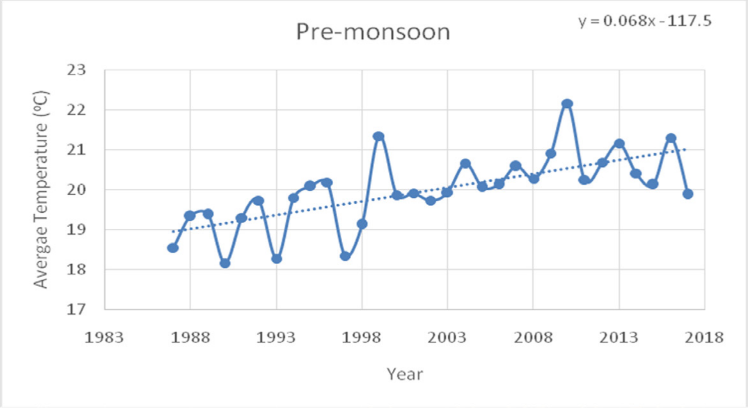


Figure 2: level by the name of figures

Kathmandu
Temperature





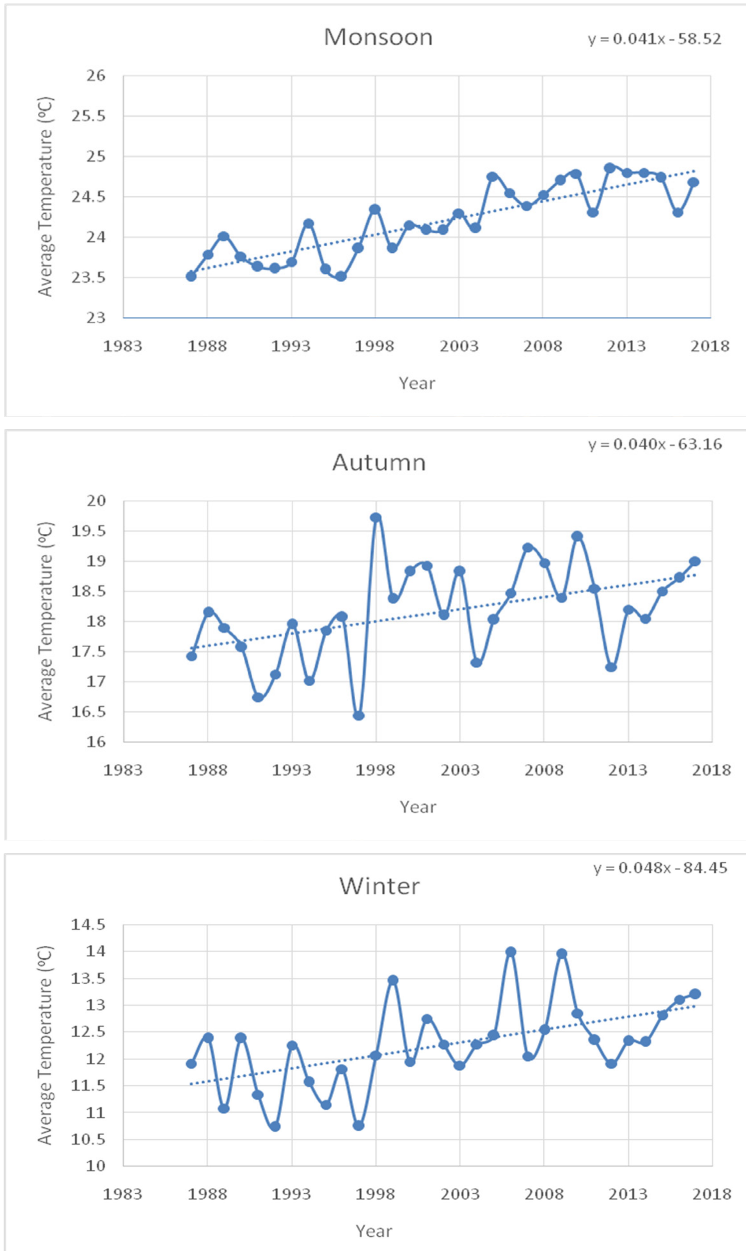
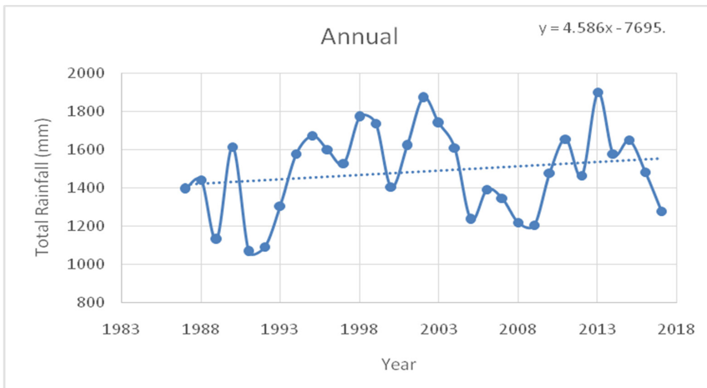
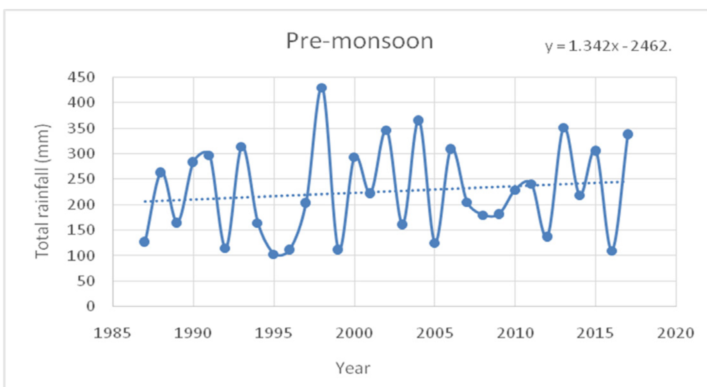


