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Journal of Nepal Physical Society

Volume 7, Issue 4, December 2021

ISSN: 2392-473X (Print), 2738-9537 (Online)

JNPS, **7** (4), 71-79 (2021)

DOI: http://doi.org/10.3126/jnphyssoc.v7i4.42934

Published by:

Nepal Physical Society

P.O. Box: 2934

Tri-Chandra Campus

Kathmandu, Nepal

Email: nps.editor@gmail.com

JNPS 7 (4): 71-79 (2022)
ISSN: 2392-473X (Print), 2738-9537 (Online)

Research Article *© Nepal Physical Society*
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Trend Analysis of Rainfall, Temperature and Relative Humidity over Kathmandu, Nepal

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Received: *12th November, 2021;* ***Revised:*** *5th December, 2021;* ***Accepted:*** *26th December, 2021*

ABSTRACT

Five years (2012-2016) data of Rainfall, Relative Humidity and Temperature from Tribhuvan International Airport Kathmandu, Nepal (TIA) station were analyzed. Nepal lies in the subtropical region in which experience four seasons in a year i.e., winter, spring, summer and autumn. The Mean, Correlation(r), And P-value were calculated to study the correlation between Rainfall, Relative Humidity and Temperature. Assuming the type I error alpha (α) as 5% the p-value was compared to it. T test was used to calculate the p-value. Assuming null Hypothesis (H_0) to show insignificant relation between two variable and alternative hypotheses (H_1) to show significant relation between two variables. The monthly analysis also shows the period of Highest Rainfall, Temperature and Relative Humidity Between June or July or August for the location of TIA Kathmandu, Nepal. The relation between Rainfall vs Relative Humidity and Relative Humidity vs temperature was found to be insignificant respectively throughout all five years. The relation between Rainfall and Temperature was found to be significant throughout all five years.

Keyword: Sub-Tropical, Correlation, P-value, Significant, Insignificant, meteorological parameters.

1. INTRODUCTION

The quantity of moisture in the air compared to what the air can contain at a given temperature is known as relative humidity. When the air is saturated, the relative humidity is at its highest. When the air is saturated, water vapor in the air condenses, resulting in the creation of microscopic water droplets. A cloud is made up of millions of these small water droplets. Such water droplets mix under particular conditions to generate large rain drops, which fall as rain owing to gravity [1]. Weather is the word used to describe the condition of the atmosphere at a specific moment and location, which is continually changing from hour to hour and from day to day. Climate is the long-term average condition of the atmosphere near the earth's surface. Temperature, precipitation, humidity, air pressure, and wind direction and velocity are all factors to consider. The climate of each nation is influenced by its geographical location (latitude, coastal or continental position) and physical environment. [2]. Because Nepal is located in the subtropical zone, it has four seasons throughout the year: winter, spring, summer, and autumn. The climatic type in any location associated with a specific time of year is known as the season. The fundamental cause of seasonal variation is a shift in the angle of the earth's axis in respect to the position of the sun at a given location. The months of January, February, and December are known as the winter months because they have the least amount of rainfall and the lowest temperature and humidity. The months of March, April, and May are known as spring months because of the rise in temperature, rainfall, and humidity. The summer months of June, July, and August are known for their excessive rainfall, warmth, and humidity. Autumn is defined by a reduction in temperature, rainfall, and humidity in the months of September, October, and November. Kathmandu, Nepal's capital, is located in the center section of the country (latitude: 27°45' N, longitude: 85o20' E) at an elevation of 1400 meters and is surrounded by four hills with elevations exceeding 1350.0 meters. [1]. The physical quantity that expresses heat and cold is temperature. The Earth has two hemispheres, one in the north and one in the south. When the earth rotates in its orbit for half a year, the northern hemisphere is tilted toward the sun, while the southern hemisphere is inclined in the opposite direction. As a result, the northern hemisphere receives the sun's harshest rays, causing the northern hemisphere's temperature to rise. Because the south hemisphere is closer to the sun, the temperature in the south hemisphere is higher than in the north. The geological temperature changes as a result of these phenomena [3]. On June 21, the Northern Hemisphere tilts closer to the sun, making it the longest day, and on December 21, the Southern Hemisphere tilts farther away from the sun, making it the shortest day, and vice versa. [4]. Because of the high temperature, the air at ground level rises and the colder air descends. The humidity varies as the temperature rises because the little air vessel expands and the volume of the vessel expands, containing more water vapor and lowering humidity. The air at ground level rises due to the high temperature, while the colder air falls. Because the tiny air vessel expands as the temperature rises, the volume of the vessel expands, containing more water vapor and lowering humidity. And when the temperature drops, the air vessel shrinks, reducing the volume of the vessel, which means it holds less water vapor, indicating high humidity. Air that is cooler has a lower potential to absorb water vapor, and vice versa. In the summer, eastern air flows via the Bay of Bengal, causing monsoon, while at the winter, western air flows through the west side of the country, lowering the temperature and causing snowfall in the higher elevations. Here in 2nd chapter, we discuss about the arrangement of the data and the method of analyzing it. In the 3rd chapter we discussed about the result with the graph and in the 4th chapter we discussed the conclusion.

