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PREDICTING RAINFALL IN MAINPAT USING THE BPN METHOD

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ABSTRACT

Climate change is a major concern on a global scale. The purpose of this study is to elucidate the causes of historical fluctuations in rainfall. While late monsoon and post monsoon regions will see notable fluctuations in rainfall amounts, pre-monsoon and early monsoon regions will become drier in the future. Rain prediction is a particularly difficult task for meteorologists. Numerous models have been used in recent years to evaluate and precisely predict rainfall. In this context, climate records can be quite useful. Long-term data retention can improve our ability to forecast rainfall. This study presents the modeling and rainfall prediction throughout Mainpat using statistical techniques, specifically the Modified ANN model and linear regression. The Indian Meteorological Department (IMD), India, supplied the rainfall data for the last 31 years. This Mainpat surface-based rain gauge collected rainfall data from metrological sites between 1991 and 2024. It has been established how much rain falls each month and year. To assess the accuracy of the data, the average, median, correlation coefficients, and standard deviation were computed for every station. When the quantity of rainfall predicted by the model was contrasted with the amount recorded by rain gauges at different sites, it was discovered that the model's rainfall forecast produced accurate results.

Keywords: Rainfall, Linear Regression, ANN, IMD, Mainpat

1. INTRODUCTION

There is compelling evidence of both global and regional changes in rainfall patterns (M. Hulmeet al. 1998; G. Fu et al. 2010). Floods and waterlogging brought on by excessive rainfall might result in crop failure. Due to its low elevation and level terrain, Mainpat is especially vulnerable to natural disasters (Khan 2013; R. S. J. Tol 2013). Variations in rainfall patterns have a significant impact on the environment, human health, and crops. According to M. Hossain et al. (2014), rainfall is a significant climatic component that can have a broad impact on a country's agricultural. Numerous examples of rainfall-related climate extremes have affected the agricultural productivity in Mainpat, Chhattisgarh, India (Aziz et al. Basak, J. K. (2014) 2011). However, crop yield is affected not only in Mainpat but also globally by reductions in rainfall totals as well as regional and temporal changes (J. De Dios Miranda et al. 2009; M. Hossain et al. 2014). During the monsoon and post-monsoon seasons, overall rainfall tended to increase, and during the winter, it tended to decrease. There was a wetter monsoon and a dryer winter, according to some researchers who examined the frequency and intensity of rainfall (Z. Hasan et al. 2014). June saw more rainy days, while July saw more heavy rainfall (Mannana et al.

2015). In contrast to Shahid's findings (S. Shahid 2010; Z. Hasan et al. 2014) regarding temporal and spatial variability, Rahman and Latah (R. Rahman and H. Lateh 2015) discovered a negative tendency in the average rainfall during the pre-monsoon. A small number of researchers (S. H. Bari et al. 2015) predicted the size of future rainfall patterns using a variety of analytical techniques. Numerous studies have been conducted

Figure 1.2: Ambikapur region is Geographically Located at 23°07'23" N Latitude, 83°11'39" E Longitude

Source: Google map

on the historical monthly average and monthly maximum rainfall changes from 1983 to 2024. Future rainfall forecasting is extremely challenging due to the multidimensional and non-linear nature of the data (S. H. Bari et al. 2015). The purpose of this study was to reveal previous monthly averages and maximums for that time frame. Mainpat, Chhattisgarh, India, is primarily a low-lying plain area of around 144,000 square kilometers situated on the deltas of massive rivers that originate in the Himalayas. Its subtropical humid climate is characterized by notable seasonal changes (S. Banik et al. 2008). When discussing the development of meteorological phenomena and calamities, the Mainpat geographic location is often highlighted. The funnel-shaped city of Mainpat, Chhattisgarh, India (Figure 1) (Mallika Roy 2013). Cyclones, floods, droughts, tornadoes, heavy rains, and other weather-related phenomena are usually caused by this particular geographic location. As a result, rainfall is immediately detected utilizing 35 rain gauges located around the nation and the Indian Meteorological Department's (IMD) weather radar. Finding a rainfall forecasting trend that will be helpful for flood forecasting, anticipating heavy rainfall, and providing early warning of severe weather is the main objective of this study. In this context, rainfall estimation is especially important at critical periods, such as the monsoon, pre-monsoon, or post-monsoon (Mallika Roy 2013; Elbeltagi 2022).