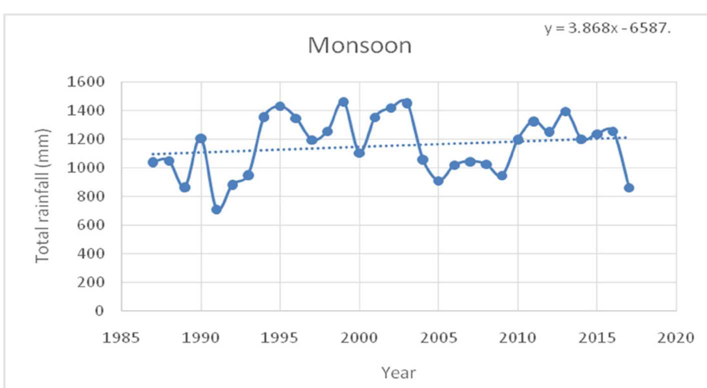
Figure 3: Level by the name of figures

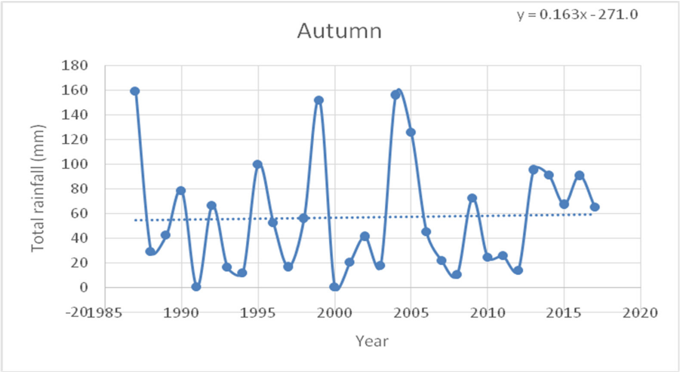
The annual pattern of temperature in Kathmandu was observed to be increasing in the rate of 0.0498 degrees per year. The highest annual average temperature recorded in 2010 (20.25 °C) whereas the lowest annual average temperature was recorded in 1997 which was 17.97 °C. The overall pattern of seasonal temperatures was also found to be increasing. The rate of increment of pre-monsoon, monsoon, autumn and winter temperature were recorded to be 0.068, 0.0413, 0.041 and 0.048 degrees per year respectively.

Rainfall









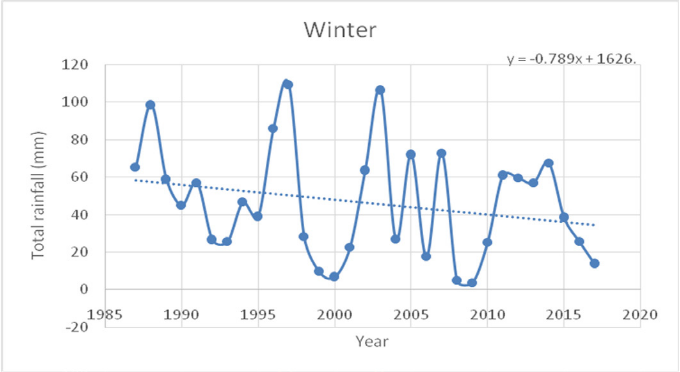
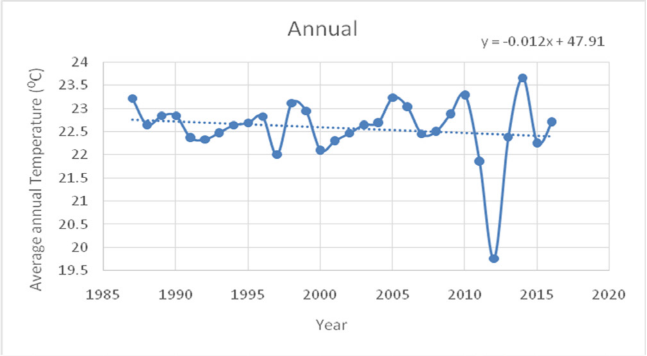