2. DATASET AND METHODOLOGY

2.1. Dataset

In this paper we have taken three parameters of data from Meteorology and Hydrology department of Nepal, which are Rainfall, Temperature, and Relative Humidity from the period of year 2012-2016 of Tribhuvan International Airport Kathmandu, Nepal. The data was then transferred to MS-Excel where the further study and arrangement were done. The data contains the information of the parameters Rainfall in milliliters (mm), temperature in Celsius (average temperature of Maximum and Minimum), the Relative Humidity in percentage (%). Arrangement of data was done according to our objectives. The first arrangement was done by calculating the mean data of each month for the year 2012-2016 respectively. The correlation analysis was made by the same data that we arranged for monthly analysis. The t-test performed was conducted in MS-Excel and calculated the p-value.

2.2. Methodology

Correlation is a statistical term that describes how two or more variables are related [5]. Positive, Negative, and Neutral correlation are the three most common signs of correlation employed in basic interpretation. When two variables move in the same direction, the correlation is called positive correlation. When two variables move in opposite directions, the correlation is called negative correlation. It's called neutral correlation when there's no relationship between two variables [6]. A correlation has three forms they are, Linear, non-linear, and Monotonic. A correlation is linear when the two-variable change at constant rate and satisfy the equation of slope $Y=mx + c$. A correlation is non-linear when the two variables don’t change at a constant rate. In this case the relationship between these variable shows a curve line pattern like parabola, hyperbola etc. A correlation is monotonic when the variable tends to move in same direction but not at a constant rate. So, we can say that all linear correlation is monotonic but the opposite is not always true [7]. There are several types of correlation coefficient but here we use Pearson correlation coefficient (r). It is used to measure strength and direction of linear relationship between two variables [8]. The alternative hypothesis is always what we are trying to prove. The null hypothesis is the hypothesis that we are always trying to provide evidence against. In our case we are trying to provide the evidence against the hypothesis that there is no significant linear correlation between two variable [9]. T test also called student T-test is an inferential statistic that allows to use sample data to generalize an assumption to an entire population [10]. A p-value is the probability that the null hypothesis is true. Considering level of significance 5% we can make the interpretation that if the p-value is smaller than the significant value we reject the null hypothesis and if the p-value is greater than the significance value we fail to reject the null hypothesis [11].

3. RESULT AND DISCUSSION

Result of monthly variation and correlation between rainfall, temperature and the relative humidity for the year (2012-2016) are mentioned here.

3.1. Monthly variation

Here in figure 1, we can see the monthly variation of rainfall, temperature and relative Humidity from year 2012-2016. Light blue color indicates the year 2012, orange color indicates the year 2013, silver color indicates the year 2014, yellow color indicates the year 2015 and dark blue color indicates the year 2016. The first graph it shows the monthly variation in rainfall. X-axis denotes the months while Y-axis denotes the average rainfall in millimeter. The highest average rainfall observed in this graph is in the month of July and lowest average rainfall is observed in the month of Janaury. Here the flow of each year in the graph is quiet similar to each other. There may be small difference in the amount of rainfall but the tendetive pattern is been followed by each year. Nepal faces moonsoon in the month of mid june to august and we can see in the graph that at these month there is increase in average rainfall. Rest of the year is quiet dry than to the month of rainfall so we can see less average rainfall in other months.

