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Trends of Temperature and Rainfall in Pokhara

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ABSTRACT
Climate is an average condition of temperature, humidity, air pressure, wind, precipitation and other meteorological elements. It is a changing phenomenon. Natural processes and human activities have helped change the climate. Temperature is a vital element of climate, which fluctuates in the course of time and leads to change other elements of the whole climate. An attempt has been made to analyze the pattern of temperature and rainfall of Pokhara with the help of the two decades' temperature and rainfall conditions obtained from the station of Pokhara airport. The increasing trend of temperature and the decreasing trend of rainfall might be the symbol of climatic modification. This trend refers to some changes in the climatic condition that may affect water resources, vegetation, forests and agriculture.

KEYWORDS: Adaptation, climate, climatic modification, desertification, environmental problem, fluctuation, greenhouse gases

INTRODUCTION

Climate is an aggregate of atmospheric conditions including, humidity, air pressure, wind, precipitation and other meteorological elements in a given area over a long period of time (Critchfield, 1990). It is not ever static but a changeable phenomenon. Such type of change occurs in quality and quantity of the components of climate like temperature, air pressure, humidity, rainfall, etc. Natural and man-induced factors are responsible for the modification of climate. It is a global issue faced by every living thing of the world. The world has got the profound impact on climate since the first industrial revolution of the mid-eighteenth century. Fossil fuels played an important role in the industrial revolution but have increased the concentration of greenhouse gases (carbon dioxide = CO_2, methane = CH_4, nitrous oxide = N_2O, ozone = O_3 etc.) in the atmosphere, which support to the modification of climate by creating the global warming situation (Paudel, 2016). The fifth assessment report of the UN, Intergovernmental Panel on Climate Change (IPCC) has expressed as the average global temperature between 1880 to 2012 increased by 0.85^0c., due to the increasing of temperature, the global average sea level between 1901 to 2010 rose by 19 cm., the global average sea level rise is predicted to be 24–30cm by 2065 and 40–63cm by 2100 (https://www.un.orgc, 5 March 2020).

Impacts of increasing temperature is interlinked from biodiversity degradation and effects on ecosystem through impacts on water balance and availability and calamities to socioeconomic and health impacts on the people (ICIMOD, 2009). Human

activities also influenced by temperature and rainfall (Pandey, 2003). Therefore, it has social, economical and ecological impacts too. Presently it is also being a matter of serious concern in Nepal. It has been experiencing the impact of increasing trend of temperature and fluctuation in rainfall for the past several years in Nepal (Pokharel, 2067 B.S.). Due to global warming, many big glaciers have been melting rapidly. As a result, the discharge of huge volumes of water has helped raise the sea level. The ranges of glacial retreats in Nepal have been found up to 20 meters per year (CNCCC, 2007). Such types of snow melting and retreat of glacier give the six-fold birth of glacial lakes, which lead to dreadful bursts (GoN, 2011). A study based on the analysis of temperature trend indicates that an annual rate of growth of temperature in Nepal is 0.06^0 c. (GoN, 2010). However, the warming trend in the country is spatially variable. Likewise, there have been severe drought and adverse weather conditions in recent years. Overall rainfall during the recent summer monsoon of the year was about 16% below the normal level (GoN, 2011). Increasing trends of temperature have shown so many effects in Nepal, such as- warmest long summer and coolest short winter; due to the low amount of snow, exposing black rocks in the Himalaya; high probability of Glacial lake outburst flow (GLOF); retreat of glaciers and snowline; drought; desertification; fluctuation in rainfall; degradation of biodiversity; spread of epidemic diseases; Berries, Peach, Apricot, Cherry were flowering before their season; Apple farming of Mustang is shifting to upper level; Disappearing local peas species; Wild Bees were shifting their shelter, etc. (IPCCC, 2007). Like this, Pokhara also is not liberating from such types of problems. So, attempts have been made to study the pattern of temperature and rainfall in Pokhara.

OBJECTIVES

The study has aimed to focus on changing pattern of temperature and rainfall in Pokhara between two decade (2000 to 2009 and 2010 to 2019 AD).

METHODOLOGY

Study area of this work is Pokhara valley of Nepal. The study focused on changing pattern of temperature and rainfall in Pokhara between two decade (2000 to 2009 and 2010 to 2019 AD). The study is based on the secondary data obtained from the weather station of Pokhara airport (827m above the sea level), which is located at 28^0 13' N and 84^0 00' E. Information of two decade's temperature and rainfall of Pokhara were collected from the Pokhara airport weather station. Among some weather stations of around Pokhara valley, weather station of Pokhara airport was selected as sample. It was selected by judgment method, because of its central location, which can represent the characteristic of climate of whole Pokhara valley. These data were taken for the main indices of the study. Different publications such as newspapers, published and unpublished documents, leaflets, brochures and the views of different authors were used for the information. Data taken from the weather station were segregated into two groups of each decade (2000 to 2009 and 2010 to 2019 AD), then tabulated and calculated as per the requirement. Mainly quantitative methods (Calculation of mean ($\bar{x}$), standard deviation (σ), Coefficient of variation (C.V.) were used for the analysis.