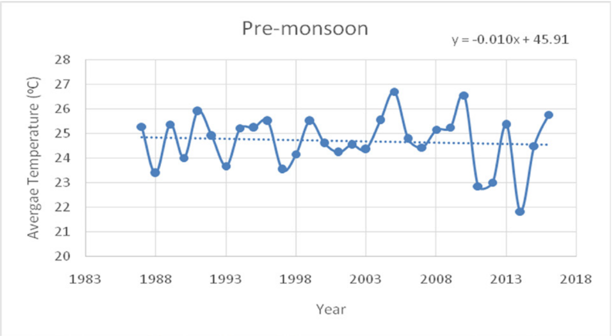
Figure 4:

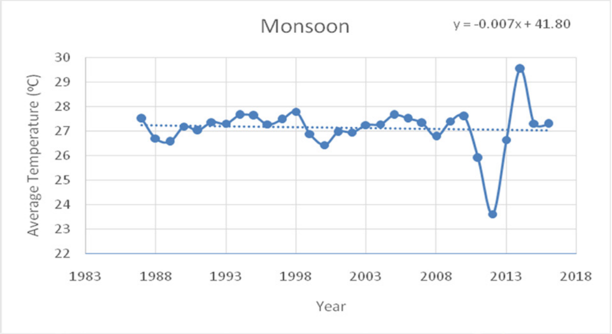
The annual rainfall of the Kathmandu station showed increasing pattern. The rate of increment was observed to be 4.5862 mm per year with maximum rainfall in 2013 (1899.3 mm) and minimum rainfall in 1999 (1067.9 mm). All the seasons showed increasing trend of rainfall except for winter season.

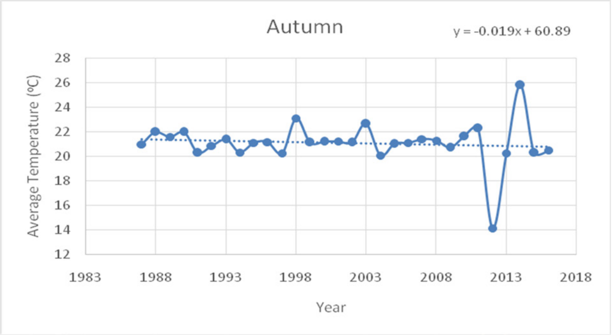
Pragatinagar , Dang :

Temperature




Pre-monsoon
y = -0.010x + 45.91
Avergae Temperature (ºC)
28
27
26
25
24
23
22
21
20
1983
1988
1993
1998
2003
2008
2013
2018
Year


Monsoon
y = -0.007x + 41.80
Average Temperature (ºC)
30
29
28
27
26
25
24
23
22
1983
1988
1993
1998
2003
2008
2013
2018
Year


Autumn
y = -0.019x + 60.89
Average Temperature (ºC)
28
26
24
22
20
18
16
14
12
1983
1988
1993
1998
2003
2008
2013
2018
Year

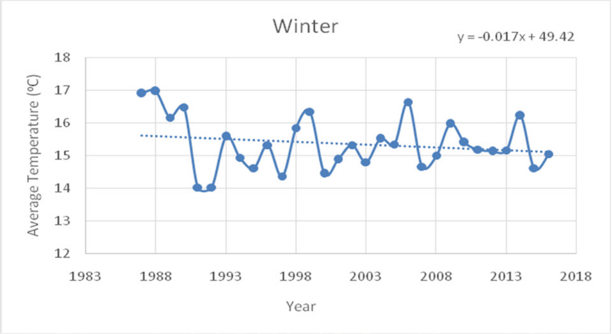
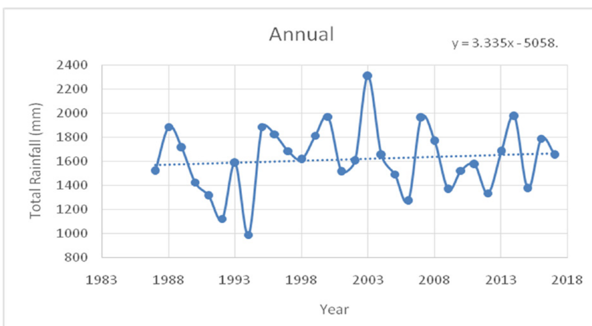

Winter
y = -0.017x + 49.42
Average Temperature (ºC)
18
17
16
15
14
13
12
1983
1988
1993
1998
2003
2008
2013
2018
Year

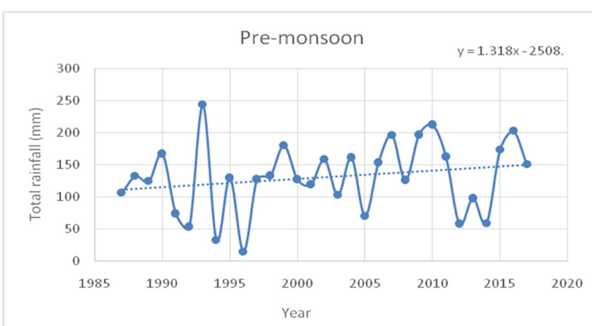
Figure 5:

