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Observed and Perceived Climate Change Analysis in the Terai Region, Nepal

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Abstract: “Climate change will modify temperature and precipitation patterns, which could challenges the farmers for crop production in the coming days. While scientific studies regarding climate change patterns are essential to find out the impacts in regards to how the threats are perceived by local people. This paper intends to determine the extent to which climate change has caused spatial-temporal changes in temperature and precipitation that occurs on annual time scales in the Kailali, Chitwan, and Rautahat districts of Nepal. Three focus indigenous groups (Chepang, Tharu, and Musahar) and a total number of 180 house- holds were interviewed during the field visit. While a secondary data were collected from the Department of hydrology and meteorology (DHM), Nepal. Mann-Kendall and Sen’s estimator of slope test were used to detect possible temperature and precipitation trend and its magnitude respectively. The findings of the study showed that the trend of minimum and maximum mean temperatures indicate significantly increased at 5 stations of three districts. Similarly, the precipitation of the post monsoon seasons is increasing at 6 stations of three districts. How- ever, pre-monsoon, monsoon, and winter precipitation have the significant decrease at three districts stations. These finding results were verified with the people’s perception. This study could be used for the formulation of effective adaptation plan and policy of climate change in this region as well as applicable to other related areas”.

Keywords: Adaptive capacity, Exposure, Vulnerability, Precipitation, Temperature, Climate Change.

Problem Statement

Indigenous peoples are among the first to face the direct consequences of climate change, owing to their dependence upon, and close relationship with the environment and its resources (McCarthy et al., 2001). Climate change exacerbates the difficulties already faced by vulnerable indigenous communities, including political and economic marginalization, loss of land and resources, human rights violations, discrimination and unemployment (UN, 2008). Maplecroft ranked Nepal the 4th most vulnerable countries in the world; a British organization based on its growing vulnerability to climate change impacts (Maplecroft, 2010). Climate change has resulted in an increase in temperature, erratic and extreme rainfall patterns, and the increased frequency of floods, landslides, and droughts that annually result in the massive loss of lives and properties (FAO, 2014; Karki et al., 2011; NAPA, 2010; Dixit et al., 2008).

While the debate over distinguishing climate-driven and poverty driven impacts continues, it is being more clear that for the poor living in remote areas of rural Nepal, help is needed now and there really is no time to waste (Gum, 2009). Therefore, this research study is needed for the vulnerability assessment of indigenous communities to climate change. It will provide valuable findings and results, which definitely support decision-making, planning, and managing the resources for such communities in upcoming days. The purpose of this work is to explore the situation of these communities due to climate change. Such case studies will be informative, and helpful for communities, individuals, relevant sectors, and stakeholders.

Objectives

The general objective of this study is to evaluate and determine climate change effects on the communities of Chepang, Musahar, and Tharu. The specific objectives of this study are:

I. To determine the extent to which climate change has caused spatial-temporal changes in temperature and precipitation that occurs on annual time scales in the Kailali, Chitwan, and Rautahat district of Nepal.

II. To assess the vulnerability of climate change among the indigenous communities (Chepang, Tharu, and Musahar).

Study Site

Nepal is a small landlocked country consisting of three regions. One of them is Tarai region located on the Southern part. Rautahat district is also situated in the Tarai region. The Latitude and Longitude of Rautahat is 26° 34' to 27°04' North and 85°31' to 86° 31' East respectively. It is situated in the height of 122 to 244 meters from sea level. The Musahars are agriculturist and agricultural laborers (Chaudhary, 2008). Their primary work is digging, because of this quality the Musahars play an important role in agricultural activities (Gautam et al., 1994).

Chitwan district is positioned in the latitude of 27°21' to 27°52' North and the longitude of 83°55' to 84°48' East. The altitude of the district ranges from 144 m to 1945 m. The Chepangs make 0.23 percentages of the total population of Nepal (CBS, 2011). More than 95% of the Chepangs live in the hilly villages of Chitawan, Makwanpur, Dhading and Gorkha districts (CBS, 2011). These communities have very low literacy rate, therefore they suffer most by climate change and its impact (Piya et al., 2012). Chepangs also depend upon livestock, wage laboring, collection and sale of forest products, handicrafts, skilled non-farm jobs, salaried jobs, and remittance for cash income (Piya, Maharjan, & Joshi, 2011).

These three districts three indigenous communities (Chepang, Musahar, Tharu) were selected for Observed and Perceived Climate Change Analysis in Figure 1. Among them, Tharus are one of the major, whereas Musahars minor indigenous communities of Tarai, Nepal according to the National Census of 2011. Similarly, Chepangs are one of the indigenous communities in habitat in the hilly regions of the Nepal.

Methodology

From each of the three selected districts as shown in Fig 1 three-village development committees (VDCs) were selected for the household survey (9 VDCs total). From the Chitwan, three VDCs (village development committee) were selected kabilas, Dahakhani, and Shaktikhor with sample size of 60 out of 589 to 1570 Chepang households. Similarly, Chaumala, Masuriya, and Urma VDCs of Kailali and Bhrishrampur, Dharampur, and Rangapur of Rautahat VDCs were selected for household survey with sample size 60 from 569-2080 Tharu and 390-760 Musahar households respectively. According to the national census 2011 data from each VDCs and the average of households were used to calculate the sampling frame.