STUDY AREA

The patterns of temperature and rainfall over the Pokhara valley (83^0 48' - 84^0 08' E and 28^0 05' - 28^0 20' N) are shown in this research. The valley has 540m slope gradient from north to south. It covers an area of 464. 24 Km^2 including the plain areas of Pokhara metropolitan city north to south slope gradient. It is headquarters of the Gandaki Province and lies on the lap of Machhapuchhre and the Annapurna range. It is

surrounded by Annapurna rural municipality from the west, Machhapuchhre rural municipality and Madi rural municipality from the north, Rupa rural municipality from the east, Shuklagandaki municipality of the Tanahun district from south-east and Putalibazar municipality and Phedikhola rural municipality of Syangja district from the south and southwest. The whole Pokhara is included in the catchment area of the Seti river and its tributaries. Some hills such as Sarangkot, Dhampus, Lumle, Gharmi, Harpak, Armala, Kahun, Arba, Kristi, Nirmalpokhari, Bharatpokhari, etc surround the valley (Fig. 1).

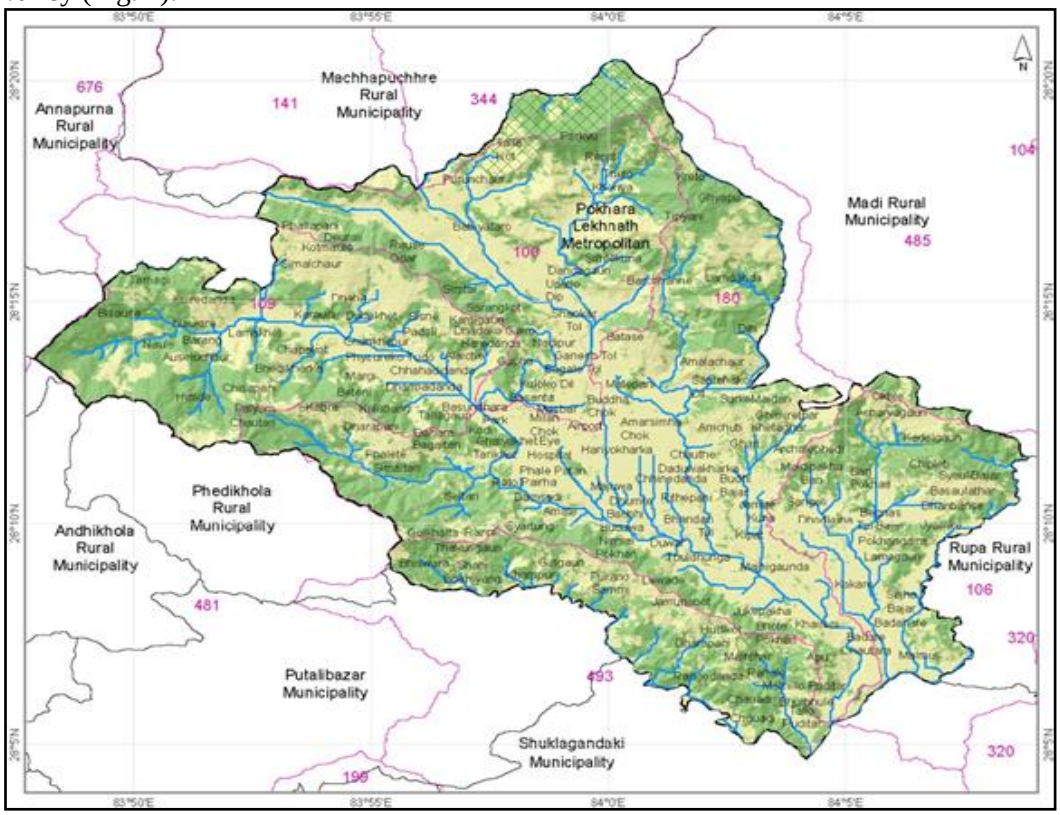

Fig 1: Location of the study area

RESULT AND DISCUSSION

Temperature and rainfall characteristics of Pokhara

'The valley floor of Pokhara may be included in the moderate subtropical type of climate' (Lamichhane, 2008), however its broad group is sub-tropical on the basis of the world climatic classification. An average annual temperature in Pokhara is around 21.5 °C. Likewise, the average rainfall in summer is around 799.33mm and in winter is around 4.00mm. During the summer Pokhara gets around 74% rainfall of the year.