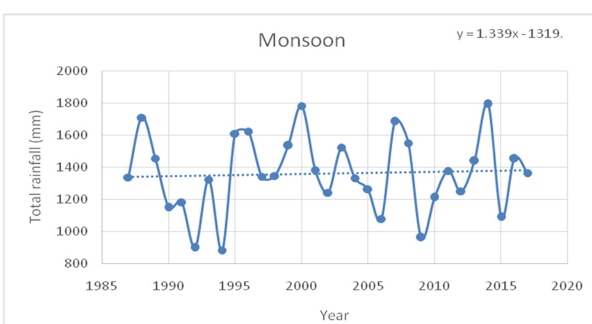
The overall annual trend of Dang (Pragatinagar) station was found to be decreasing in the rate of 0.01oC per year. For the period of 1987-2016 AD, the maximum annual temperature was recorded in 2014 (23.68oC) and minimum temperature was recorded in 2012 (19.77oC). Temperature was observed to be decreasing for all the seasons. The rate of decrement for premonsoon, monsoon, autumn and winter seasons were 0.01, 0.0073, 0.02 and 0.017 degrees per year respectively.

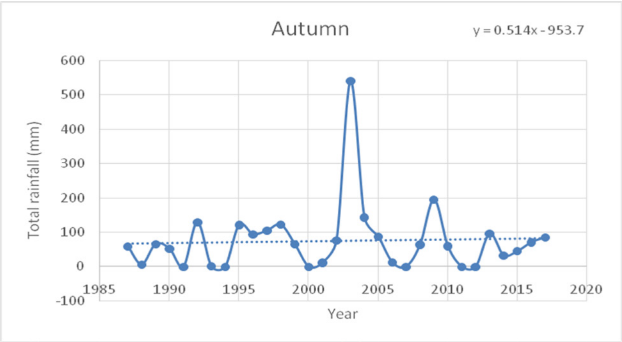
Why the temperature of Pragatinagar, Dang seems decreased in all the season??/ But, precipitation seems increased, justify it.

Rainfall









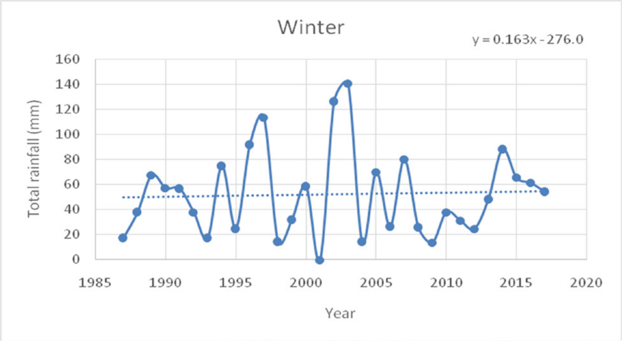
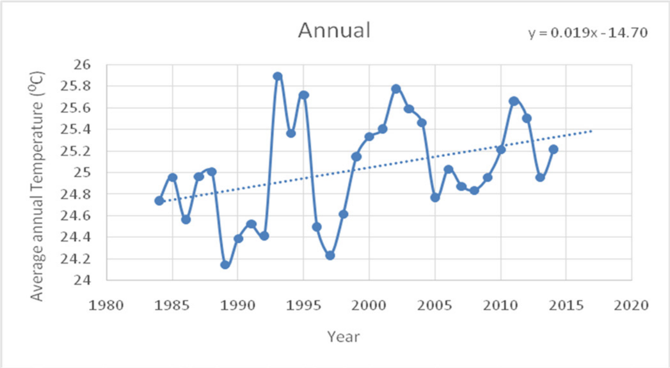


Figure 6:

The total annual rainfall of Tulsipur station was calculated to be increasing with the rate of 3.36 mm/yr. For the entire observation period minimum and maximum rainfall was recorded to be 991.9 and 2305.2 in 1994 and 2003 AD respectively. The trend was seen to be increasing for all four seasons.