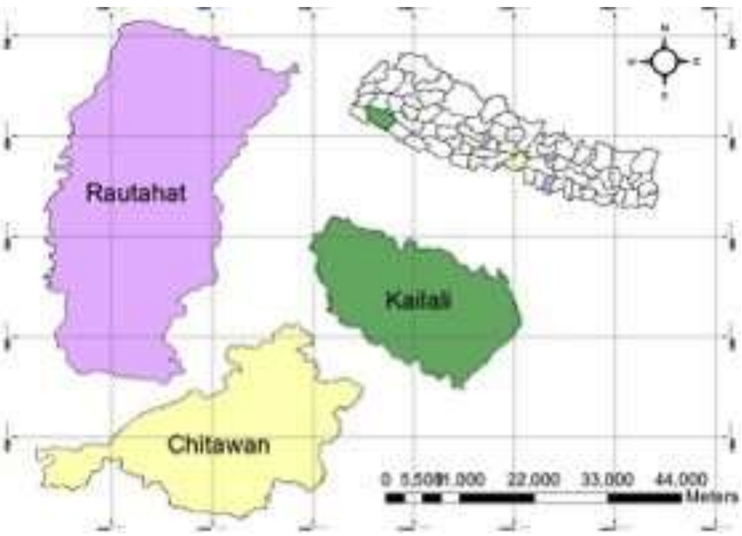

Figure 1: *Map of Nepal showing three study districts in three different colors. Source: Thapa 2019*

Verbal informed consent was taken from each respondent. A structured and semi-structured both English and Nepali version of the literate participant questionnaire was distributed to the respondent. Structured questionnaire was used as a major tool for collecting data as well as information of the indigenous community. The researcher visited the Chepang, Tharu and Mushar communities to collect the data. Secondary data was collected from the Department of hydrology and meterology (DHM), Nepal. Monthly rainfall (9 stations) and monthly temperature (6 stations) data for the period of 30 years (1985-2015) for the three districts Chitwan, Rautahat and Kailali were obtained from Department of hydrology and meteorological, Nepal (DHM, 1977-2015). Three variables will be used such as monthly maximum temperature, monthly minimum temperature, and monthly precipitation amounts. The Mann-Kendall test (M-K test): Mann–Kendall statistical tests (Mann, H.B. 1945; Kendall, M.B. 1975) were used to detect trends in temperature and rainfall during the last three decades. This test is the most common one used by researchers in studying hydro-meteorological time series trends (Longobardi, et.al. 2010) and can be used even if there is a seasonal component in the series. This method tests if there is a trend in the time series data. It is a non-parametric rank-based procedure, robust to the influence of extremes and suitable for application with skewed variables (Hamed 2008). More particularly, this technique can be adopted in cases with non-normally distributed data, data containing outliers and non-linear trends (Helsel and Hirsch 1992; Birsan et al. 2005).

Theil Sen’s Slope: If a linear trend is present in a time series, the true slope of the existing trend can be computed using the non-parametric TS approach (Sen, et.al.

1968). This test is widely used and robust as it is less sensitive to outliers and missing values in data (Theil, H. 1992). This nonparametric Mann- Kendall and Sen's Slope statistical test were used in the temperature and precipitation time series data to determine the significance of a trend and estimate the magnitude of the trend.

All the data was kept in order for coding and editing. Simple descriptive statistics was used for data analysis example frequency, percentage, means score, standard deviation. Inferential statistic was used such as: ANOVA test for hypothesis and variable testing, non parametric Mann-Kendall as well Sen.'s slope method for trend detection and its magnitude using R programming, and Microsoft Excel. To better observe the trend for the temperature and precipitation, fitting nonparametric lowess curve to the data using the lowess function in R. The data was presented in table, bar diagrams, graphs, maps and pie chart for the analysis.

Results and Discussion

Temperature: Observed and Perception's Analysis

The temperature data of Chitwan, Rautahat, and Kailali districts for 30 years (1985 to 2015) was used for its trend analysis. The autocorrelation test was performed to all time series in order to check the randomness of the data (Modarres and Da Silva 2007). As all lag-1 serial correlation coefficients were statistically not significant, there was no need to pre-white the data, and all statistical tests described above are applied to the original time series (Luo et al. 2007).

Temperature time series data were analyzed for tend with a Mann-Kendall test as well as trend magnitude with Sen's slope estimator for each station separately. At below Table section provides the calculations of the Mann- Kendall statistics and p-values derived for each distinct station. The annual mean temperature of Chitwan, Rautahat, and Kalali for this period was found to be 23.20 ˚C, 21.97 ˚C, and 23.12 ˚C respectively.