1.1. OBJECTIVES

At the moment, climate change is a significant worldwide concern that is being closely examined by numerous groups. The problem of global warming is the subject of numerous studies. As a result, we also see climate change-related changes in rainfall across different regions. Rainfall variations have a big influence on a nation's agriculture and way of life. Our research article's goal is to predict the kind of rainfall that will fall in the southern regions of Bangladesh in the future by analyzing the amount of rainfall that has already occurred there. And with the aid of the linear regression method, we have attempted to get as close to the right value as we can.

2. LITERATURE REVIEW

Winter, pre-monsoon, monsoon, and post-monsoon are the four main seasons in Mainpat's climate. The periods between the SW-monsoon (monsoon) and the monsoon (winter) are referred to as pre-monsoon and post-monsoon.

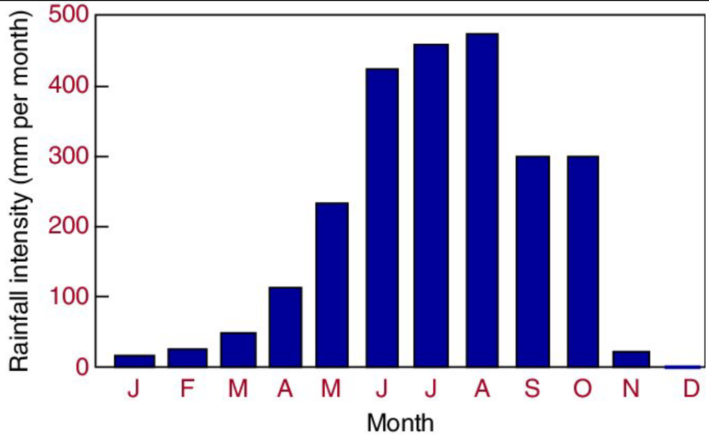

Figure 2: The Graph of Mainpat Average Monthly Precipitation (1989-2024)

The average summer temperature in the country is from 26.9 to 31.1 °C, while the average winter temperature ranges from 17.6 to 20.6 °C. The average yearly relative humidity in Mainpat is between 70.5 and 78.1 percent (Mohammad Shohidul Islam 2013). The humidity ranges from over 84% during the monsoon season to only roughly 55% during other months (Figure 2). Mainpat a. Interseason (December to February) Pre-monsoon (March to May), monsoon (June to September), and post-monsoon (September to October) are the three distinct seasons. The hilly range forest, high flood plains, rivers, and excessive rains are all directly tied to and caused by the forest in this area (Islam 2003; Shahriar et al. 2021). A long-range model for forecasting summer monsoon rainfall based on power regression (Islam et al. 2005; Aziz et al. 2022). The experimental results showed that the model error was 4%. S. Nkrintra talked about developing a statistical forecasting technique for ANN using regional nonparametric methods and multiple linear regression (Di Nunno et al. 2022). M. T. Mebrhatu created a model for forecasting the three types of rainfall in Eritrea's highlands: below, above, and normal (Guhathakurta 2005). The height of children's growth potential has been accurately predicted using a model for human height prediction based on multiple polynomial regressions (Fabio et al. 2022). For advanced life support, Vaccari modeled nutrient recovery data and plant motion time series using multivariable polynomial regression (Yaseenet al. 2021). Numerous articles concerning rainfall forecasts have been read, but the intended outcomes have not yet been achieved. The figure we obtained is rather accurate. Additionally, using the Linear Regression Method, we have tried to estimate the future rainfall in the southern region of Mainpat. And a lot of individuals will find this information useful. We anticipate that the need for it will rise in the future.

3. STUDY AREA & DATA

3.1. STUDY AREA

Mainpat, also referred to as the Shimla of Chhattisgarh, is a plateau that rises 1099 meters above sea level. This stunning plateau, which covers 368 square kilometers, is alive with rare plants, Ayurvedic herbs, and a wide variety of birds. Tibetan exiles arrived on this plateau in 1962–1963, bringing with them a Buddhist culture that is universal. The sole temple devoted to Lord Buddha is the Buddha Temple. A stunning waterfall that cascades from a height of 60 meters can be seen at a location called Tiger Point.