Mirchaiya , Siraha

Temperature



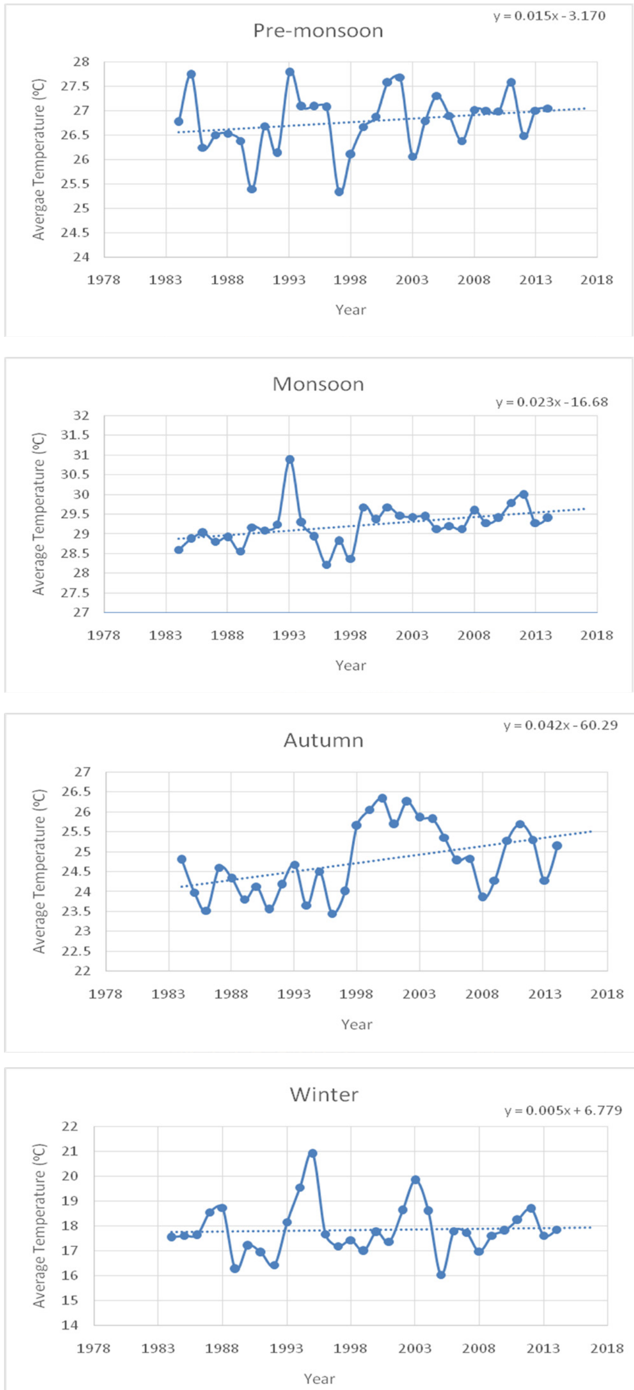
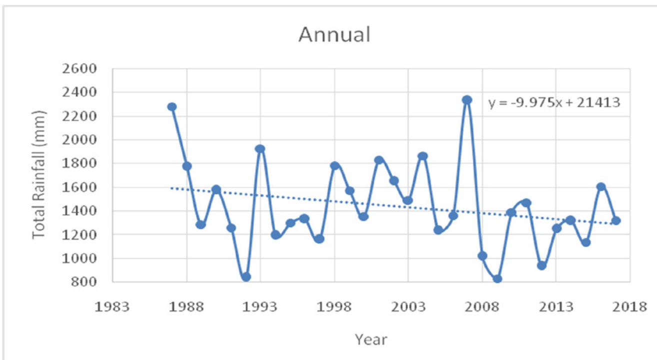
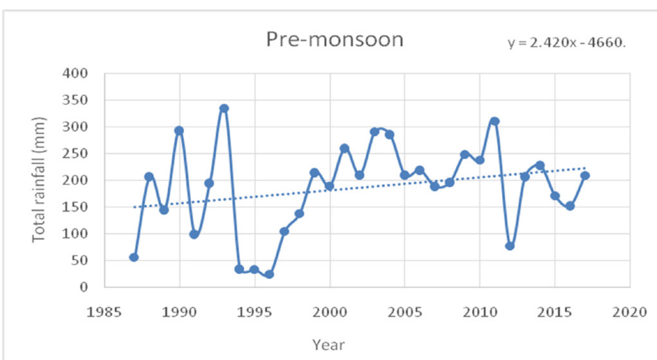

Pre-monsoon
y = 0.015x - 3.170
Avergae Temperature (ºC)
28
27.5
27
26.5
26
25.5
25
24.5
24
1978
1983
1988
1993
1998
2003
2008
2013
2018
Year
Monsoon
y = 0.023x - 16.68
Average Temperature (ºC)
32
31.5
31
30.5
30
29.5
29
28.5
28
27.5
27
1978
1983
1988
1993
1998
2003
2008
2013
2018
Year
Autumn
y = 0.042x - 60.29
Average Temperature (ºC)
27
26.5
26
25.5
25
24.5
24
23.5
23
22.5
22
1978
1983
1988
1993
1998
2003
2008
2013
2018
Year
Winter
y = 0.005x + 6.779
Average Temperature (ºC)
22
21
20
19
18
17
16
15
14
1978
1983
1988
1993
1998
2003
2008
2013
2018
Year

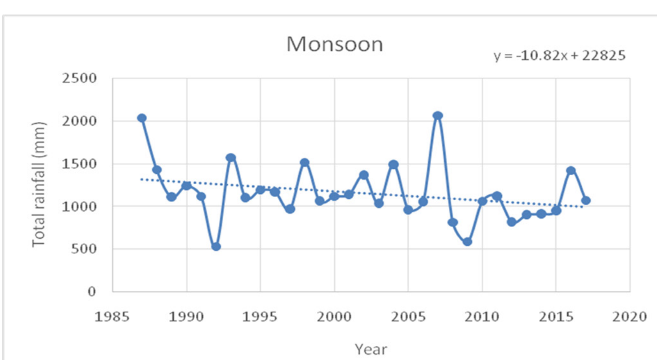
Figure 7:

The average annual temperature in Lahan station was observed to be mounted with time in the rate of 0.02oC per year. The average annual temperature attained minimum and maximum values of 24.15oC and 29.89oC in 1989 and 1993 AD. The overall trend of seasonal temperature was also observed to be positive. The rate of increment for pre-monsoon, monsoon, autumn and winter seasons were 0.015, 0.023, 0.042 and 0.005 degrees per year respectively.