Temperature

On the basis of climate Pokhara is under the subtropical climatic region. The average temperature of Pokhara in summer is around 31^0c. and in winter is around 21^0c. The study focused on changing pattern of temperature and rainfall in Pokhara between two decade, so the data have segregated into two groups of each decade. The distribution of temperatures of Table 1 and 2 indicates their changing patterns of the two decades in Pokhara.

Table 1: Average temperature (0^0c.) of Pokhara from 2000 to 2009

Months	January		February		March		April		May		June	
Year	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
2000	**20.5**	7.3	**20.6**	7.6	**26.1**	10.9	**30.2**	12.6	**29.7**	15.7	**30.0**	16.3
2001	**19.6**	7.5	**23.3**	10.0	**27.9**	12.3	**30.8**	15.5	**29.6**	19.1	**30.7**	21.6
2002	**20.1**	7.1	**23.4**	9.9	**27.1**	13.7	**29.2**	16.5	**29.8**	19.3	**31.4**	21.6
2003	**19.7**	6.9	**21.9**	9.6	**25.7**	12.8	**30.1**	16.9	**30.2**	17.6	**30.8**	21.1
2004	**19.8**	7.5	**23.4**	10.3	**29.3**	15.9	**28.9**	16.8	**30.6**	19.3	**31.0**	21.1
2005	**19.3**	7.8	**22.7**	9.7	**27.3**	13.8	**30.2**	15.2	**30.2**	17.6	**31.7**	21.0
2006	**21.4**	7.2	**25.5**	13.3	**27.3**	12.9	**29.2**	15.8	**30.4**	19.8	**30.5**	21.4
2007	**19.8**	7.1	**20.3**	10.0	**25.8**	12.9	**29.9**	16.8	**31.3**	19.6	**30.9**	21.8
2008	**19.0**	7.6	**21.4**	8.3	**27.6**	13.7	**29.9**	16.0	**30.4**	17.7	**30.5**	21.5
2009	**21.9**	8.4	**25.7**	10.6	**28.7**	12.6	**33.0**	17.4	**30.8**	19.1	**31.5**	21.4
Average of decade	**20.11**	7.44	**22.82**	9.93	**27.28**	13.15	**30.04**	15.95	**30.30**	18.48	**30.90**	20.88

Months	July		August		September		October		November		December		Annual mean	
Year	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
2000	**30.0**	19.7	**29.5**	22.0	**28.7**	20.5	**27.9**	17.3	**23.9**	13.8	**20.6**	8.3	**26.47**	14.3
2001	**30.7**	22.5	**30.4**	22.2	**29.8**	20.8	**28.7**	17.8	**25.5**	13.2	**21.1**	8.8	**27.34**	15.9
2002	**30.2**	22.4	**30.3**	22.1	**29.7**	20.7	**28.0**	16.2	**24.6**	12.4	**20.9**	8.9	**27.05**	16.0
2003	**30.5**	22.1	**31.4**	22.4	**30.1**	21.0	**29.0**	17.6	**24.7**	13.3	**21.2**	8.9	**27.10**	15.8
2004	**29.9**	22.1	**31.4**	22.6	**29.4**	21.2	**27.3**	16.2	**23.5**	11.1	**21.1**	8.7	**27.13**	16.1
2005	**31.0**	22.3	**30.5**	22.2	**30.9**	21.5	**26.8**	16.9	**23.6**	11.8	**21.0**	7.2	**27.10**	15.6
2006	**31.3**	23.1	**31.2**	22.6	**29.8**	21.4	**28.0**	17.2	**24.0**	13.1	**21.2**	10.0	**27.48**	16.5
2007	**29.8**	22.6	**30.4**	22.6	**29.1**	21.1	**28.1**	18.4	**24.4**	12.0	**20.5**	7.6	**26.69**	16.0
2008	**31.1**	22.2	**30.5**	21.8	**30.1**	19.4	**28.4**	15.8	**25.4**	11.9	**22.3**	9.5	**27.21**	15.5
2009	**31.1**	22.8	**30.5**	22.6	**30.3**	21.0	**27.9**	17.2	**24.2**	12.2	**21.4**	9.7	**28.00**	16.3
Average of decade	**30.61**	22.18	**30.61**	22.32	**29.79**	20.86	**28.01**	17.13	**24.38**	12.48	**21.13**	8.70	**27.15**	15.8

Source: Pokhara Airport Weather Station – 2000 to 2009

According to Table 1, the average maximum temperature of the previous decade (2000 to 2009) is 27.15^0c and the average minimum temperature is 15.8^0c. The standard deviation (σ) of maximum temperature is 0.396 and coefficient of variation (C.V.) is 1.46, which shows the little fluctuation of temperature year by year of the decade. Nevertheless, the annual mean maximum temperature of six years is below average ($\bar{x}$ = 27.15) and four years is above average. Like this, the minimum temperature of four years is below average (Mean = 15.8) and the minimum temperature of six years is above average of the minimum temperature of this decade (Table – 1 and appendix - 1).

