Influence of Climatic Factors on Monsoon Rainfall in Potohar Region, Pakistan

Samreen Fatima[1], Mehwish Shafi Khan[2]*, Imra Khalid[1]
1Department of Statistics, University of Karachi, Karachi, Pakistan.
2Department of Mathematics, University of Karachi, Karachi, Pakistan.
*Email: mehwish.skhan@uok.edu.pk

ABSTRACT

The climate of Pakistan is more 'continental' than the other parts of the sub-continent, which comes under a more typical monsoon season. Almost all the Agriculture sector in Pakistan mainly depends upon rainfall. In this study, the rainfall pattern is analyzed from 2000 to 2018 for Potohar region (Rawalpindi and Jhelum). Moreover, crop in the region depends completely on rainfall on suitable timings. Furthermore, the region has faced severe to moderate drought condition in the history due to absence of or untimely rainfall. In order to analyze the influence of climatic variables affecting the rainfall pattern in the region, multiple linear regression is used. Additionally, Seasonal autoregressive integrated moving average (SARIMA) model has been applied to model and forecast the rainfall pattern of the selected data.

Keywords: Monsoon Rainfall, Multiple Linear Regression, Potohar, SARIMA.

INTRODUCTION

Pakistan has diverse climate mostly varies from dry to humid conditions. In Pakistan, there are two seasons of rainfall, summer and winter. During the summer monsoon period (July to September) easterly depressions form in the Arabian Sea and the Bay of Bengal, produce rainfall over low elevation plains of Pakistan. August is the peak month of this season and mostly causes floods during this month. Nearly 60% of annual rainfall over most parts of Pakistan is received during summer (June to September). Various studies have addressed the climatic influence on rainfall pattern in different parts of the world using multiple approaches (Dabral and Murry; Ray et al.; Hossain, Esha and Alam Imteaz; Fatima and Khan; Ibebuchi and Abu). The intensity of rainfall (R) depends on various climate variables such as: temperature (T), wind speed (WS), relative humidity (RH), sunshine hours (SS), atmospheric pressure (ATP) and etc. In this study the climatic factors are analyzed which might play an important role in occurrence of rainfall. For the purpose, Multiple Linear Regression and SARIMA are employed for analyzing the climatic parameters.

OBJECTIVE

The main objective of this study is to identify the climatic parameters which affects rainfall at both Rawalpindi and Jhelum. Also, the study aims to quantify the contribution of significant parameters in occurrence of rainfall at each station. In addition to this, SARIMA model is also applied to forecast the rainfall at these stations.

METHODOLOGY

The study area includes: Rawalpindi and Jhelum. The area lies between 33.00º N to 36.00º N and experiences semi-arid to humid climate. These districts are highly dependent on rainfall for the agricultural sector. The monthly data: average temperature (T), Atmospheric pressure (ATP), wind speed (WS), sunshine (SS), amount of precipitation (R), humidity (RH) between 2000 – 2018 (18 years) are obtained from Pakistan Meteorological Department (PMD). Moreover, multiple linear regression model is used to investigate the relationship between rainfall and climatic parameters. Furthermore, SARIMA model is applied in order to predict average monthly rainfall for Potohar region of Pakistan.

CONCLUSION/RESULT

In this study, the influence of climatic factors such as: temperature, relative humidity, sunshine hours, atmospheric pressure and windspeed on rainfall pattern at Rawalpindi and Jhelum have been analyzed.

Table 1. Descriptive Statistics.

	Rawalpindi					Jhelum				
	Minimu	**Maxim**	**Mea**	**Varian**	**Skewne**	**Minimu**	**Maxim**	**Mea**	**Varian**	**Skewne**
T	8.3	33.5	22.4	52.89	-0.29	10.5	34.9	24.1	51.3	-0.37
WS	2.5	18.4	10.8	10.14	0.04	0	5	1.93	1	0.32
RH	18	67	42.4	127.17	-0.04	15	70	46.0	174.84	-0.31
AT	977.7	1019.7	1005	70.53	-0.37	992.3	1017.3	1005	56.23	-0.11
SS	94.8	325.3	222.	2191.8	-0.18	92.7	382.7	230.	2057.5	-0.26
R	0	647	103.	15718.	1.84	0	485.3	69.5	6901.6	1.81

Basic statistics of the data reveals that variance of the rainfall at Rawalpindi (Rp) and rainfall at Jhelum (R_J) is high among all the variables. Moreover, the T, RH, ATP, SS is negatively skewed whereas; WS, R_P and R_J were positively skewed at both stations (Table **1**).

Table 2. Correlation Between Rainfall and Selected Climatic Variables.