Rainfall







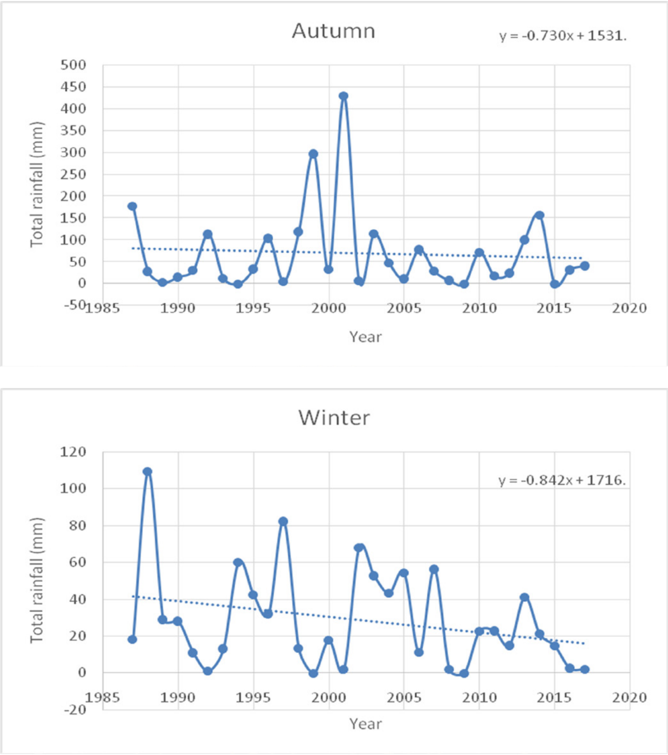


Figure 8:

The annual rainfall of the Siraha station showed decreasing pattern. The rate of decrement was observed to be 9.9757 mm per year with maximum rainfall in 2007 (2331.9 mm) and minimum rainfall in 1992 (840.2 mm). All the seasons showed increasing trend of rainfall except for pre-monsoon.

Flood hazard susceptibility

Rainfall during the monsoon season is caused by the influence of both the south-east and south-west Monsoon, characterized by intense rainfall during the four months from June to September, contributing to 80% of the rainfall. During the monsoon, rivers originating from the Mahabharat range; viz., the Kankai, Kamal, Bangmati, West Rapti and Babai causes greater damage in floodplains of Terai region. Riverine floods from the major perennial rivers generally rise slowly in the southern Terai plains. Inundations of large areas are due to overflowing river banks resulting in extensive damage to life and properties. Flash floods (ICIMOD, 2007) are severe floods that occur with little or no warning. They are characterized by little time lapse between the start of the flood and peak discharge. Flash floods are dangerous because of the suddenness and speed with which they occur. They are triggered by extreme rainfall, glacial lake outbursts, landslide damming or the failure of dams – whether man-made or caused by landslides, debris, ice, or snow. Water flow in the rivers in the Siwalik range in southern Nepal are characterized by a sharp rise of flood water followed by a rapid recession, often causing high flow velocities, resulting in damage crops, property, lives, and livelihoods. Damming of a river by a landslide is a potentially dangerous situation. Such a blockage of the river flow is more common in narrow valleys where the slopes are steep on both sides of the river. Landslide dams will eventually collapse, causing heavy downstream flooding resulting in loss of life and property. Glacial lakes are common in the high altitude areas of the country. These lakes often contain huge volume of water. The lakes are dammed behind moraine ridges which are stable depending on the amount of ice within these ridges; and their unstable condition may lead to a breakage of the same, creating a Glacial Lake Outburst Flood (GLOF) with the potential to cause great damage downstream. Altogether 2,315 glacial lakes have been identified in Nepal and about 14 GLOFs recorded to have occurred between 1935 and 1991 in Nepal (ICIMOD, 2007). In total, 20 glacial lakes have been identified as being potentially dangerous at present (cite latest literatures and study of ICIMOD).

Drought hazard susceptibility

Nepal is experiencing a rapidly worsening drought, caused by erratic rainfall in summer and an almost total lack of rainfall during winter. Some studies of past drought suggest that unusual events were randomly found in the country's historical records. Every year for the past decade, few parts of the country have experienced very short or very long dry periods even within the wet season (DHM, 2001-2009). To cite, the western half of the country has been influenced by a dry spell till the end of July while the eastern half was havocked by floods in 2002 (DHM, 2001-2009). Similarly, the southern plains of far and midwestern regions recorded almost 75% of the normal rainfall while the eastern Terai experienced dry spell followed by heavy rainfall in July in 2004 (DHM, 2001-2009). During severe dry winter in 2006, the country received less than 25% of the normal winter rain, affecting winter crops (DHM, 2001-2009). In the same year, monsoon was also weak. June, July and August remained dry, except for flooding in July in the mid and far western regions. Eastern regions experienced drought and western regions were affected by floods, both of these events affect the agricultural production. Nine districts of the Terai (Southern plains) region were declared as dry regions for the first time in Nepal. After 2006, 2009 winter is another driest winter in Nepal. Only a few spells of isolated rainfall was recorded in the western parts in February and in the mountainous regions in December (DHM, 2009). The study on drought in time and space is most essential. It is also important to study the probability of having a consecutive dry period during the growing season of a crop. Despite several technical constraints, there is an urgent need for early warning and drought monitoring system in Nepal due to the wake of global warming and climatic changes. The present study on drought in Nepal is the first attempt to analyze the drought in detail by using standardized precipitation and soil moisture indices.