Table 2: Average temperature (0^0c.) of Pokhara from 2010 to 2019

Months Year	January		February		March		April		May		June	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
2010	**21.9**	7.6	**23.0**	9.4	**29.0**	15.4	**31.8**	18.1	**30.7**	19.4	**31.7**	21.4
2011	**19.3**	5.6	**23.5**	9.0	**27.9**	12.5	**30.2**	14.7	**30.9**	18.2	**30.9**	20.1
2012	**19.0**	5.6	**22.6**	9.4	**27.1**	13.2	**29.8**	16.4	**31.6**	18.7	**31.5**	21.7
2013	**20.2**	6.3	**22.3**	10.0	**27.9**	14.3	**30.1**	16.2	**29.8**	19.6	**30.4**	22.0
2014	**20.3**	7.5	**22.4**	9.2	**26.9**	12.7	**31.2**	16.0	**31.7**	19.0	**31.9**	21.8
2015	**21.0**	8.3	**23.1**	11.2	**26.2**	14.0	**28.1**	16.3	**31.3**	19.3	**31.6**	21.3
2016	**19.9**	8.3	**24.6**	11.2	**28.1**	14.3	**31.8**	18.4	**30.6**	19.3	**30.8**	22.1
2017	**22.0**	7.4	**25.2**	11.1	**25.8**	13.2	**29.8**	16.7	**30.1**	18.6	**31.8**	21.5
2018	**20.5**	6.8	**24.1**	11.1	**28.3**	14.2	**29.0**	16.6	**29.4**	19.3	**31.4**	22.1
2019	**20.4**	7.0	**21.8**	10.1	**26.3**	12.7	**28.7**	17.4	**31.1**	18.2	**31.5**	21.6
Average of decade	**20,45**	7.04	**23.26**	10.17	**27.35**	13.65	**30.25**	16.68	**30.72**	18.96	**31.35**	21.56

Months Year	July		August		September		October		November		December		Annual mean	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
2010	**30.3**	22.4	**30.4**	22.3	**29.6**	20.9	**28.5**	17.2	**24.7**	13.6	**21.2**	6.8	**27.73**	16.23
2011	**30.1**	21.4	**30.7**	21.0	**31.0**	20.4	**28.7**	16.4	**23.1**	11.4	**20.8**	5.8	**27.25**	14.71
2012	**29.9**	22.8	**30.7**	22.4	**30.1**	21.4	**27.6**	16.4	**24.1**	10.8	**21.1**	8.7	**27.09**	15.63
2013	**30.8**	22.8	**31.1**	22.5	**30.7**	21.3	**27.2**	18.3	**24.4**	11.6	**20.3**	8.6	**27.10**	16.13
2014	**31.4**	22.8	**30.5**	22.4	**30.5**	21.2	**27.9**	16.5	**24.6**	13.7	**21.2**	8.5	**27.54**	15.94
2015	**31.2**	22.5	**30.9**	22.4	**31.1**	21.9	**28.1**	17.7	**24.7**	14.0	**20.4**	8.4	**27.31**	16.44

2016	**30.0**	22.5	**32.1**	22.7	**30.1**	21.5	**28.9**	18.4	**25.5**	11.9	**23.1**	9.7	**27.96**	16.70
2017	**30.9**	22.5	**30.7**	22.7	**31.1**	21.9	**29.2**	18.8	**25.3**	12.5	**23.0**	9.3	**27.91**	16.35
2018	**31.2**	23.0	**31.1**	22.7	**30.4**	21.9	**27.7**	16.2	**24.3**	12.1	**20.8**	8.2	**27.35**	16.18
2019	**31.2**	22.9	**32.3**	23.3	**29.6**	21.7	**28.0**	18.1	**25.7**	15.0	**19.6**	8.1	**27.18**	16.34
Average of decade	**30.70**	20.56	**31.05**	22.44	**30.42**	21.41	**28.18**	17.40	**24.64**	12.66	**21.15**	7.41	**27.44**	15.83

Source: Pokhara Airport Weather Station – 2010 to 2019

Table 2 shows the average maximum (27.44^0c) and minimum (15.83^0c) temperatures of the decade 2010 to 2019. In this decade, both of these temperatures have increased in comparison with the previous decade. It indicates some fluctuations of temperature. The standard deviation (σ) of maximum temperature is 0.309, and coefficient of variation (C.V.) is 1.13, which shows nominal fluctuations of temperature year by year than former decade. However, the annual mean maximum temperature of six years is below average ($\overline{x}$ = 27.44) and of the four years is above average. Like this, the minimum temperature of three years is below average ($\overline{x}$ = 15.83) and of seven years is above average of this decade (Table – 2 and appendix - 2). Thus, if such an increase of temperature is recorded every decade of centuries, the climate of Pokhara will be modified.