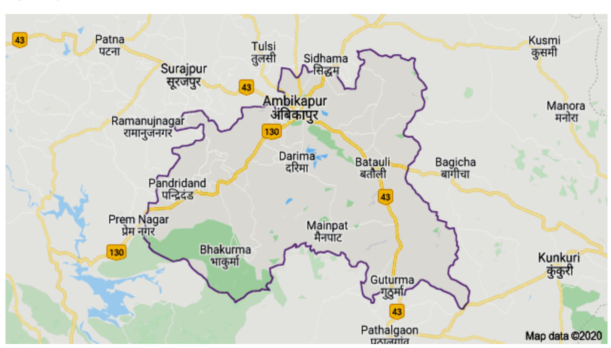

Figure 1.1 Mainpat Found at Latitude 83.2828°E and Longitude 22.8199°N.

Source: IMD Pune, Kalpana-I Image NE Sector of India)

The surroundings of Parpatiya are heart-stirring and breathtakingly gorgeous. Mehta Point, a breathtaking waterfall surrounded by towering mountain ranges, is about 8 miles from Mainpat. The lovely stream known as Dev Pravah (Jaljali) flows endlessly into an 80-meter waterfall in Kamleshwa. Bandarkot, Raksamada, Bhalumada, and Paiga Khoh are among the Mainpat caves. Buddha Math, Kala Mandir, Banjara Temple, Jungleshwar Temple, Shivalaya, Panhi Pankhna, and Dulha-Dulhan are some of the pilgrimage sites in Mainpat. Beautiful valleys like Kadnai, Kardna, Sakriya, Govindpur, and Paiga make Mainpat blush green. There are two-room forest department shelters that are run by the Chhattisgarh Tourism Board. There are several ways for us to get to Mainpat.

Data

The current analysis used a long-term recorded climate dataset. The Mainpat area of Chhattisgarh is where the rainfall data was collected. Rain gauge rainfall data for the study area was provided by the Indian Meteorological Department (IMD) between 1989 and 2024. The data, which included measurements of the daily and three-hour rainfall accumulations at many rain gauge sites, was collected from IMD stations.

4. METHODS

The linear regression (LR) approach (one or more independent variables) models the linear connection between a dependent variable (predicated) and predictors. This approach is based on least squares and is widely used in climatology to develop models for reformulating climate variables from tree-ring records. The regression model is used to generate estimates of the predicted variable outside of the time period utilized to fit the data. Confidence intervals summarize the degree of uncertainty in the reformation and can be computed in a number of ways.

4.1. LINEAR REGRATION MODEL

The linear regression line is fitted using the most widely used method, least squares. This method determines the line that best fits the observed data by lowering the sum of the squares of the vertical deviations between each data point and the line. If a point is exactly on the straight line, the residuals' algebraic sum is zero (S. Banik et al. 2008). A residual is the difference between an observation made at a specific moment in time and the value that was extrapolated from the trend line at that same moment. The equation for a linear regression line is given as follows:

$$y = a + bx \text{-------------------------------} (1)$$

where y is the observation or observations of the dependent variable. Regarding the independent variables, observation x is made. The regression coefficient "b" and the intercept "a" are estimated using the least squares approach.

$$\hat{a} = \bar{y} - \hat{b}\bar{x} \text{----------------------------} (2)$$

$$\hat{b} = \frac{\sum(x-\bar{x})\,(y-\bar{y})}{\sum(x-\bar{x})} \text{---------------------------} (3)$$

The coefficient of determination is R2 = SS resulting from regression/total SS.

$$ss = \frac{\sum(\hat{y}_i - \bar{y})^2}{\sum(\hat{y}_i - \bar{y})^2} - (4)$$

In order to fit regression lines, the monthly average rainfall throughout the rainy season was plotted against time (an independent variable) in years. After that, linear regression lines were fitted to ascertain rainfall trends. Regression line fitting and diagram construction were done using Microsoft Excel.

5. INTENSITY TREND

Secular trend, or simply trend, is the general tendency of the data to rise or fall over a long period of time (Ghosh, Sanjib 2015; S. Banik et al. 2008). Temperature, precipitation, and agricultural output data are collected over time and are therefore called time series data, which is a collection of observations that change over time; four components of the time series are seasonal, trend, cyclical, and irregular (Patterson, 1987); "trend" can mean either the long-term change in the dependent variable over a large period of time, or the general movement of a series over a long period of time (Webber and Hawkins, 1980).