ASSESSMENTS USING FUTURE PROJECTIONS

Rainfall change

The OECD model projections on rainfall have a semblance to those presented in IPCC 2007. In terms of winter precipitation, the models project almost no change in precipitation in Western Nepal and up to 5-10% increase in precipitation in Nepal. During the summer months, however, projections depict that an increase in precipitation for the whole country is in the range of 15 to 20% . The NCVST (2009) study, projects both increase and decrease in mean annual rainfall with no clear trends. In terms of spatial S-distribution, the study findings project an increase in monsoon and post-monsoon rainfall, as well as an increase in the intensity of rainfall, and a decrease in winter precipitation.

Table 3:Potential rainfall change (Cite)

Year	Annual Mean		Monsoon Rainfall	
2030s	+0%	-34-+22%	+2%	-40-+143%
2060s	+4%	-36-+67%	+7%	-40-+143%
2090s	+8%	-43-+80%	+16%	-532-+135%

Overall, these climate change projections are in line with the observations on climate change in Nepal. Observations and projections indicate that there is likely to be marked warming which show that higher elevations can result to reduced snow and ice coverage, increased climatic variability and more frequent extremes – as evident in the increased incidences of floods, droughts, and precipitation in most of the country, but decreased rainfall in the mid-hills of Nepal.

Temperature

The OECD study general circulation model run with the SRES B2 scenario show mean annual temperature to increase by an average of 1.20c by 2030, 1.70 and 3^0 C by 2100 compared to a pre-2000 baseline. The highest changes in the temperature may be the 5.6 0C in 2100(The worst case as provided by this model. The NCVST (2009) study using GCM and Regional circulation Model (RCM) projects the mean annual temperature to increase by 1.4oC by 2060and 4.70C 2030, 2.80C by 2060 and 4.7 0 by 2090. In general, both studies show higher temperature increment projections for winter compared to the monsoon season. In terms of spatial distribution, the NCVST 2009 study shows that the higher increment in temperature over western and central Nepal as compared to eastern Nepal for the year 2030, 2060 and 2090 with projections for western Nepal being the greatest. Similar trends are projected for the frequency of hot days and night for the year 200 and 2090.

Extreme events

The transect appraisal exercise and literature review revealed that Nepal is exposed to various types of hydro-meteorological extreme events. Climate change will further exacerbate the existing scenario. More than 4000 people died in the last ten years due to climate-induced extreme events and disasters cite pls. Data from the MoHA shows that every year, more than one million people are susceptible to climate induced disasters such as floods, landslides melting of ice and snow etc.

CLIMATE RISK AND VULERNABILITY ASSESSMENT

Hazard characterization

Vulnerability is defined as the degree to which a system is susceptible to or incapable to cope with the adverse effects of climate change. Vulnerability can be represented based on mathematical models available in pertinent IPCC Assessment Reports as listed below:

Vulnerability = f [(Sensitivity, Exposure, Adaptive Capacity)]

Sensitivity is the degree to which a system will respond, change or yield to climate change. Exposure pertains to the placement of a system in relation to potential impacts that may occur from natural or mad-made hazards. **Adaptive Capacity** refers to the ability of the system to withstand, absorb or modify to the extent required to withstand the projected impacts of climate change. Adaptation can be either intrinsic or planned. Planned adaptations are measures that are incorporated either in response to past incidents or in anticipation of future risks. **Vulnerability** assessment is performed by evaluating sub-project area through prioritization of impact of hazards, exposure level and adaptive capacity to evaluate overall vulnerability. The following climate change impacts shall be evaluated:

- Precipitation(Extreme Rainfall Event)
- Temperature
- Earthquake
- Flood
- Drought
- GLOF

The Sub project areas are classified based on their topographical distribution. The proposed projects are characterized with almost all the ecological zones of Nepal. The following table shows that the ecological zones and the proposed site.

Sensitivity and exposure assessments show that the hilly area is the highest prone to climate change impacts. Sub projects in the hilly areas are the ones that will suffer the most from rainfall-induced vulnerabilities, such as landslides. The 13 sub projects located in the hilly regions have comparatively higher vulnerability. Three subprojects are most prone to river floods, namely: (i) Pragatinagar, (ii) Shubhaghat and (iii) Kanchanpur area.