The second graph, we can see the monthly variation of temperature. The X-axis denote the months while Y-axis denote the average temperature. Here average daily temperature is calculated by taking mean temperature of max and min temperature. We can see that the high temperature was recorded in the month of June July and August. Which also state that these months are referred as summer seasons. The winter months of December, January, and February are marked by cold temperatures and are referred to as the "winter months". Earth has two hemispheres Northern and Southern. Nepal lies in Northern Hemisphere. When the Northern hemisphere of the earth tilts toward sun we experience longer days and the temperature also rises. Same as when northern hemisphere of the earth tilts away from the sun we experience low temperature and day is shorter. Northern hemisphere contains more land than the southern hemisphere. This geographic condition causes the temperature of northern hemisphere be more than the southern hemisphere. The land heats up quickly and cools down quickly. Due to this condition northern hemisphere record high temp and low temp in summer and winter respectively than to the southern hemisphere.

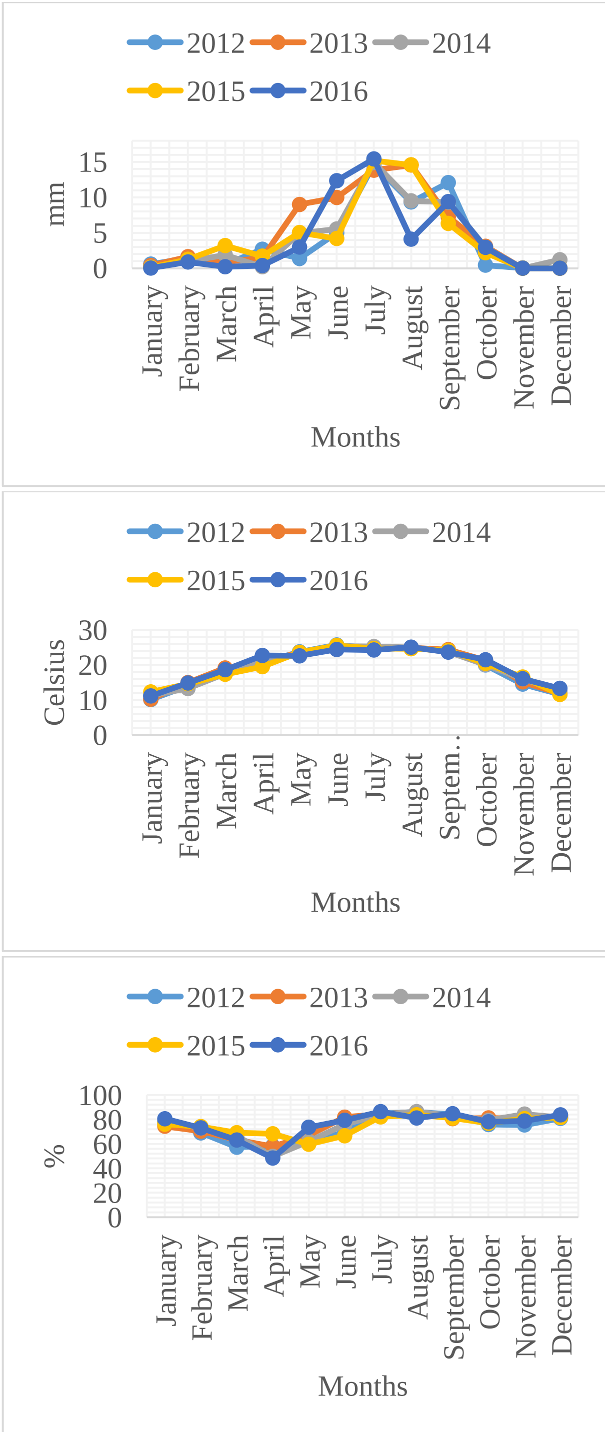

Fig. 1: Monthly variation of Rainfall, Temperature and Relative Humidity.