Since the trend variance occurs over a significant period of time, the station's 33 years of available data were judged suitable for the trend analysis. Consequently, the stations in Hatiya, Sandwip, and Cox's Bazar were excluded from this study. To follow the usual tendency of the monsoon, the relationship between the two variables—rainfall and time—determines the trend. Rainfall for the designated stations and trend data have been calculated using the least squares method. The annual average rainfall in Chittagong is increasing by 0.31 percent, based on the simple regression coefficient.

6. CORRELATION COEFFICIENT

The correlation coefficient indicates the degree of the linear relationship between two variables. A number between -1 and +1 is always accepted, and a value of +1 or -1 indicates a perfect correlation, where all points would fall in a straight line and have a residual of zero. If the coefficient of correlation is near or equal to 0, then there is no correlation between the variables. A positive correlation coefficient indicates an upward relationship between the variables, while a negative correlation value indicates a downward relationship. To find the correlation coefficients between rainfall and time, the following formulas were applied. The correlation coefficient can be calculated using the following formula given the pairs of values: (x1, y1), (x2, y2),……….. (xn, yn).

$$r = \frac{\sum(x-\bar{x})\,(y-\bar{y})}{\sqrt{\sum(\hat{y}_i-\bar{y})^2(\hat{y}_i-\bar{y})^2}} \text{--------------------}(5)$$

The correlation coefficients for the Chittagong station were calculated using the above methodology, and the results are shown in Tables 3 and 4.

7. RESULT AND DISCUSSION

7.1. ANALYSIS OF MONTHLY & YEARLY RAINFALL

Figure 4 shows that the rainfall trend in the Mainpat region is increasing, indicating a positive linear relationship between rainfall and time. The R2 value of -1.480 indicates that time only accounts for 9.85 percent of the variation in rainfall. The trend of rainfall was then calculated using the strength of the linear relationship between the variable and time. The correlation coefficient computes these associations. The monsoon average rainfall trend values for the stations in Table 1 are shown in Figure 4.

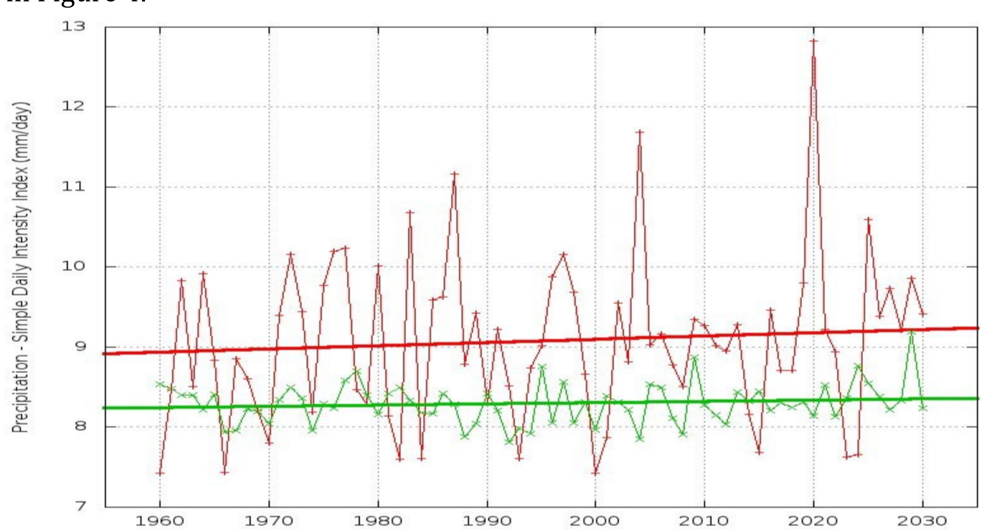

Figure 4: Plot with trend analysis for prediction of Mainpat Chhattisgarh Regions Annual Average Rainfall

A linear line going upward is also depicted in Figure 4, suggesting that rainfall activity is increasing over time. A number of statistical measures, including the average, median, correlation coefficient, and standard deviation, are simultaneously calculated for yearly average rainfall total stations.

