A STATISTICAL ANALYSIS TO PREDICT INDIAN MONSOON VARIABILITY FOR THE REGION OF COASTAL KARNATAKA

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Abstract: The yearly rainfall in India is classified into four distinct seasons, according to the Indian Institute of Tropical Meteorology (IITM) and the Indian Meteorological Department (IMD). These seasons include winter, pre-monsoon (PRM), southwest monsoon (SWM), and northeast monsoon (NEM or post-monsoon). What is commonly referred to as the winter monsoon is the total seasonal precipitation that occurs during the months of January and February. The pre-monsoon period extends from March to May. The southwest monsoon (SWM) is the term used to describe the rainfall that occurs from June to September, whereas the northeast monsoon occurs from October to December. A number of fundamental statistics, including long-period average (LPA), long-period deviation (LPD), skewness, and kurtosis, are at the same level as they are in other regions of Karnataka. The southwest monsoon is the time of year that experiences the highest measures of rainfall. The Artificial Neural Network (ANN) technique was utilized by us in order to solve the aforementioned issues, as it demonstrates a non-linear relationship and a modest correlation. Forecasting is made easier by the ANN approach, which also allows for the management of unstructured non-relationship conditions. With the use of the Artificial Neural Network (ANN) technology, we are attempting to create a model that is suited for a variety of input nodes, and the Root Mean Squared Error (RMSE) value can be minimized in accordance with this methodology.

Index Terms –**Rainfall, Pre-monsoon (PRM), South-west monsoon (SWM), North-east Monsoon (NEM), ANN technique and RMSE.**

I. INTRODUCTION

A total of approximately 1,91,791 square kilometers are encompassed by the state of Karnataka, which can be found in the south-western part of India. North Karnataka, South Karnataka, and coastal Karnataka are the three subdivisions that make up the state of Karnataka, from a meteorological point of view, as shown in Figure 1. According to the Indian Institute of Tropical Meteorology (IITM) and the Indian Meteorological Department (IMD), the annual rainfall in India can be broken down into four distinct seasons: winter, pre-monsoon (PRM), southwest monsoon (SWM), and northeast monsoon (NEM which is also known as post-monsoon). What is commonly referred to as the winter monsoon is the total seasonal precipitation that occurs during the months of January and February. The pre-monsoon period extends from March to May. The southwest monsoon (SWM) is the term used to describe the rainfall that occurs from June to September, whereas the northeast monsoon occurs from October to December. The pre-monsoon period is the time period that we are focusing on in this study, which is the total seasonal precipitation that occurs between January and May.

The average rainfall of the state of Karnataka is about 125cm. South Interior Karnataka receives an average annual rainfall of 128 cm and North Interior Karnataka receives an average annual rainfall of 73 cm whereas Coastal Karnataka is the region that receives the highest rainfall in the state with an average annual rainfall of 346 cm. The maximum amount of rainfall occurs during SWM in the region of coastal Karnataka. The main focus of the work will be towards analyzing and developing a model for the region of coastal Karnataka. In this paper, the main work will be focusing on the developing mathematical models to predict Indian monsoon on district and taluk wise for the state of Karnataka.

The previous literature on Indian rainfall studies has two models namely dynamical models and statistical models. Dynamical models depend on the physics of the atmospheric process which results in the system of partial differential equations, which are very tedious to solve and involve large-scale computations. Statistical models completely depend upon data analysis, which results in pattern identification. For the statistical studies MATLAB and statistical methods are used to validate and develop the model. The artificial Neural Network (ANN) technique is convenient to drive rainfall data as a time series with its past values and also helps forecasting and unstructured non-relationship can be handled through the ANN approach. The temporal disaggregation of rainfall data was presented by Nagesh Kumar (2004) through the utilization of an Artificial Neural Network model that was equipped with a back propagation algorithm. Additionally, a sigmoidal function was utilized for the activation of neurons. The training error, also