The third graph, we can see the monthly variation in relative humidity. The X-axis denotes the months while Y-axis denotes the percentage of air saturation. The high RH recorded in the month of summer July and August. While low RH recorded in the month of spring March, April and May. Humidity depends upon temperature and pressure. Since the pressure is constant at this region, we neglect the condition [1]. But when temperature increases the capacity of air molecule absorbing the water molecule increases and vice versa [3]. Due to this nature or dependency, we can see the sudden drop in RH in the month of spring due to increase in temperature [4]. In winter the RH are quite high because when the temperature increase in day the air molecules absorbs as much as it can. And when there is sudden decrease in temperature its stats to condense after reaching 100% saturation state. The temperature at which the air is 100% saturated is called Dew point temperature [4]. If the temperature decreases below the dew point, then the condensation process begins and there is fog, dewfall etc. Dew to this phenomenon we have high RH in winter than in spring. In spring when the temperature is high the dew point temperature lies quiet below than the normal temperature. In which air is not able to be 100% saturated to and start condensation.

3.2. Correlation

Here in figure 2 we can see the correlation between Rainfall vs Temperature, Rainfall vs RH, RH vs Temperature for the year 2012. The first graph is the correlation between Rainfall in X-axis and Temperature in Y-axis is 0.689, which has the p-value of 0.013 which is less than the significance level α (0.05) which further reject the null hypothesis stating that the correlation between them is significant moderate positive correlation. The second graph is correlation between Rainfall in X-axis and Relative Humidity in Y-axis is 0.564, which has p-value of 0.055 which is greater than the significance level α (0.05) which further does not reject the null hypothesis stating that the correlation between them is insignificant moderate positive correlation. The third graph is for correlation between Temperature in X-axis and Relative Humidity in Y-axis is 0.047, which has the p-value of 0.884 which is greater than the significance level α (0.05) which further does not reject the null hypothesis stating that the correlation between them is insignificant negligible positive correlation.

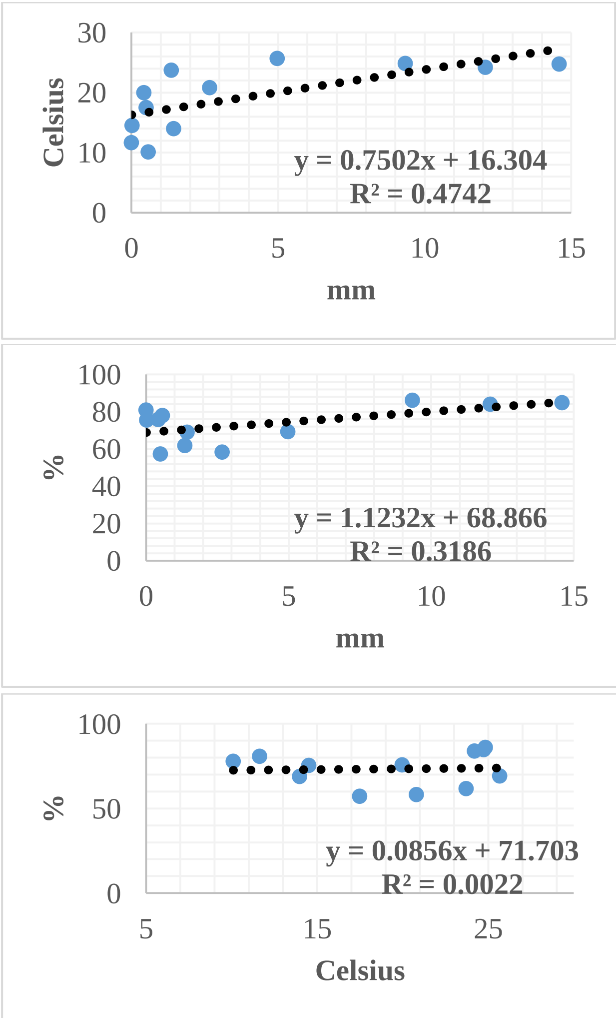

Fig. 2: Shows the correlation between Rainfall vs Temp, Rainfall vs RH and RH vs Temp for the year 2012

Here in figure 3 we can see the correlation between Rainfall vs Temperature, Rainfall vs RH, RH vs Temperature for the year 2013. The first graph side is the correlation between Rainfall in X-axis and Temperature in Y-axis is 0.818, which has the p-value of 0.001 which is less than the significance level α (0.05) which further reject the null hypothesis stating that the correlation between them is significant high positive correlation. The Second graph is the correlation between Rainfall in X-axis and Relative Humidity in Y-axis is 0.445, which has p-value of 0.146 which is greater than the significance level α (0.05) which further does not reject the null hypothesis stating that the correlation between them is insignificant low positive correlation. The third graph is the correlation between Temperature in X-axis and Relative Humidity in Y-axis is 0.134, which has the p-value of 0.677 which is greater than the significance level α (0.05) which further does not reject the null hypothesis stating that the correlation between them is insignificant negligible positive correlation.