Table 1: A few computations of the monsoon average rainfall trend values over Mainpat

Year	Avg. Rf (mm)	Trend Values
1983	394.68	421.95
1988	341.00	435.07
1993	515.24	436.79
1998	412.51	441.98
2003	459.76	447.24
2008	648.19	453.37
2013	511.41	452.78
2018	532.54	442.01
2023	546.98	440.00

Table 2: Correlation Coefficient in Mainpat Chhattisgarh

Station	Correlation Coefficient
Mainpat Chhattisgarh	0.092

A statistical measure of how accurately changes in one variable's value forecast changes in another is called a correlation coefficient. The values of two variables rise or fall simultaneously when they are positively correlated (Table 2). The increasing trend for Mainpat indicates that rainfall and time are positively correlated. Rainfall and time have a 0.091 correlation value in Mainpat (Table 3).

Table 3: Monthly Rainfall Statistic by Station

Statistical Parameters	Value
Average	279.093
Median	279.479
Correlation Coefficient	0.099
Standard Deviation	67.078

Table 4: Prediction Performance for the rainfall on the dataset

Model	MSE	RMSE	MAE	R2
ANN	145.151	13.007	11.789	-1.475

7.2. RAINFALL VARIATION IN MAINPAT

Rainfall in Mainpat, India, is estimated to occur every two to three years, every six years, and every eleven years. The annual variation in monsoon rainfall may be the natural response mechanism of the ocean-atmospheric system to variations in numerous physical parameters. Climate change, which can be caused by both natural and man-made factors, may also be related to this.

7.3. RAINFALL PATTERN

In order to evaluate changes in rainfall patterns, the entire year was split into four seasons. Changes in total rainfall from 1983 to 2024 were examined. The pre-monsoon period, which lasts from March to May, is when the hot season begins. The monsoon season lasts from June to September, whereas the post-monsoon season lasts from October to November. Winter, which lasts from December to February, is the frigid season. We noticed a notable shift in the rainfall trends in our investigation. Of the 34 locations, two displayed an increasing tendency in total rainfall during Bangladesh's winter, while 32 showed a declining trend. However, out of 34 weather stations, 31 indicated an increasing tendency in total rainfall during the monsoon season, 30 showed an increasing trend in post-monsoon rainfall, and 20 showed an increasing trend in pre-monsoon rainfall. Furthermore, the majority of the time, the patterns that were seen were not statistically significant. However, a considerable number of stations displayed a declining tendency of total rainfall during the winter, whereas the majority of stations displayed a rising trend of rainfall during the monsoon and post-monsoon seasons. We found that the results of the analysis of total rainfall are in line with the basic predictions of climate change, which state that wet times would become wetter and day periods will become drier. The average annual rainfall in the Mainpat regions of India rose between 1983 and 2024. which is displayed in Table 5.

Table 5: Mainpat in Amount of Rainfall (mm per Year) in Four Seasons During 1983-2024

Region	Winter	Pre-Monsoon	Monsoon	Post-Monsoon
Mainpat Chhattisgarh	-0.497	-0.197	4.097	-1.654

8. CONCLUSION

Landslide vulnerability assessment and division may be necessary for property management. Planning, land use, and use shall adhere to the designated land division, any applicable policies, and any applicable laws. Most landslides in Chittagong happen during the peak of the season's precipitation intensity. Rainy seasons should be routinely observed to evaluate the situation, particularly in regions that are vulnerable to landslides. In the event of any dangerous landslides, early warnings should be sent to the residents of the impacted communities. Campaigns to raise awareness should also address proper land use and property land management. One acknowledgedly important component of adapting to the increased frequency of floods caused by global climate change is an adequate flood prediction system that can offer precise forecasts during floods with sufficient lead time. By making improvements to the nearby structures and infrastructure, flooding injuries can be decreased. Techniques for battling floods have been employed to keep control structures from failing and causing damage. Combating floods is a pressing way to lessen their negative impacts on the environment and society, especially when management strategies have failed. Evacuation is essential anywhere buildings or other options don't offer a safe haven in the event of flooding. A reasonable way of life would be for the government to set aside a sizeable amount of money to help with flood relief in the case of climate change. Flood insurance is often required to control the expense of flood damage. In certain countries with advanced insurance markets, it is currently accessible.

CONFLICT OF INTERESTS

None.

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None.

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