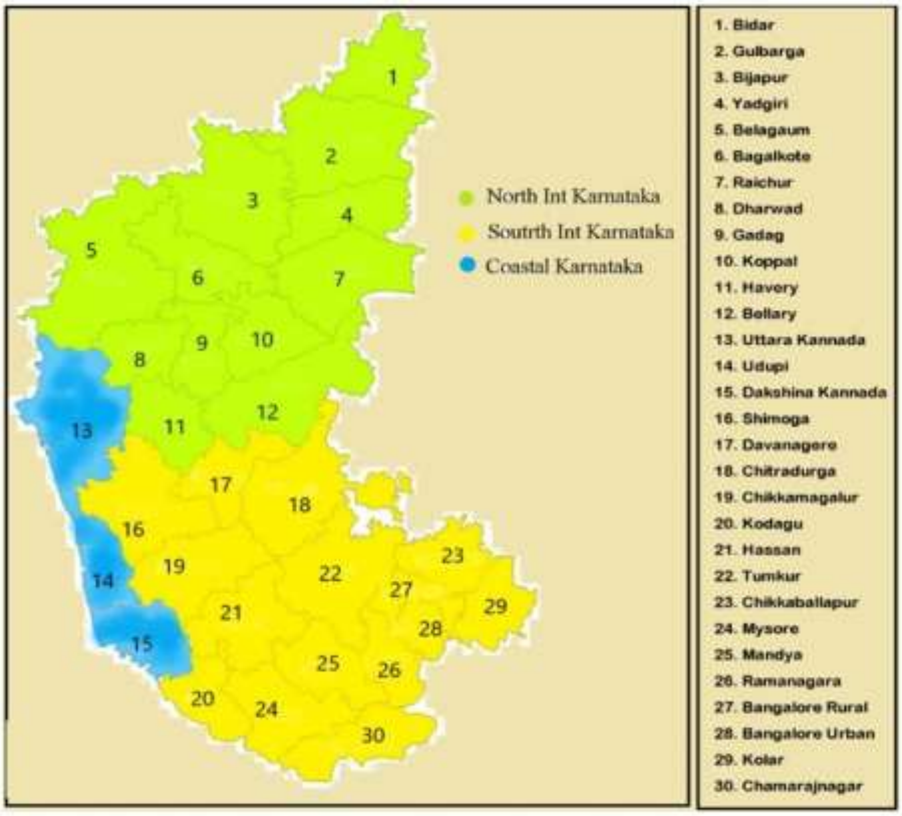

Fig 1: Karnataka map with subdivision and the regions from Indian Institute of Tropical Meteorology (IITM).

known as the root mean square error, was calculated by first squaring the difference between the desired output of the networks and the training pattern, and then adding up all of the outputs and all of the training patterns.

Another artificial neural network (ANN) model was constructed for the rainfall data for the entire country of India by Pritpal and Bhogeswar (2013). In total, they provided five distinct artificial neural network topologies that were three-layered (input, hidden, and output) and had 43, 57, 73, 91, and 111 parameters respectively. The efficiency of this combination model was determined to be 0.65 during the course of the training period that lasted for 84 years. In light of the aforementioned considerations, Kokila Ramesh and R. N. Iyengar (2017) built a novel artificial neural network (ANN) model that takes into account the variability of all the seasons in order to estimate the monsoon rainfall for India and its vast regions in 2017. This model's parameters were optimized to achieve the best possible results. In addition, we arrived at the model that utilized solely the rainfall from the Indian monsoon and its historical data relationship, which does not decrease under any circumstances. A simple artificial neural network (ANN) architecture with six nodes at the input layer, a hidden layer with five neurons, and output is capable of explaining approximately 80 percent of the observed inter-annual variability of observed standard weighted rainfall data, according to Kokila Ramesh and Radha Gupta's (2019) demonstration of a new artificial neural network (ANN) model for forecasting Indian monsoon rainfall. For the period of time spanning from 1901 to 2000, this has been proved using six different sets of Indian Rainfall data series which cover wide regions of India.

II. DATA:

The data that was evaluated in this inquiry were the monthly rainfall totals for the state of Karnataka. These rainfall totals were distributed throughout the stations of coastal Karnataka, south interior Karnataka, north interior Karnataka, and that for the entire state of Karnataka. Data from the Karnataka State Natural Disaster Monitoring Centre (KSNDMC) and the Indian Institute of Tropical Meteorology (IITM) are taken into consideration for the validation of the data. A period of 51 years, beginning in 1960 and ending in 2010, is taken into consideration. This information was obtained from the Karnataka State Natural Disaster Monitoring Centre in Bangalore as well as the Indian Institute of Tropical Meteorology (http://www.tropmet.res.in). When it comes to the coastal regions of Karnataka, the fundamental statistics that have been determined include the long-term average (LTA), the long-term deviation (LTD), the skewness, and the kurtosis.