TREND ANALYSIS OF DISASTERS

Nepal is prone to several classes of hazards ranging from hydro-meteorological, geological, biological, industrial and accident-related disasters. Several disasters have been reported in past. In view of the youngest mountain, Himalaya, the region is a hotspot for geological formation and activities. This leads to frequent large earthquakes, landslide, floods and other collateral hazards. Apart from these activities, the country is prone to cloud burst, hailstorm, high winds and heat strokes in central and Terai Region. Climate change has accelerated the frequency of hazard occurrence.

Flood, landslide and health hazards are consistent threats to human life in Nepal. The casualty rate for these hazards is consistent over the decade. The analysis shows that about 750 people are killed every year due to these hazards. There is a need for initiating major steps for reducing the impacts through suitable mitigating measures.

According to the MoHA when??/ dataset, during the period of two years under review (2015 and 2016), a total of 16 types of disasters have been noted and 13 types of disaster have been recorded. As Table 2.1 displays, a total of 2,940 events of disaster have been recorded, of which incidents of fire are highest (N=1,856), followed by incidents of lightning (N=299), landslide (N=290), flood (N=244) and heavy rainfall (N=118). Other disasters also took place but less in frequency (by two digits or even less).

The data from the 2015 to 2016 analysis gives an overview of the disasters and loss due to the disaster. The MoHA dataset archives maintain data for a total of 16 kinds of active disasters in Nepal. The disasters noted are, in alphabetic order, Asinapani (heavy rainfall with hailstones), avalanche, boat capsize, cold wave, drowning, earthquake, epidemic, fire, flood, heavy rainfall, high altitude, landslide, snow storm, thunderbolt, wind storm, excluding the "other" category. This simple fact well illustrates that Nepal is exposed to multiple hazards at a time (Annex 1 where is annex¿?). The 2010 Nepal Hazard Risk Assessment (ADPC, NGI and CECI 2010) identifies 13 districts of Nepal, out of 75 districts in total, exposed to four types of hazards, while other three districts exposed to as many as five types of hazards. The remaining 59 districts are categorized as the ones exposed to three types of hazards. This finding corroborates our observation on Nepal's exposure to multi hazard vulnerability. By analyzing three categories of national level disaster data on loss (namely, human casualties, financial loss and the number of family affected), our own assessment further reveals that flood, earthquake, landslide, fire and lightning, in order of intensity and effect, are the top five deadly disasters in Nepal for the review period (2015-2016) (see Box 2.1). According to the MoHA dataset, during the period of two years under review (2015 and 2016), a total of 16 types of disasters have been noted and 13 types of disaster have been recorded. As Table 2.1 displays, a total of 2,940 events of disaster have been recorded, of which incidents of fire are highest (N=1,856), followed by incidents of lightning (N=299), landslide (N=290), flood (N=244) and heavy rainfall (N=118). Other disasters also took place but less in frequency (by two digits or even less).

In terms of human loss, earthquake, fire, flood, landslide and thunderbolt cause higher human suffering in the country. Human Casualties: Of these killer hazards, earthquake stands out from the rest in all respects – death, disappearance as well as human injuries. This is evidently due to the 2015 Earthquake. Of the total 9,708 human deaths, earthquake alone claimed the lives of a total of 8,970 persons (92.5 percent). After earthquakes, landslide, lightning, fire and flood claimed the lives most (in a range between 101 and 276 each) in those two years. Note that over the years thunderbolt is becoming one of the severe disasters in Nepal.

Conclusion: socio-economic losses

When one looks at the impacts of disasters on economic and financial loss, earthquake clearly stands out in all respects. This includes houses damaged, economic loss and number of families affected (Table 2.2). All disasters recorded in MoHA database reveal that a total of one million, eighty-five thousand, seven hundred and ninety-seven houses were damaged during the review period, of which 98.7 percent of the houses damaged was caused by earthquake. This is followed by a host of other disasters attributable to fire and landslide (0.3 percent) and to flood, heavy rainfall and windstorm (0.2 percent) (Table 2.2). Of the total more than seven hundred nine billion rupees of economic loss during the review period (2015 and 2016), about 99.5 percent was due to earthquake alone. Another category of disaster that caused economic loss the second most is fire. But its effect was far less (0.3 percent) compared to the effect of earthquake. Unfortunately, the data related to the losses of old heritage sites in the country is very blurred. Even in the case of 2015 earthquake, the impact to the old temples, monasteries and other old historical infrastructures from rural areas of the country are almost unavailable. Moreover, due to the lack of proper and regular maintenance such old infrastructures in many urban and rural areas have been either damaged or have ultimately collapsed. Several villages/ communities have been displaced due to regular hit by disasters in mountain and hill areas of Nepal. Such displaced people either shift to other parts of the same districts or to the flat plain of Terai Nepal. Due to such displacement or migration to the new locations many community groups lose their indigenous informal institutions and also the indigenous knowledge and practices.

The authors wanted to review past and projected climate change and associated hazards in three ecological regions in Nepal. They have used CRVA tools for the assessment and looks tried to correlate the implication of climate changes and induced disaster in water supply and sanitation projects but not clearly discussed. The general information about climate change and associated hazrads are found in this documents. So, it can be published as a review reports in your journal.

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