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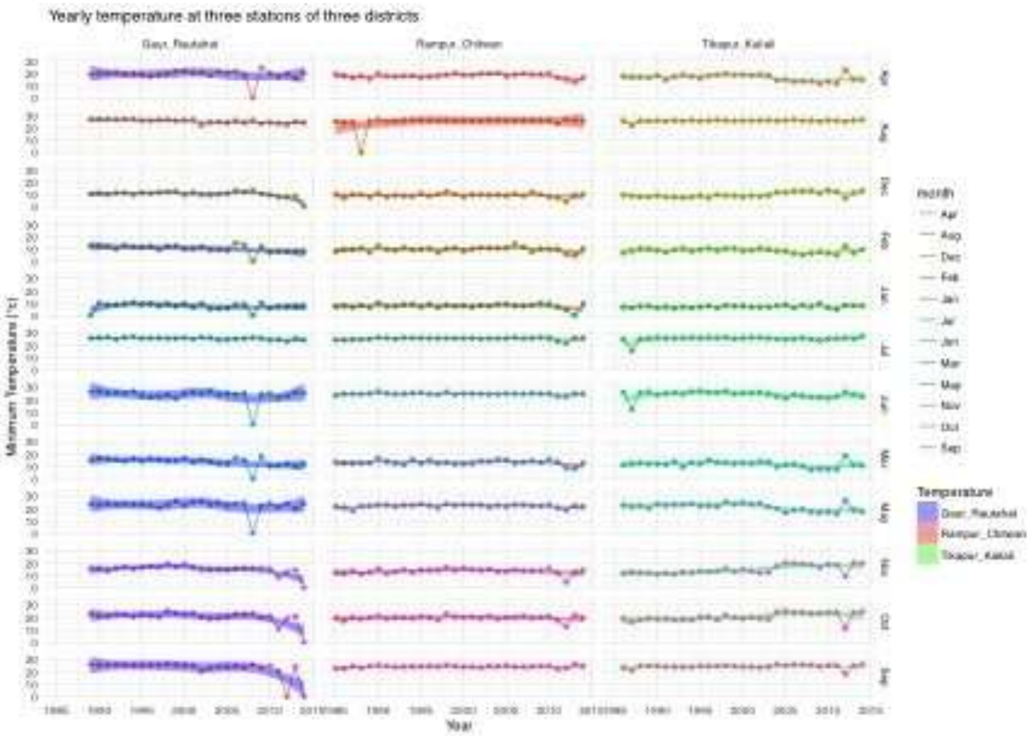

Figure 2: Trend of annual minimum mean temperature at Gaur, Rampur, and Tikapur stations of Rautahat, Chitwan, and Kailali respectively. Source: Thapa 2019

The trend of minimum mean temperature fall was slow towards downward at Gaur station of Rautahat in the month October, November, and December in between 2011s to 2015. At Rampur stations of Chitwan these months January, February, April, March, October, November in the year 2011 to 2013 shows fall of minimum mean temperature. In case of Tikapur station of Kailali minimum mean temperature shows steady trend throughout 1985 to 2015. Approximately few spike falls in June, July, September, October and November as well as rise in April, March, and May in between 2011 and 2013 (Figure 2).

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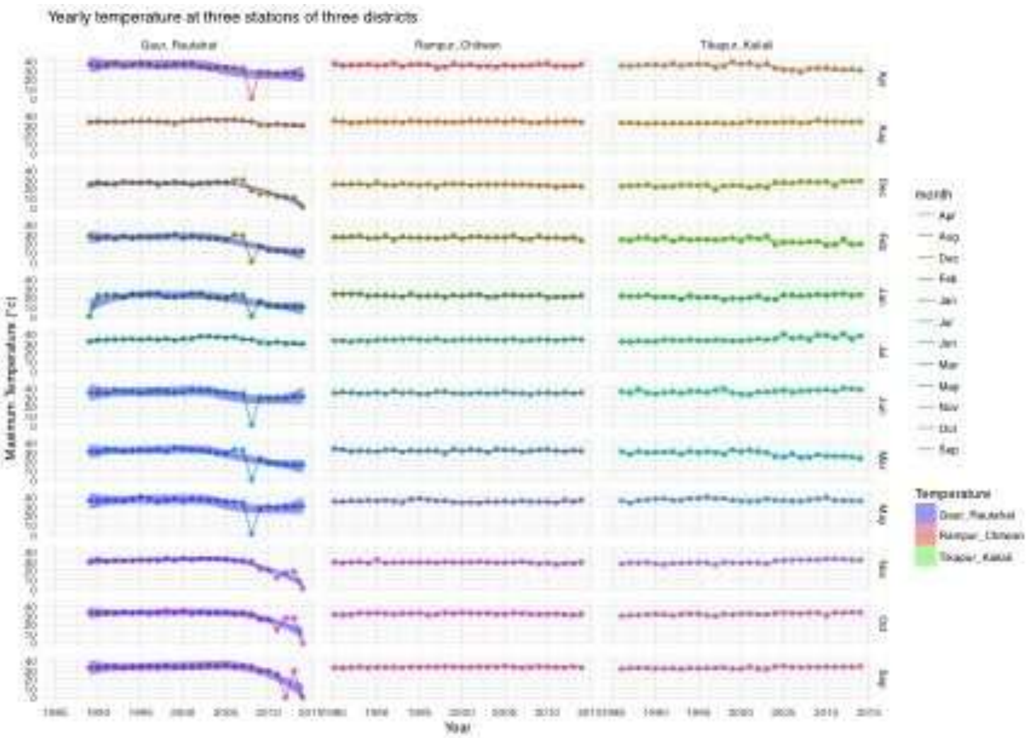

Figure 3: Trend of annual maximum mean temperature at Gaur, Rampur, and Tikapur stations of Rautahat, Chitwan, and Kailali respectively Source: Thapa 2019

The trend of maximum mean temperature fall was negative but slow for the month October, November, and December in between 2010s to 2015 at Gaur stations of Rautahat. In Rampur station shows that there was constant rate of maximum mean temperature from the month January to December in the year 1985 to 2015. Tikapur station exhibits slow fall of a trend in maximum mean temperature. These falls are in April, March, and May starting from 2010 to 2015 (Figure 3).