Table 1 Basic Statistics of Rainfall Data for Coastal Karnataka during 1960 – 2010

COASTAL KARNATAKA						
	IITM			KSNDMC		
	PRM	SWM	NEM	PRM	SWM	NEM
LPA (m_R cm)	20.79	297.84	26.11	33.85	292.5	25.05
LPD (σR cm)	18.81	52.29	14.13	21.84	72.78	15.64
SKEWNESS	0.96	0.93	1.06	1.24	0.65	0.44
KURTOSIS	4.28	4.05	4.28	3.8	4.28	2.95

Table 2: Basic Statistics of Rainfall Data for South Interior Karnataka during 1960 - 2010

SOUTH INTERIOR KARNATAKA						
	IITM			KSNDMC		
	PRM	SWM	NEM	PRM	SWM	NEM
LPA (m_R cm)	15.52	52.31	21.44	13.52	47.94	18.61
LPD (σ_R cm)	4.81	10.42	7.9	3.91	8.71	6.13
SKEWNESS	0.44	0.02	0.4	0.36	-0.04	0.19
KURTOSIS	2.51	2.46	2.26	2.54	2.28	2.3

Table 3: Basic Statistics of Rainfall Data for North Interior Karnataka during 1960 – 2010

NORTH INTERIOR KARNATAKA						
	IITM			KSNDMC		
	PRM	SWM	NEM	PRM	SWM	NEM
LPA (m_R cm)	10.13	59.68	14.43	10.66	55.27	13.61
LPD (σ_R cm)	4.21	12.24	6.34	2.1	6.08	3.68
SKEWNESS	0.35	0.18	0.59	0.55	0.25	0.53
KURTOSIS	2.07	2.46	3.13	2.85	2.07	2.98

Table 4: Basic Statistics of Rainfall Data for All Karnataka during 1960 - 2010

ALL KARNATAKA						
	IITM			KSNDMC		
	PRM	SWM	NEM	PRM	SWM	NEM
LPA (m_R cm)	46.44	409.83	61.99	44.51	380.92	58.65
LPD (σ_R cm)	24.58	64.29	22.83	23.16	71.5	17.78
SKEWNESS	0.83	0.72	0.64	1.19	0.55	0.38
KURTOSIS	2.73	3.63	2.8	3.74	3.06	2.48

To validate the collected data from Karnataka State Natural Disaster Monitoring Centre (KSNDMC) and Indian Institute of Tropical Meteorological (IITM) and also to visualize the seasonality pattern and its trends, the time series plots are depicted in Fig 2, Fig 3 and Fig 4 for the region of coastal Karnataka.

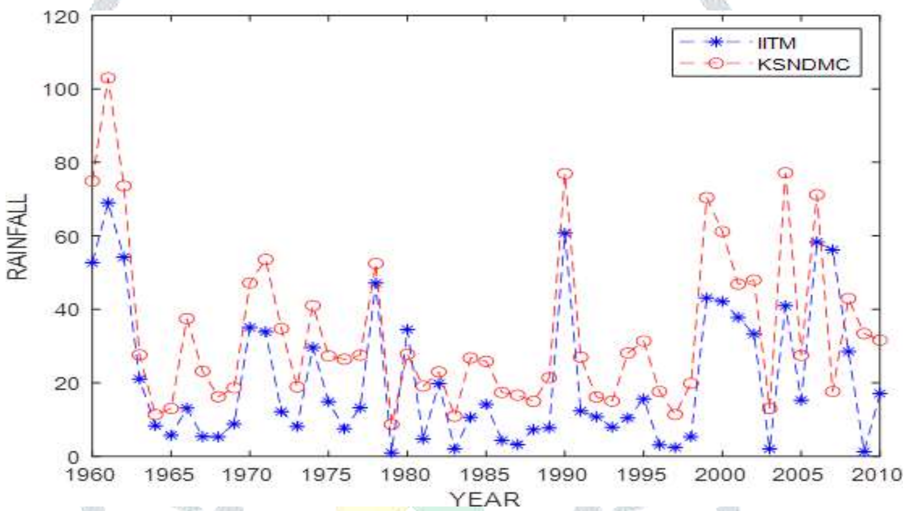

Fig 2: The time series plot of for the coastal Karnataka – PRM during 1960 – 2010