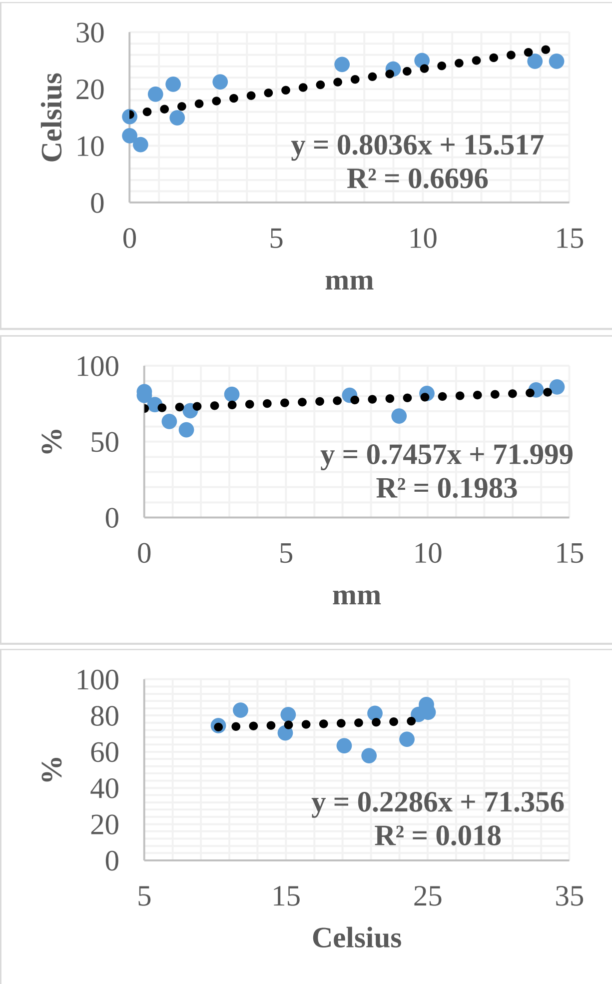

Fig. 3: Shows the correlation between Rainfall vs Temp, Rainfall vs RH and RH vs Temp for the year 2013

Here in figure 4 we can see the correlation between Rainfall vs Temperature, Rainfall vs RH, RH vs Temperature for the year 2014. The first graph is the correlation between Rainfall in X-axis and Temperature in Y-axis is 0.771, which has the p-value of 0.003 which is less than the significance level α (0.05) which further reject the null hypothesis stating that the correlation between them is significant high positive correlation. The second graph is the correlation between Rainfall in X-axis and Relative Humidity in Y-axis is 0.416, which has p-value of 0.178 which is greater than the significance level α (0.05) which further does not reject the null hypothesis stating that the correlation between them is insignificant low positive correlation. The third graph is the correlation between Temperature in X-axis and Relative Humidity in Y-axis is 0.001, which has the p-value of 0.998 which is greater than the significance level α (0.05) which further does not reject the null hypothesis stating that the correlation between them is insignificant negligible positive correlation.