Table 3: Changing pattern of temperature (0^0c.) between two decades (2000 to 2009 and 2010 to 2019)

Average temperature of Previous decade (2000 to 2009)	January		February		March		April		May		June	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
	20.11	7.44	**22.82**	9.93	**27.28**	13.15	**30.04**	15.95	**30.30**	18.48	**30.90**	20.88
Average temperature of subsequent decade (2010 to 2019)	**20,45**	7.04	**23.26**	10.17	**27.35**	13.65	**30.25**	16.68	**30.72**	18.96	**31.35**	21.56
Changing pattern of temperature between two decades	+ **0.34**	- 0.40	+ **0.44**	+ 0.24	+ **0.07**	+ 0.50	+ **0.21**	+ 0.73	+ **0.42**	+ 0.48	+ **0.45**	+ 0.68
Average temperature of Previous decade (2000 to 2009)	July		August		September		October		November		December	
	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
	30.61	22.18	**30.61**	22.32	**29.79**	20.86	**28.01**	17.13	**24.38**	12.48	**21.13**	8.70
Average temperature of subsequent decade (2010 to 2019)	**30.70**	20.56	**31.05**	22.44	**30.42**	21.41	**28.18**	17.40	**24.64**	12.66	**21.15**	7.41
Changing pattern of temperature between two decades	+ **0.09**	- 1.62	+ **0.44**	+ 0.12	+ **0.63**	+ 0.55	+ **0.17**	+ 0.27	+ **0.26**	+ 0.12	+ **0.02**	- 1.29

Source: Pokhara Airport Weather Station – 2000 to 2019

The following figure shows the changing patterns of temperature:

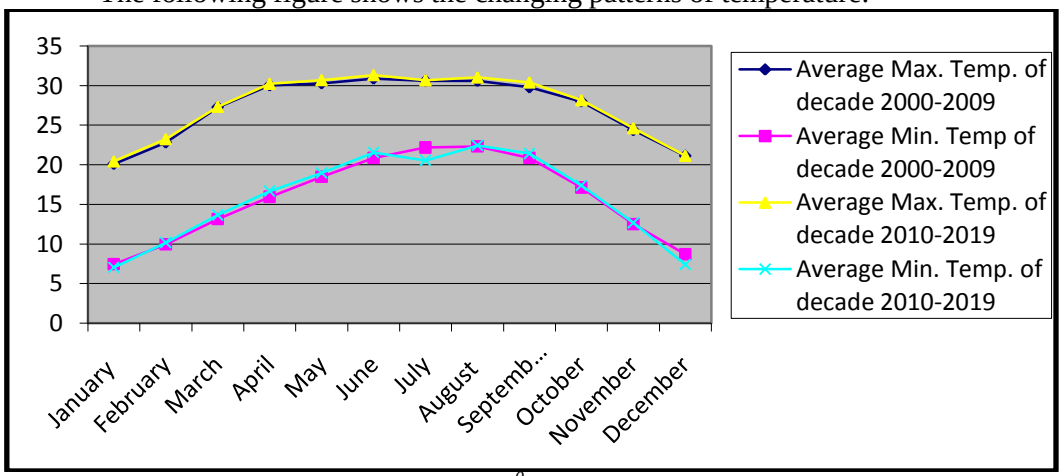

Fig 2: Changing patterns of temperature (0^0c) between two decades by months

The comparison of the two-decades' data indicates that every month of recent decade is warmer than the previous decade and the increasing rate of temperature is 0.30^0 C. between two decades. In the case of maximum temperature, every month of subsequent decade is higher than the same months of the previous decade. And in the case of minimum temperature, apart from January, July and December, it seems similar as the maximum temperature of the subsequent decade. So, the pattern of temperature of Pokhara is in the increasing trend (Table – 3, Fig. 2).

Rainfall

Pokhara is the highest rainfall area of Nepal. June, July and August are the heaviest rainfall months of the year while November, December and January are the lowest. Pokhara airport weather station is situated at the central part of the Pokhara valley. Therefore, it may represent the data of the whole study area. The average rainfall of Pokhara in summer is around 799.33mm and in winter is around 4.00mm. During the rainy season Pokhara gets around 74% rainfall of the year. Table-4 shows the rainfall of the previous decade (2000 to 2009) and Table- 5 shows the rainfall of the subsequent decade (2010 to 2019). Thus, like temperature, rainfall also shows a symptom of climatic modification in Pokhara.