Gaur stations maximum, minimum, and annual mean temperature rejects H0 (Null Hypothesis). That indicates that there is a trend in the time series data. That is increasing trend as Sen's slope and Tau is positive. Mean minimum temperature of Rampur station had trend according to the test result, whereas mean maximum of Rampur station showed insignificance by accepting alternative hypothesis ($p>0.05$). At Rampur station maximum, minimum, and annual mean temperatures showed increasing trend. The Rampur Tau score can justify that and Sen's slope has positive value. Tikapur and Rampur stations maximum, minimum, and annual mean temperature rejects H0. Rejecting H0 indicate that there is trend in time series data. Maximum, minimum, and annual mean temperature of Tikapur, and Dhangadhi had increasing trend. These calculated value of Kendall Tau and Sen's slope, which are positive justified upward trend of data (Table 1).

The trend analysis of temperature showed the increasing trend of both the annual average minimum, maximum, and annual temperatures of Rautahat. The trend of maximum, minimum, and annual mean temperatures increased by 0.0182 ˚C/year, 0.001 ˚C/year, and 0.012 C/year that was similar to the findings of previous studies (ICIMOD, 2007; Timsina, N. (2011); Dhakal, et.al. 2016). The Chitwan Rampur, and Bharatpur stations maximum, and minimum mean temperatures showed an increasing trend that is accordance with the previous study that a significant upward trend for both minimum (p= 0.014) and maximum temperature (p = 0.018) was observed (Paudel, B. et.al. 2014; Thapa, 2010). Similarly, as per the study by Shambhu Chamakar (2010) submitted to NAPA, MOE, overall temperature of the Chitwan is increasing. Kailali three stations showed the increasing trend of maximum and minimum mean temperatures. The range of minimum and maximum temperatures is increasing over time, as a minimum temperature is increasing faster than the maximum temperature. Though this upward trend is in line with the previous studies (Shrestha et. al. 1999; Dhakal, et.al. 2009; Houghton et al. 2001; Upadhya and Grover 2012; Mandala 2012; Krishna 2014).

The trend analysis showed an increase in the minimum, average and max- imum temperature significantly over 35 years period with 0.077, 0.043, and 0.010 0C respectively (Dhakal, 2013). According to (Baidhya, Regmi and Shrestha 2007), the national average temperature increase in Nepal is 0.042 0C per year, which is less than the average maximum temperature in the study area. The detailed analysis (Practical Action 2009) looking over a pe- riod of 30 years (1976-2005) reports that maximum and mean temperatures are rising. This evidence is sufficient to prove that the people's perception of hotter summer and less cold winter.

The Musahar, Chepang, and Tharu people's perceptions of the temper- ature change over the last 5 years of Rautahat, Chitwan, and kailali respec- tively are presented in Figure 4. The majority of the respondents mentioned that there was an increase in the summer (91.67%) temperature. Relatively close to half respondents responded increase in winter (42.22%) temperature.

Table 1: Mann Kendall and Sen's slope estimate test results of annual mean, maximum, and minimum temperature for 1985 to 2015 of three districts.

Rautahat				
Stations: Gaur				
Mean Temperature	Tau	Interpretat-on	Sen's slope (°C/year))	Trend
Maximum	0.238	Reject H0	0.0182	Increasing
Minimum	0.187	Reject H0	0.001	Increasing
Chitwan				
Stations: Rampur				
Maximum	0.002	Accept H0	0.0196	Increasing
Minimum	0.147	Reject H0	0.0035	Increasing
Stations: Bharatpur				
Maximum	0.064	Accept H0	0.0391	Increasing
Minimum	0.302	Reject H0	0.001	Increasing
Kailali				
Stations: Dhangadhi				
Maximum	0.088	Reject H0	0.0151	Increasing
Minimum	0.108	Reject H0	0.01	Increasing
Stations: Godavari				
Maximum	0.14	Reject H0	0.0262	Increasing
Minimum	0.118	Reject H0	0.01	Increasing

*Statistically significant at 95% confidence level

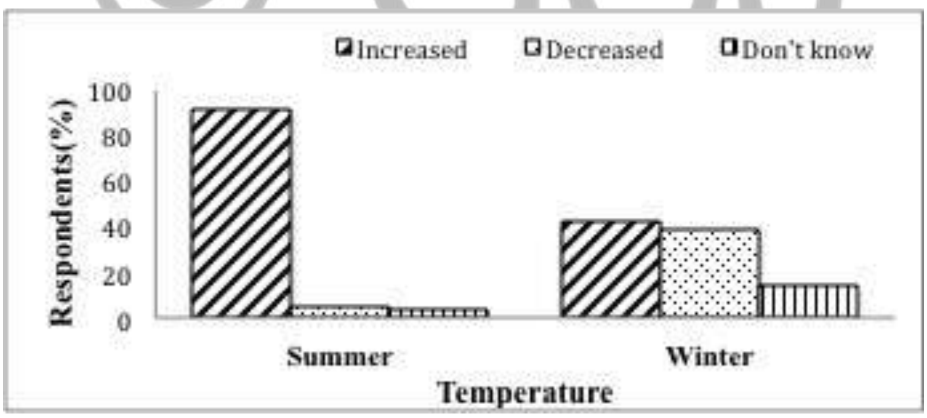

Figure 4: Respondents (N=60) perception of the recent temperature compared to last 5 years in three districts. Source: Thapa 2019