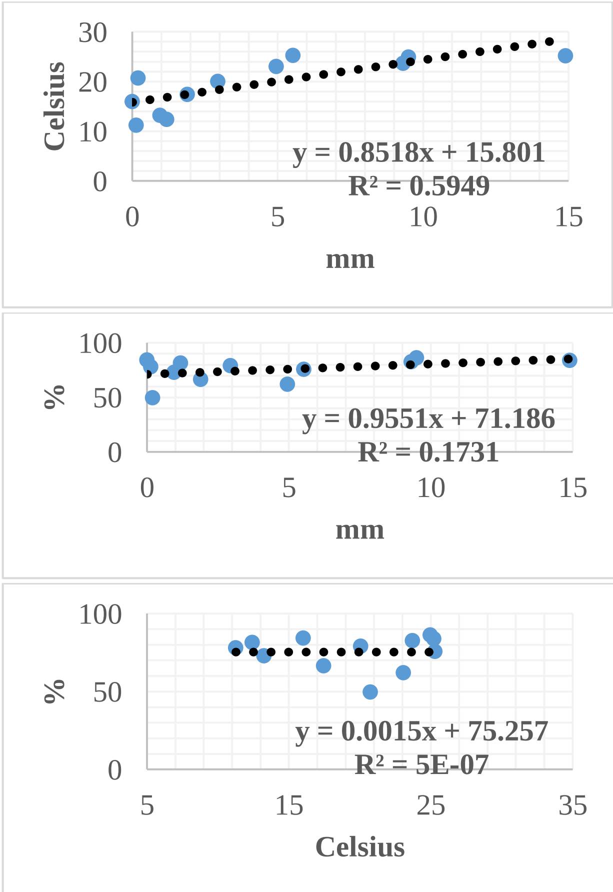

Fig. 4: Shows the correlation between Rainfall vs Temp, Rainfall vs RH and RH vs Temp for the year 2014.

Here in figure 5 we can see the correlation between Rainfall vs Temperature, Rainfall vs RH, RH vs Temperature for the year 2015. The first graph is the correlation between Rainfall in X-axis and Temperature in Y-axis is 0.728, which has the p-value of 0.007 which is less than the significance level α (0.05) which further reject the null hypothesis stating that the correlation between them is significant high positive correlation. The second graph is the correlation between Rainfall in X-axis and Relative Humidity in Y-axis is 0.307, which has p-value of 0.331which is greater than the significance level α (0.05) which further does not reject the null hypothesis stating that the correlation between them is insignificant low positive correlation. The third graph is the correlation between Temperature in X-axis and Relative Humidity in Y-axis is -0.147, which has the p-value of 0.649 which is greater than the significance level α (0.05) which further does not reject the null hypothesis stating that the correlation between them is insignificant negligible negative correlation.

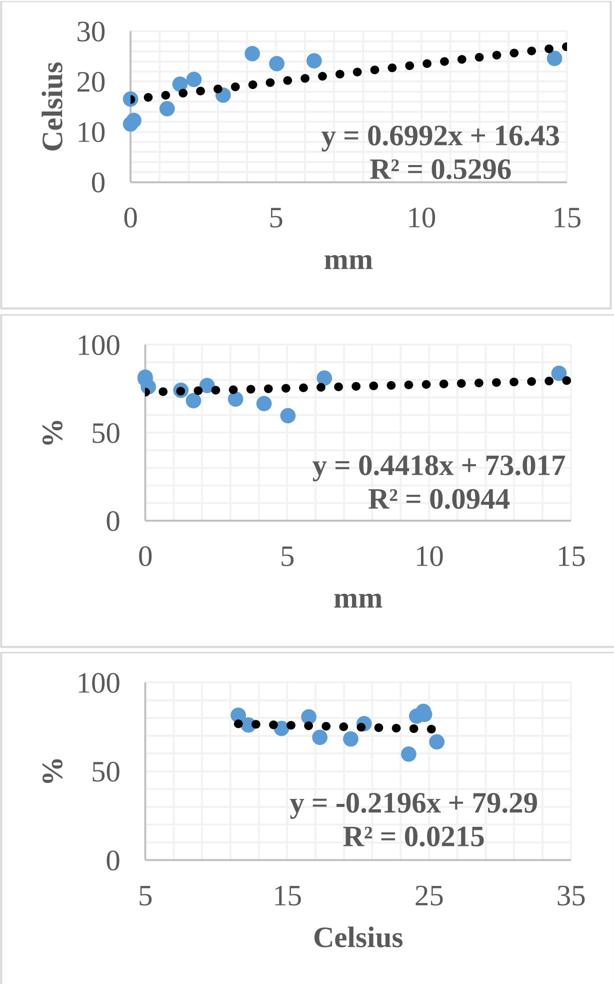

Fig. 5: Shows the correlation between Rainfall vs Temp, Rainfall vs RH and RH vs Temp for the year 2015

Here in figure 6 we can see the correlation between Rainfall vs Temperature, Rainfall vs RH, RH vs Temperature for the year 2016. The first graph is the correlation between Rainfall in X-axis and Temperature in Y-axis is 0.666, which has the p-value of 0.018 which is less than the significance level α (0.05) which further reject the null hypothesis stating that the correlation between them is significant moderate positive correlation. The second graph is the correlation between Rainfall in X-axis and Relative Humidity in Y-axis is 0.464, which has p-value of 0.128 which is greater than the significance level α (0.05) which further does not reject the null hypothesis stating that the correlation between them is insignificant low positive correlation. The third graph is the correlation between Temperature in X-axis and Relative Humidity in Y-axis is -0.054, which has the p-value of 0.867 which is greater than the significance level α (0.05) which further does not reject the null hypothesis stating that the correlation between them is insignificant negligible negative correlation.