Table 4: Average rainfall (mm.) of Pokhara from 2000 to 2009

Months / Year	January	February	March	April	May	June	July
2000	0.0	13.0	50.0	200.0	683.0	876.0	1032.0
2001	3.0	25.0	15.0	112.0	359.0	712.0	856.0
2002	44.0	54.0	62.0	202.0	437.0	703.0	1815.0
2003	37.0	85.0	100.0	203.0	246.0	785.0	1292.0
2004	31.0	11.0	28.0	269.0	373.0	772.0	817.0
2005	58.0	11.0	88.0	105.0	310.0	282.0	549.0
2006	0.0	5.0	84.0	147.0	586.0	494.0	434.0
2007	0.0	160.0	59.0	220.0	380.0	616.0	931.0
2008	12.0	2.0	29.0	114.0	333.0	604.0	487.0
2009	0.0	0.0	25.0	46.0	260.0	609.0	763.0
Average of decade	**18.50**	**36.60**	**54.00**	**161.80**	**396.70**	**645.30**	**897.60**

Months / Year	August	September	October	November	December	Annual mean Rainfall
2000	1122.0	573.0	13.6	19.0	0.0	381.80
2001	1522.0	716.0	115.0	77.0	0.0	376.00
2002	693.0	335.0	96.0	24.0	0.0	372.08
2003	586.0	953.0	17.0	17.0	42.0	363.58
2004	789.0	867.0	184.0	33.0	0.0	347.83
2005	925.0	314.0	326.0	4.0	0.0	247.66
2006	580.0	449.0	275.0	3.0	17.0	256.16
2007	676.0	1186.0	73.0	25.0	12.0	361.50
2008	1209.0	265.0	103.0	0.0	0.0	263.16
2009	1026.0	303.0	220.0	0.0	4.0	271.33
Average of decade	**912.80**	**596.10**	**142.26**	**20.20**	**7.50**	**324.11**

Source: Pokhara Airport Weather Station – 2000 to 2009

Table - 4 shows the average rainfall ($\bar{x}$ = 324.11mm.) of the previous decade (2000 to 2009). The standard deviation (σ) of average rainfall is 53.66, and coefficient of variation (C.V.) is 16.56, which shows fluctuations of average rainfall year by year. Although the annual mean rainfall within the four years of the present decade is below average ($\bar{x}$ = 324.11mm.), and above average in the six years (Table – 4, appendix- 3).

Table 5: Average rainfall (mm.) of Pokhara in the decade 2010 to 2019

Months / Year	January	February	March	April	May	June	July
2010	0.1	55.1	72.9	74.9	271.6	539.2	1083.9
2011	19.2	32.3	27.9	161.9	284.4	474.9	1041.2
2012	12.4	53.8	16.2	137.3	186.2	499.3	877.6
2013	17.6	68.7	30.1	114.1	277.3	823.1	973.9
2014	17.5	17.8	74.0	48.2	125.5	687.8	800.4
2015	54.3	30.3	167.9	128.2	213.8	506.9	923.0
2016	2.3	0.1	93.5	24.6	241.9	589.0	877.5
2017	5.5	0.0	108.3	330.9	291.2	482.6	1071.0
2018	1.4	0.0	55.6	220.9	437.2	365.8	702.8
2019	34.8	113.5	91.2	180.4	350.0	608.3	545.0
Average of decade	**16.51**	**37.16**	**73.76**	**142.14**	**267.91**	**557.69**	**889.63**

Months / Year	August	September	October	November	December	Annual mean Rainfall
2010	1187.8	595.6	76.6	9.0	0.0	330.56
2011	690.4	549.1	71.5	133.7	0.0	290.54
2012	711.9	538.5	232.7	0.0	0.0	272.15
2013	490.6	319.2	233.0	22.3	0.0	280.83
2014	1421.7	581.2	158.9	10.1	26.9	330.83
2015	781.8	702.9	215.2	2.9	0.0	310.60
2016	381.6	972.0	335.4	0.0	0.0	293.16
2017	620.5	712.1	120.6	0.6	0.0	311.94
2018	600.4	557.6	57.4	0.6	0.0	249.98
2019	317.9	612.1	200.1	9.2	39.6	258.51
Average of decade	**720.46**	**614.03**	**170.14**	**18.84**	**6.65**	**292.91**

Source: Pokhara Airport Weather Station – 2010 to 2019

The average rainfall of the subsequent decade (2010 to 2019) is $\bar{x}$ = 292.91mm. Standard deviation (σ) of average rainfall is 26.71, and coefficient of variation (C.V.) is 9.12, which shows little fluctuations of average rainfall year by year. Although the annual mean rainfall within the five years of the present decade is below average ($\bar{x}$ = 292.91mm.), and above average in the seven years (table – 5, appendix- 4).