However, few of respondents (4.99%) mentioned that there was a decrease in summer temperature and a sizable number of people (38.33%) said that win- ter temperature was decreasing when compared to last 5 years temperature. The few number of people (3.33%) responded don't know about a change in summer temperature. In winter temperature respondents (13.88%) stated don't know about the change.

The finding of temperature upward trend in Rautahat district was con- sistent with the people's perception. According to the people perception for last 5 years, people perceived increase in both the summer and winter tem- peratures. The similar result was found by other studies (Bhusal, Y. 2009; Tiwari, et.al. 2010) Local people have perceived that extremely hot days are more than cooler days in this last 5 years back (Piya, et.al. 2012). Percep- tion of chepang communities of Chitwan: the result obtained from the survey revealed that 95 percent of the local people interviewed perceived long-term changes in temperature. Among them, majority of farmers perceived increase in temperature while few of them noticed a decrease in temperature (Thapa, 2010).

This result showed the clear indication of the warming trend in the area. Therefore, the local people's perceptions were similar with the statistical data in the region. That was a majority of the respondents mentioned that there was an increase in the summer temperature, whereas few number of people responded that winter temperature was increasing when compared to last 5 years temperature. Similarly, most of the respondents in the Kailali area have perceived that temperature was increased (Thapa, et.al. 2015).

Precipitation: Observed and Perception's Analysis

The observed precipitation trend was analyzed for pre-monsoon (March- May), monsoon (June-September) and post-monsoon (October-February). The precipitation was significantly increasing for post-monsoon season; how- ever pre-monsoon, monsoon, and winter precipitation was decreasing in the recent years.

There are two rainy seasons: one in the summer (June to September), when the southwest monsoon brings more than 75 percentages of the total rainfall, and the other in winter (December to February), accounting for less than 25 percentages of the total (FAO, 2010). With the summer monsoon, rain first falls in the southeast and gradually moves west with diminishing intensity. Thus, more rain naturally occurs in the east. On the other hand, during winter, rain occurs as a result of westerly disturbances. This rain first enters Nepal in the west and gradually moves east with diminishing intensity. The overall precipitation (January-December) is slightly negative secular trend random variation in the Gaur stations of Rautahat district. In the plot at Gaur station of Rautahat exhibits downward trend during the latter part of the twentieth century. It shows that there was steady rate of rainfall in the month January, February, June, July, April, March, May and November from year 1985 to 2015. Though the mean rainfall of September, October, June, July, and August had random variation.

The trend of mean rainfall at Rampur stations of Chitwan showed the trend of cyclic in the month May, June, July, August, September, October. At Tikapur stations of Kailali mean rainfall trend was cyclic in between 1985s to 2015. Such trend was shown in the month May, June, July, August, September, and October (Figure 5).

The pre-monsoon (March-May) rainfall shows cyclic trend in April be- tween 1985 and 2015. In May rainfall exhibits random variation. There was fall of rainfall at Gaur in the year 2013, 2104, and 2015. The trend of Mon- soon (June-September) rainfall was slow decreasing from the year 2010 to 2015. At Gaur station in July 2008 there was heavy rainfall of 1000 mm. The post monsoon mean rainfall showed the cyclic trend in between 1985 and 2015 (October-November). It showed the trend of downward in the winter (December-February) in between 2008 to 2015 (Figure 6).

For the stations of Rautahat, Chitwan, and Kailali Mann-Kendall and Sen's slope estimate test on precipitation data are presented in the below