Climatic Variable	Rawalpindi		Jhelum	
	Correlation	**P-Value**	**Correlation**	**P-Value**
T	0.355	0	0.397	0
RH	0.65	0	0.5	0
WS	0	0.98	0.22	0
ATP	-0.38	0	– 0.52	0
SS	-0.03	0.699	– 0.02	0.788

Rawalpindi

The R_p has weak positive correlation with WS and T, weak negative correlation with SS and ATP, respectively. On the other hand, R_p has strong correlation with the RH (Table **2**). Furthermore, the RH, T and ATP are found significant unlike the WS and SS which remained insignificant. The final MLR model for Rawalpindi is as follows:

$$R_p = 345.722 + 0.977\ (T) + 3.141\ (RH) – 51.575\ (ATP)$$

The model suggests that as T and RH (ATP) increase the R_p increases (decreases) by the factors 0.977, 3.141 and 51.575, respectively.

Jhelum

The R_J has weak positive correlation WS and a weak negative correlation with SS and moderate negative relation with ATP and moderate positive correlation with T and RH (Table 2). Additionally, the RH, T, ATP and WS were significant and the SS was insignificant. The final MLR model for Jhelum is as follows:

$$R_J = 1395.13 – 1.8\ (T) + 1.88\ (RH) – 201.53\ (ATP)$$

The model suggests that as T and ATP (RH) increase the R_J decreases (increases) by the factors 1.8, 201.53 and 1.88, respectively.

Moreover, the results of SARIMA show that the Jhelum has the minimum in-sample and out-sample forecast error (Table **3**).

Table 3. In Sample and Out Sample Forecast of SARIMA.

Región	Moldes	In-Sample		Outsample	
		MAE	**RMSE**	**MAE**	**RMSE**
Jhelum	SARIMA$(0,0,1)(1,0,1)_{12}$	34.88	50.7	34.3	49.8
Rawalpindi	SARIMA$(0,1,1)(1,0,1)_{12}$	62.38	86	61.2	85.01

Rainfall at both stations has been forecasted using SARIMA for the year 2019 (Figure **1**).

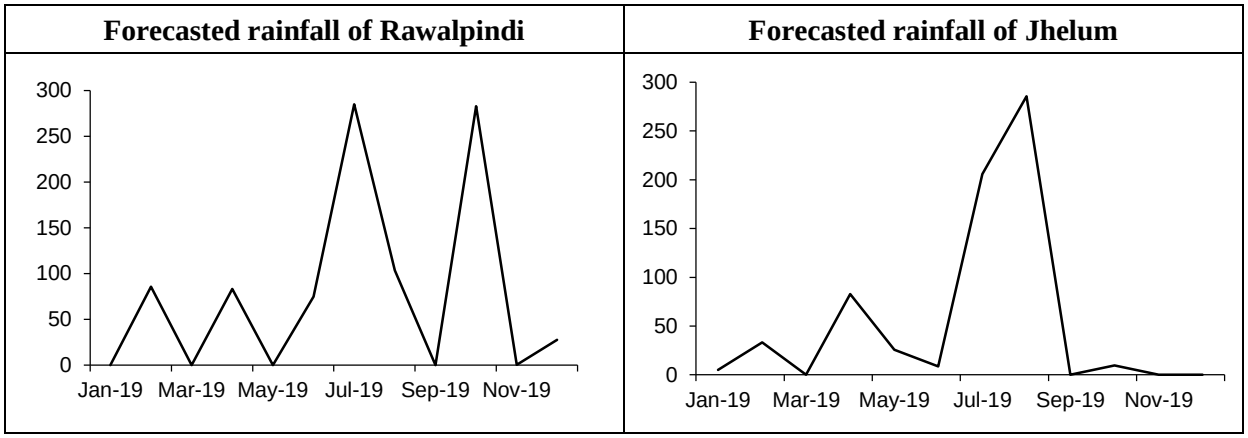

Figure 1. Rainfall forecast of Rawalpindi and Jhelum.

Overall, it is found that temperature, relative humidity and atmospheric pressure are found the most influencing climatic variables affecting the rainfall pattern at both the stations.

ACKNOWLEDGMENT

The author(s) acknowledge the Pakistan Meteorological Department (PMD), Pakistan for data collection. We further extend appreciation to the reviewing committee of IBRAS.

REFERENCES

1. Dabral, PP, and Mharhoni Z Murry. "Modelling and Forecasting of Rainfall Time Series Using Sarima." *Environmental Processes* 4.2 (2017): 399-419. Print.
2. Fatima, Samreen, and Mehwish Shafi Khan. "Forecasting Rainfall in Potohar Region of Pakistan in the Perspective of Drought." *PUNJAB UNIVERSITY JOURNAL OF MATHEMATICS* 50.4 (2018): 119-32. Print.
3. Hossain, Iqbal, Rijwana Esha, and Monzur Alam Imteaz. "An Attempt to Use Non-Linear Regression Modelling Technique in Long-Term Seasonal Rainfall Forecasting for Australian Capital Territory." *Geosciences* 8.8 (2018): 282. Print.
4. Ibebuchi, Chibuike Chiedozie, and Itohan-Osa Abu. "Rainfall Variability Patterns in Nigeria During the Rainy Season." *Scientific Reports* 13.1 (2023): 7888. Print.
5. Ray, Soumik, et al. "Time Series Sarima Modelling and Forecasting of Monthly Rainfall and Temperature in the South Asian Countries." *Earth Systems and Environment* 5 (2021): 531-46. Print.