Table 6: Changing pattern of rainfall (mm.) between two decades (2000 to 2009 and 2010 to 2019)

Average rainfall of Previous decade (2000 to 2009)	January	February	March	April	May	June
	18.50	**36.60**	**54.00**	**161.80**	**396.70**	**645.30**
Average rainfall of subsequent decade (2010 to 2019)	**16.51**	**37.16**	**73.76**	**142.14**	**267.91**	**557.69**
Changing pattern of rainfall between two decades	**-1.99**	**+0.56**	**+19.76**	**-19.66**	**-128.79**	**-87.61**

Average rainfall of Previous decade (2000 to 2009)	July	August	September	October	November	December
	897.60	**912.80**	**596.10**	**142.26**	**20.20**	**7.50**
Average rainfall of subsequent decade (2010 to 2019)	**889.63**	**720.46**	**614.03**	**140.14**	**18.78**	**6.65**
Changing pattern of rainfall between two decades	**-7.97**	**-192.34**	**+17.93**	**-2.12**	**-1.42**	**-0.85**

Source: Pokhara Airport Weather Station – 2000 to 2019

The following figure shows the changing patterns of temperature between two decades by months.

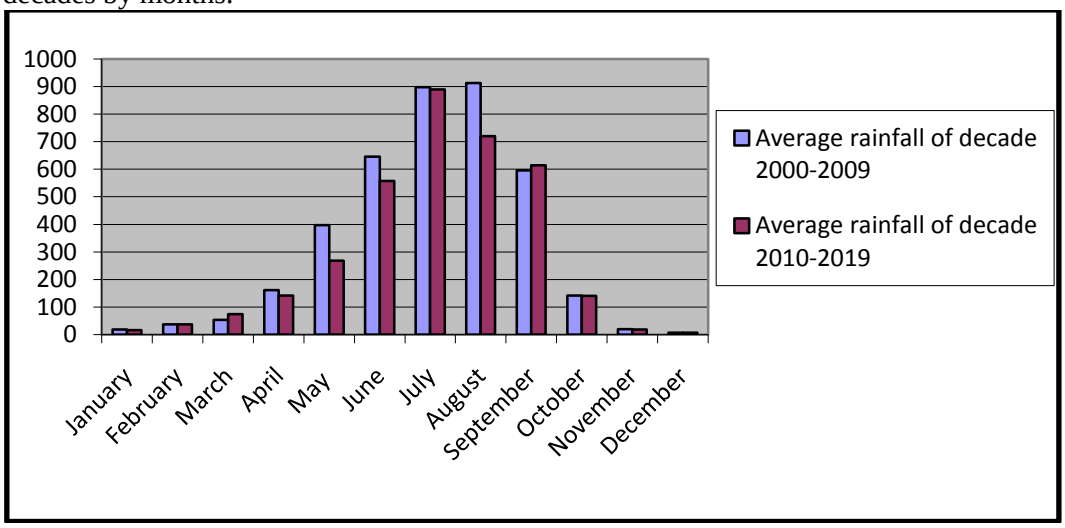

Fig 3: Changing patterns of rainfall (m.m.) between two decades by months

The comparison of the two-decade's data indicates that the out of twelve month, nine months of recent decade is getting lower rainfall than the previous decade. The decreasing rate of rainfall is 40.45 mm. between two decades. From this evidence, it can say that the rainfall in recent years has been decreasing. Thus, this decreasing trend of rainfall has also become an indicator of climatic modification in Pokhara (table-6).

CONCLUSIONS

This study conclude that Pokhara have been getting increasing trend of temperature and decreasing trend of rainfall

Average maximum temperature of the previous decade is 27.15^0c, standard deviation (σ) of maximum temperature is 0.396, and coefficient of variation (C.V.) is 1.46. These figures have shown the fluctuation of temperature year by year of the decade (2000 to 2009).

In the case of subsequent decade, average maximum temperature is 27.44^0c, standard deviation (σ) of maximum temperature is 0.309, and coefficient of variation (C.V.) of temperature is 1.13. These facts, shows that increasing trend of temperatures and little fluctuations on it by year in the decade (2010 to 2019).

The comparison of two-decade's average maximum temperature shows that every month of recent decade are warmer than the previous decade and increasing rate of temperature between two decades is 0.30^0 C. Such an increase of temperature is indicates the climate of Pokhara is going to be modified.

Average rainfall of previous decade (2000 to 2009) is 324.11mm. The standard deviation (σ) of average rainfall is 53.66, and coefficient of variation (C.V.) of rainfall is 16.56. It shows the yearly fluctuations of average rainfall in some extent.

In subsequent decade (2010 to 2019) average rainfall is 292.91mm., standard deviation (σ) of average rainfall is 26.71, and coefficient of variation (C.V.) is 9.12. These data have shown little fluctuations of average rainfall year-by-year and decreasing trend than previous decade.

A comparison of two-decade's rainfall indicates the recent decade is getting lower rainfall than the previous decade. The decreasing rate of rainfall in a decade is 40.45 mm. From this evidence, this decreasing trend of rainfall has also become an indicator of climatic modification in Pokhara.