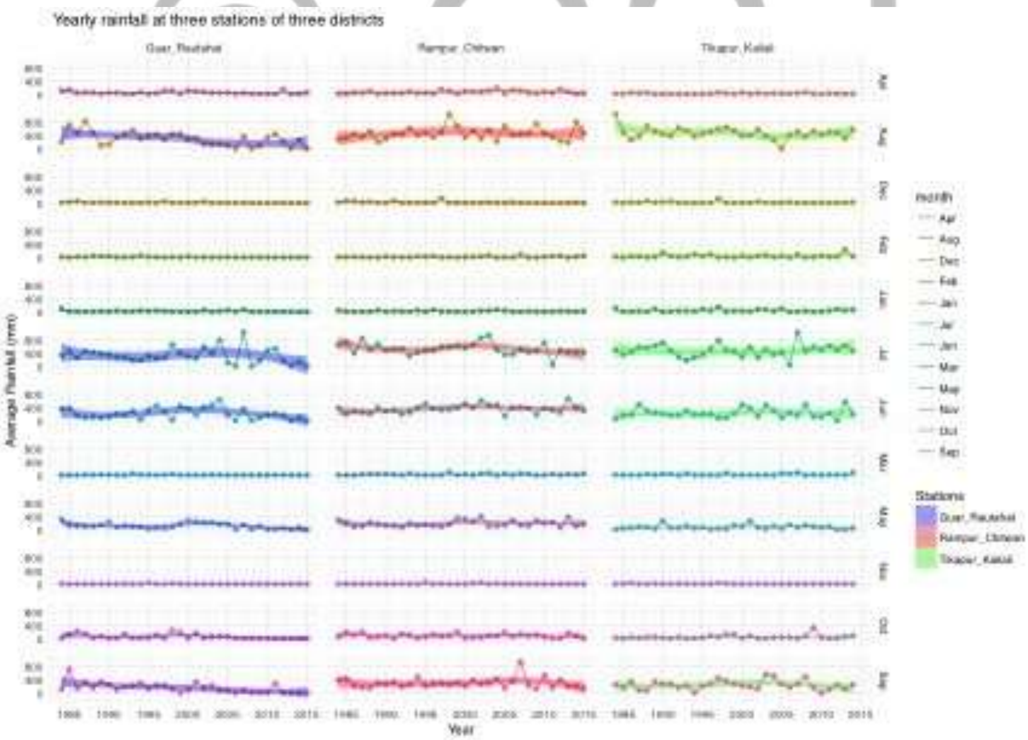

Figure 5: *Trend of average annual rainfall at Gaur, Rampur, and Tikapur Stations of Rautahat, Chitwan, and Kailali respectively.* Source: Thapa 2019

Table 2. If the p value is less than the significance level α (alpha) = 0.05, H0 is rejected. Rejecting H0 indicates that there is a trend in the time series, while accepting H0 indicates no trend was detected. On rejecting the null hypothesis, the result is said to be statistically significant. For this test, the Null Hypothesis was rejected for two stations, Ramoilli and Gaur. Therefore, this results shows there was a downward trend in the average annual rainfall data at two stations of Rautahat.

The pre monsoon and post monsoon data of Ramoilli stations whose p- value is greater than 0.05 accept null hypothesis (p = 0.05). That means these two seasons data of Ramoilli statistically insignificant at the 95% confidence level. Monsoon and winter exhibits decreasing trend, as indicated by the negative value Tau and Sen's slope. However, three seasons (Pre monsoon, Monsoon, and winter) at Gaur stations showed decreasing trend while post monsoon shows increasing trend as indicated by the positive value of Tau and Sen's slope. Sen's slope method quantified that the pre monsoon, monsoon, and winter are all decreasing at a rate of -0.6942 mm/year, -1.1561 mm/year, and -0.523 mm/year respectively; however, the post-monsoon rainfall has been increasing at the rate of 0.120 mm/year, and 0.7565 mm/year since 1985.

Mann Kendall and Sen's slope test results specifies the downward trend, as indicated by the negative Tau (τ) and Sen's slope values in average annual rainfall time series data at Rampur, and Jhawani stations of Chitwan. At Jhawani station monsoon and winter rainfall insignificant with research hypothesis by accepting null hypothesis ($p>0.05$). However other seasons indicate trend in both stations. Post monsoon of two stations showed upward trend whereas other seasons showed downward trend. These pre monsoon, monsoon, and winter decreasing trend could be known by negative value of Tau and Sen's slope. However the positive value of Tau and Sen's slope of post monsoon were increased by the rate of 1.05 mm/year, and 0.7045 mm/year respectively at both stations.

The two stations indicates decreasing trend in rainfall time series data by rejecting H0 (Null hypothesis) as well as negative value of Tau and Sen's slope. From the below Table 2 result provides two stations mean rainfall of kailali time series data and specifies trend. Post monsoon of two stations exhibits upward trend. Monsoon rainfall had increasing trend for Dhangadhi stations while Tikapur station exhibits downward trend. However, pre monsoon, and winter of these (Tikapur, and Dhangadhi) showed downward trend in the rainfall data.

Post-monsoon rainfall in most of the eastern, central and western de- velopment regions are increasing trend, a similar trend was found in this study of two districts Chitwan, and Rautahat of central development region (Marahatta, et.al. 2009). The post-monsoon (0.120 mm/year) rainfall was on an increasing trend at Gaur station. Additionally annual average rain- fall (-0.0098 mm/year), monsoon, and winter at Gaur, and Ramoilli showed decreasing trend, which was similar to the findings of (Dhakal, et.al. 2009; Dhakal, et.al. 2016) in which they had mentioned average annual rainfalls, monsoon, and winter decreasing at a rate of 10.21 mm/year, 11.75 mm/year, and 0.59 mm/year respectively and post monsoon had been increasing at the rate of 1 mm/year since 1984. At the two stations of Kailali showed a rise of post-monsoon rainfall, which was similar with another scholar (GOV, 2010; Thapa, et.al. 2015).