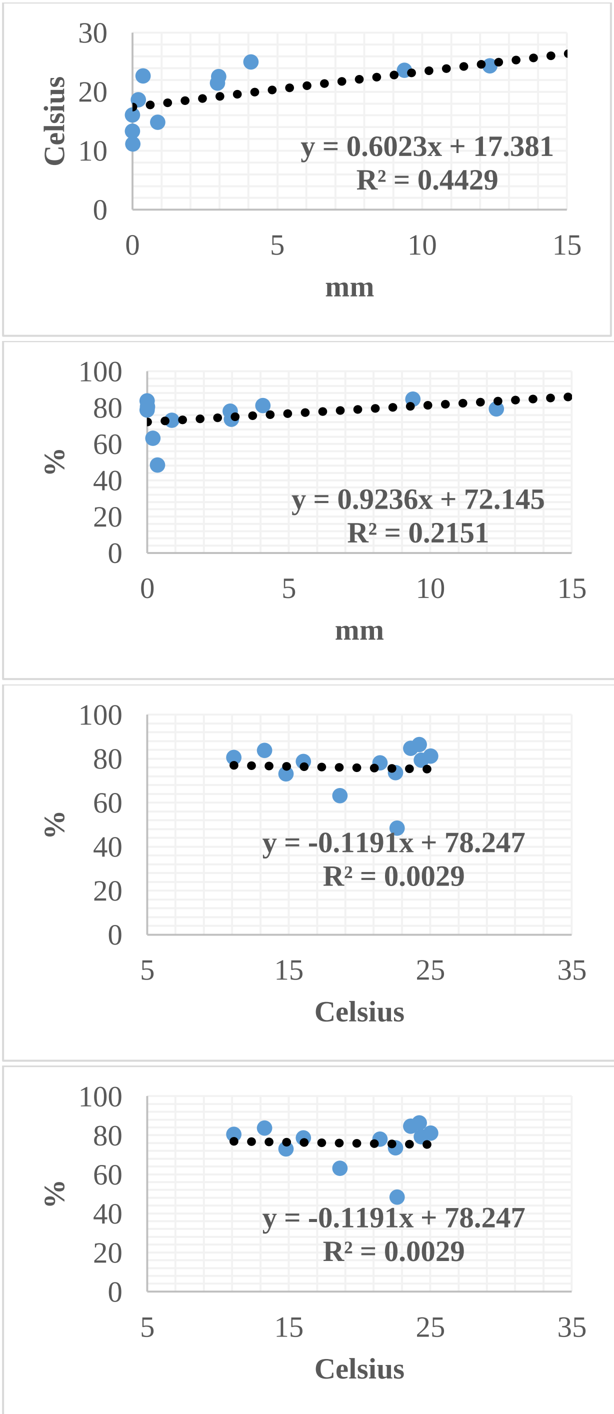

Fig. 6: Shows the correlation between Rainfall vs Temp, Rainfall vs RH and RH vs Temp for the year 2016

Table 1: Monthly average data of rainfall, Relative Humidity and Temperature from the year 2012-2016.