Increasing trend of temperature and decreasing trend of rainfall is a bad symptom for climatic balance and makes warmer but less wet environment. Such type of changing pattern of temperature and rainfall may lead to the modification of climate in Pokhara in future. It is not delay to make policies and programs for mitigation and adaptation and the betterment of climate in Pokhara.

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APPENDIX – 1:

Standard deviation from average maximum temperature of previous decade (2000 to 2009)

X	x = (X- $\bar{x}$)	x^2
26.47	-0.68	0.463
27.34	0.19	0.037
27.05	-0.10	0.010
27.10	-0.05	0.003
27.13	-0.02	0.001
27.10	-0.05	0.003
27.48	0.33	0.109
26.69	-0.46	0.212
27.21	0.06	0.004
28.00	0.85	0.723
ΣX= 271.57		Σx^2= 1.565

Here,

N= 10

$\bar{x}$ = ΣX / N = 271.57 / 10 = 27.15 **∴ $\bar{x}$ = 27.15**

σ (Standard deviation) = $\sqrt{(\Sigma x^2 / N)}$

= $\sqrt{(1.565 / 10)}$

= $\sqrt{(0.157)}$

= 0.396

∴ σ = 0.396

Coefficient of variation (C.V.) = **σ** / $\bar{x}$ (100)

= 0.396 / 27.15 (100)

= 1.46

∴ C. V. = 1.46

APPENDIX– 2:

Standard deviation from average maximum temperature of subsequent decade (2010 to 2019)

X	x = (X- $\bar{x}$)	x^2
27.73	0.29	0.085
27.25	-0.19	0.037
27.09	-0.35	0.123
27.10	-0.34	0.116
27.54	0.10	0.010
27.31	-0.13	0.017
27.96	0.52	0.271
27.91	0.47	0.221
27.35	-0.09	0.009
27.18	-0.26	0.068
ΣX= 274.42		Σx^2= 0.957

Here,

N=10

$\bar{x}$ = ΣX / N = 274.42 / 10 = 27.44 **∴ $\bar{x}$ = 27.44**

σ (Standard deviation) = $\sqrt{(\Sigma x^2 / N)}$

= $\sqrt{(0.957/ 10)}$

= $\sqrt{(0.096)}$

= 0.309

∴ σ = 0.309

Coefficient of variation (C.V.) = **σ** / $\bar{x}$ (100)

= 0.309 / 27.44 (100)

= 1.13

∴ C. V. = 1.13

APPENDIX– 3:

Standard deviation from average rainfall of previous decade (2000 to 2009)

X	x = (X- $\bar{x}$)	x^2
381.80	57.69	3328.13
376.00	51.89	2692.57
372.08	47.97	2301.12
363.58	39.47	1557.88
347.83	23.72	562.63
247.66	-76.45	5844.60

Here,

N= 10

$\bar{x}$ = ΣX / N = 3241.10 / 10 = 324.11 **∴ $\bar{x}$ = 324.11**

σ (Standard deviation) = $\sqrt{(\Sigma x^2 / N)}$

= $\sqrt{(28802.76 / 10)}$

= $\sqrt{(2880.27)}$

= 53.66

256.16	-67.95	4617.20	**∴ σ = 53.66**
361.50	37.39	1398.01	
263.16	-60.95	3714.90	
271.33	-52.78	2785.72	
ΣX= 3241.10		Σx^2= 28802.76	Coefficient of variation (C.V.) = **σ** / $\bar{x}$ (100)

= 53.66 / 324.11 (100)

= 16.66

∴ C. V. = 16.56

APPENDIX– 4:

Standard deviation from average rainfall of subsequent decade (2010 to 2019)

X	**x = (X- $\bar{x}$)**	**x^2**	Here,
330.56	37.65	1417.52	N = 10
290.54	-2.37	5.61	$\bar{x}$ = ΣX / N = 2929.10 / 10 = 292.91 **∴ $\bar{x}$ = 292.91**
272.15	-20.76	430.97	σ (Standard deviation) = $\sqrt{(\Sigma \mathbf{x^2} / N)}$
280.83	-12.08	145.92	= $\sqrt{(7139.41 / 10)}$
330.83	37.92	1437.92	= $\sqrt{(713.94)}$
310.60	17.70	312.93	= 26.71
293.16	0.25	0.06	**∴ σ = 26.71**
311.94	19.03	362.14	
249.98	-42.93	1842.98	
258.51	-34.40	1183.36	
ΣX= 2929.10		Σx^2= 7139.41	Coefficient of variation (C.V.) = **σ** / $\bar{x}$ (100)

= 26.71 / 292.91 (100)

= 9.12

∴ C. V. = 9.12