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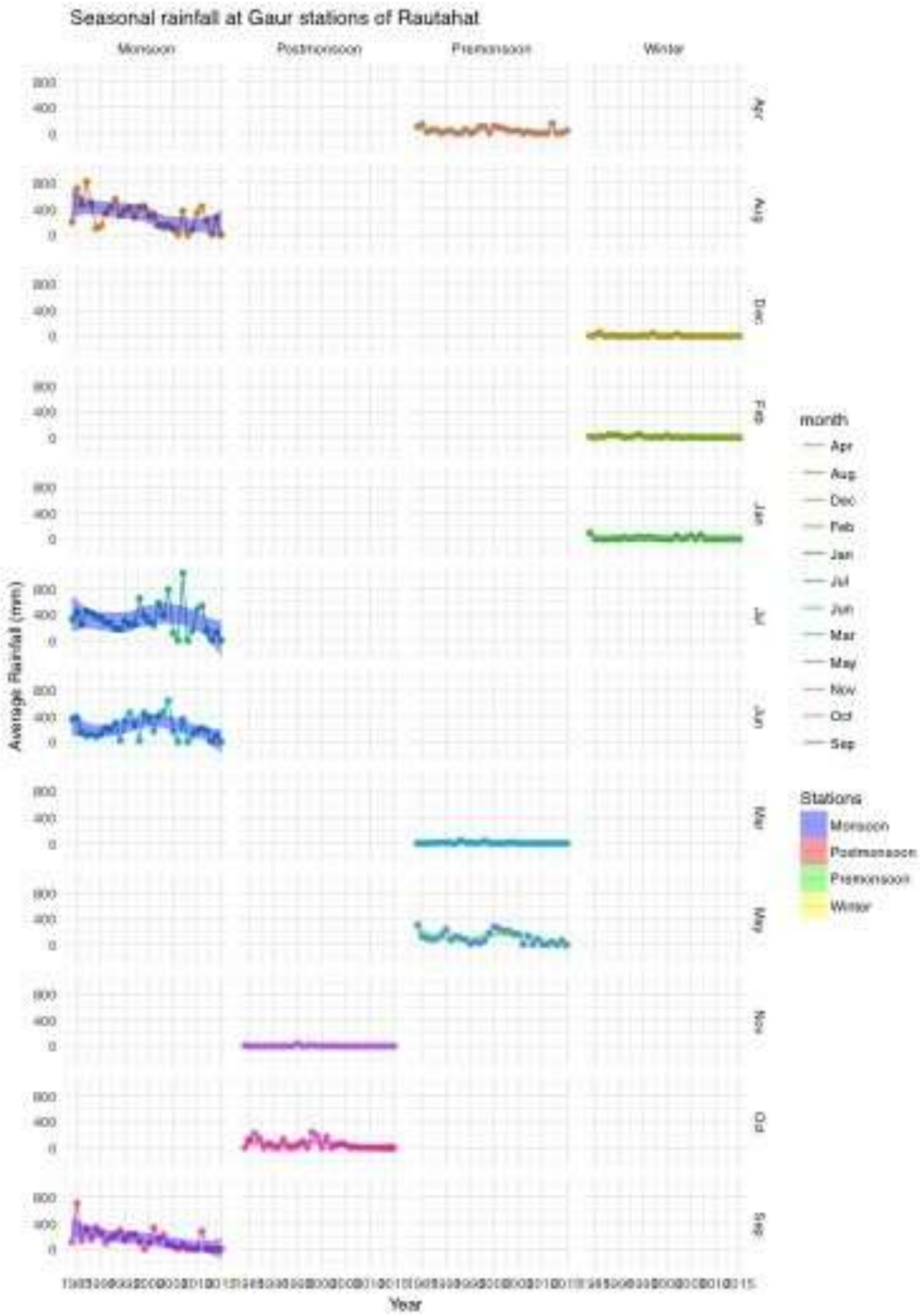

Figure 6: Trend of average seasonal rainfall at Gaur Station of Rautahat.

Source: Thapa 2019

Table 2: Mann Kendall and Sen's slope estimate (mm/period) test results of annual average rainfall of Rautahat, Chitwan, and Kailali.

Rautahat				
Stations: Gaur				
Mean Rainfall	Tau	Interpretation	Sen's slope (mm/year)	Trend
Pre monsoon	-0.245	Reject H0	-0.6942	Decreasing
Monsoon	-0.306	Reject H0	-1.1561	Decreasing
Post Monsoon	0.175	Accept H0	0.120	Increasing
Winter	-0.329	Reject H0	-0.523	Decreasing
Annual mean	-0.127	Reject H0	0	Decreasing
Stations: Ramoilli				
Pre Monsoon	-0.003	Accept H0	-0.8152	Decreasing
Monsoon	-0.147	Reject H0	-0.2323	Decreasing
Post Monsoon	0.053	Accept H0	0.7565	Increasing
Winter	-0.127	Reject H0	0	Decreasing
Annual mean	-0.0739	Reject H0	-0.0098	Decreasing
Chitwan				
Stations: Rampur				
Pre Monsoon	-0.553	Reject H0	-1.812	Decreasing
Monsoon	-0.126	Reject H0	-0.898	Decreasing
Post Monsoon	0.484	Accept H0	1.05	Increasing
Winter	-0.156	Reject H0	-0.0259	Decreasing
Annual	-0.0692	Reject H0	-0.0329	Decreasing