2012			
Months	**Rainfall (mm)**	**Temp (Celsius)**	**Humidity (%)**
January	0.574	10.097	77.898
February	1.441	13.976	68.940
March	0.503	17.487	57.244
April	2.670	20.803	58.258
May	1.361	23.711	61.768
June	4.973	25.673	69.233
July	14.590	24.737	84.790
August	9.342	24.835	86.090
September	12.073	24.198	83.962
October	0.426	19.971	75.773
November	0.023	14.513	75.475
December	0.000	11.639	80.845
2013			
Months	**Rainfall (mm)**	**Temp (Celsius)**	**Humidity (%)**
January	0.371	10.223	74.434
February	1.621	14.945	70.396
March	0.881	19.103	63.324
April	1.483	20.855	57.827
May	8.987	23.531	66.903
June	9.970	25.028	81.818
July	13.823	24.900	84.127
August	14.561	24.905	86.094
September	7.243	24.342	80.603
October	3.087	21.273	81.223
November	0.000	15.152	80.518
December	0.000	11.789	82.971
2014			
Months	**Rainfall (mm)**	**Temp (Celsius)**	**Humidity (%)**
January	0.135	11.256	78.121
February	0.954	13.248	72.998
March	1.894	17.453	66.566
April	0.200	20.745	49.740
May	4.952	23.074	62.116
June	5.527	25.298	75.793
July	14.900	25.218	83.955
August	9.500	24.968	86.360
September	9.313	23.713	82.708
October	2.942	20.065	79.156
November	0.000	16.015	84.347
December	1.184	12.423	81.560
2015			
Months	**Rainfall (mm)**	**Temp (Celsius)**	**Humidity (%)**
January	0.110	12.274	76.092
February	1.257	14.605	74.155
March	3.184	17.305	69.142
April	1.700	19.483	68.230
May	5.029	23.566	59.705
June	4.187	25.552	66.588
July	15.181	24.685	82.052
August	14.581	24.603	83.779
September	6.313	24.130	81.087
October	2.181	20.427	76.852
November	0.000	16.528	80.667
December	0.000	11.561	81.587
2016			
Months	**Rainfall (mm)**	**Temp (Celsius)**	**Humidity (%)**
January	0.013	11.126	80.511
February	0.872	14.812	73.053
March	0.203	18.624	63.131
April	0.367	22.667	48.380
May	2.977	22.553	73.600
June	12.340	24.375	79.290
July	15.413	24.232	86.373
August	4.090	25.037	81.142
September	9.390	23.627	84.678
October	2.935	21.455	78.055
November	0.000	16.042	78.693
December	0.000	13.297	83.726

Table 2: Correlation between the parameters from year 2012-2016.

2012	Correlation	P-Value	Remark
Rainfall Vs Rh	0.564	0.055882	p≥α
Rainfall Vs Temp	0.689	0.013275	p<α
Rh Vs Temp	0.047	0.884952	p≥α
2013	**Correlation**	**P-value**	**Remark**
Rainfall Vs Rh	0.445	0.146902	p≥α
Rainfall Vs Temp	0.818	0.001139	p<α
Rh Vs Temp	0.134	0.677837	p≥α
2014	**Correlation**	**P-value**	**Remark**
Rainfall Vs Rh	0.416	0.178518	p≥α
Rainfall Vs Temp	0.771	0.003308	p<α
Rh Vs Temp	0.001	0.998279	p≥α
2015	**Correlation**	**P-value**	**Remark**
Rainfall Vs Rh	0.307	0.331227	p≥α
Rainfall Vs Temp	0.728	0.007301	p<α
Rh Vs Temp	-0.147	0.649023	p≥α
2016	**Correlation**	**P-value**	**Remark**
Rainfall Vs Rh	0.464	0.128818	p≥α
Rainfall Vs Temp	0.666	0.018167	p<α
Rh Vs Temp	-0.054	0.867306	p≥α

4. CONCLUSION

Time series analysis helped us to find the monthly relationship between Rainfall, temperature, and relative humidity which were discovered to be consistent throughout five years. High rainfall in June and July, and low rainfall in November, December, January, and February were recorded throughout five years. Similarly, high temperatures were recorded in June, July, and August, while low temperatures were recorded in January and February. When we looked at the graph for relative humidity, we saw a flat line for the bulk of the months, but a decrease in March, April, and May. Using statistical tool, we discovered that in all five-year correlations between relative humidity and temperature, rainfall and relative humidity were inconsequential, whereas rainfall versus temperature was significant. The general study of meteorological parameters was done to see if there was any change in the yearly cycle, which came to be false.

ACKNOWLEDGEMENT

The author would like to express gratitude to Meteorology and Hydrology Department of Government of Nepal for the excess of data. Authors also would like to express gratitude to all the Professors Department of Physics, St. Xavier's College for their valuable suggestions.

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