mean				
Stations: Jhawani				
Pre Monsoon	-0.487	Reject H0	-1.5604	Decreasing
Monsoon	-0.028	Accept H0	-0.2308	Decreasing
Post Monsoon	0.045	Reject H0	0.7045	Increasing
Winter	-0.14	Reject H0	-0.0244	Decreasing
Annual mean	-0.073	Reject H0	-0.0279	Decreasing
Kailali				
Stations: Dhangadhi				
Pre Monsoon	-0.303	Reject H0	-0.3784	Decreasing
Monsoon	0.012	Accept H0	0.100	Increasing
Post Monsoon	0.273	Accept H0	0.0235	Increasing
Winter	-0.203	Reject H0	-0.136	Decreasing
Annual mean	-0.109	Reject H0	-0.0378	Decreasing
Stations: Godavari				
Pre Monsoon	-0.306	Reject H0	-0.4863	Decreasing
Monsoon	0.0586	Accept H0	0.7161	Decreasing
Post Monsoon	0.315	Accept H0	0.001	Increasing
Winter	-0.204	Reject H0	-0.1265	Decreasing
Annual mean	-0.102	Reject H0	-0.0444	Decreasing

*Statistically significant at 95% confidence level

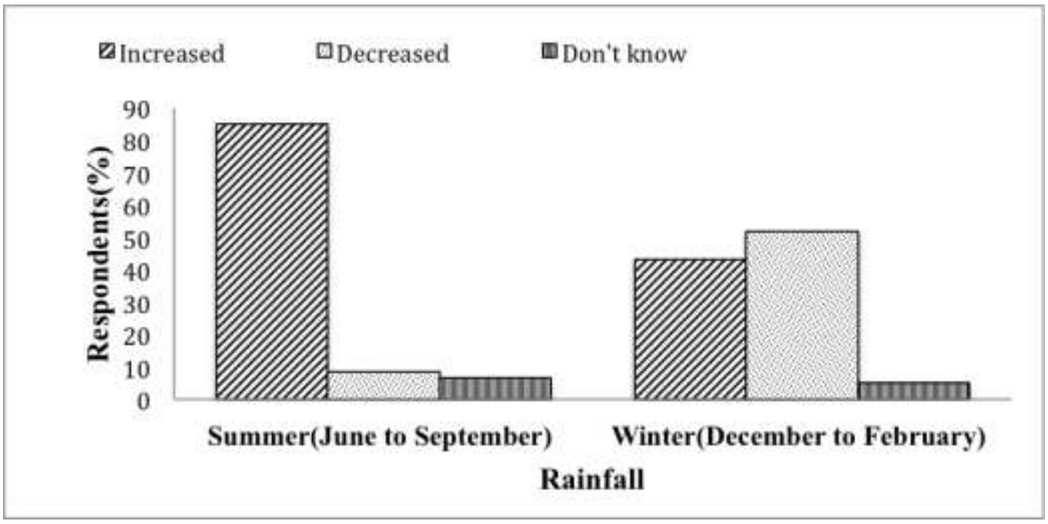

Figure 7: Respondents (N=60) perception of the recent rainfall compared to last 5 years in three districts. Source: Thapa 2019

The Musahar, Chepang, and Tharu people's perception of the rainfall change over the last 5 years are presented in Fig 7. The majority of the respondents mentioned that there was an increase in the summer (85%) rain- fall. However, more than half of respondents (51.67%) mentioned that there was a decrease in winter rainfall and a sizable number of people (43.33%) said that winter rainfall was increasing when compared to last 5 years rainfall. Similarly, equivalent number (5%) of the respondents doesn't know about the change in winter rainfall (Figure 7).

The trend of rainfall supports local people's perception (Thapa, et.al. 2015). The majority of the respondents mentioned that there was an increase in the summer (86.67%) rainfall. However, more than half of respondents (53.33%) mentioned that there was a decrease in winter rainfall. The respondents reacted as summer rainfall significantly increased (above 90%) in three districts that similar to the study depicts an increase in precipitation in summer months across the country in the range of 15-20% (OECD, 2003). Recorded data shows increasing summer rainfall, decreasing winter rainfall, and decreasing annual rainfall over the last ten years (Piya, 2011). The precipitation was significantly increasing for the post-monsoon season; however, pre-monsoon precipitation was decreasing in the recent years. This result was supported by the previous studied (Baidya, et.al. 2008; Malla, G. 2009).

Conclusion

A study is about Observed and Perceived Climate Change Analysis in the Terai Region, Nepal. The sample size of the study was 180. At 5 stations of Rautahat, Chitwan, and Kailali had increasing trend of mean maximum and minimum temperature. The three districts stations had increasing trend of post monsoon season. The pre monsoon, monsoon, and winter trend were decreasing. Furthermore, more than 90% people of three districts stated increase in summer temperature and more than 35% increase in winter temperature. Likewise, above 85 % specified increase summer rainfall as well as more than 51% decreases winter rainfall.

Similarly, mean minimum and maximum temperature at Gaur (Rautahat), Rampur, Jhawani (Chitwan), and Tikapur, Dhangadhi, Godavari (Kailali) had increasing trend (p¡0.05) that accepted research hypothesis of temperature having significant increasing trend. Total 9 stations results of annual, and seasonal (pre monsoon, monsoon, and winter) rainfall had significant decreasing trend which accepted research hypothesis.

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