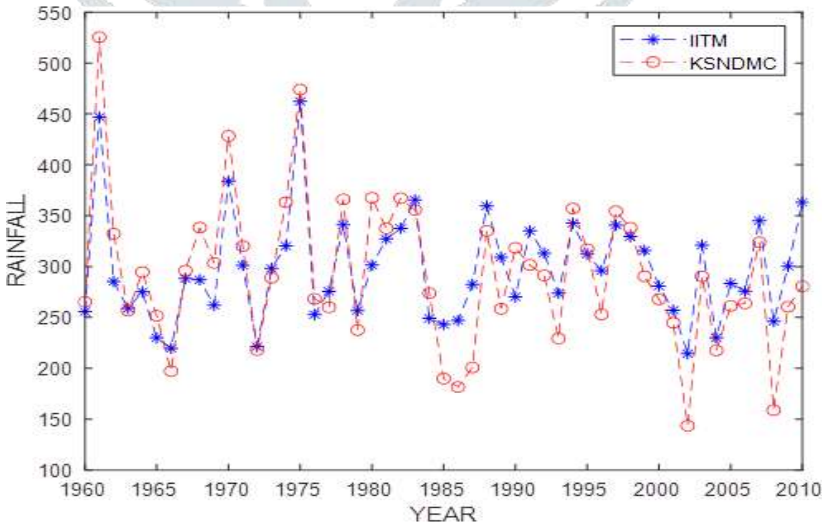

Fig 3: The time series plot of for the South Interior Karnataka – SWM during 1960 – 2010

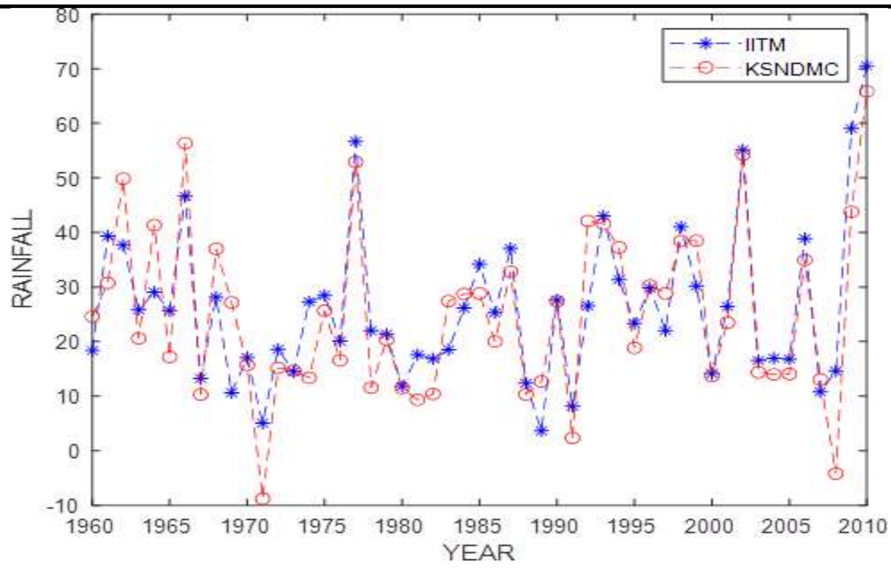

Fig 4: The time series plot of for the North Interior Karnataka – NEM during 1960 – 2010

A correlation coefficient is evaluated to check how well one series predicts the values in the other. The lag relationship refers to how far the data is equalizes, and its sign determines which year series is shifted. By considering this we had taken season wise 5 years lag relationship for the region of coastal Karnataka. It is depicted in Table 5, Table 6 and Table 7. The highest lag value with the highest correlation coefficients induces the best fit. A correlation coefficient is evaluated to check how well the data is correlating each other.

Table 5: Year wise lag relationship between PRM - PRM

YEAR LAG RELATIONSHIP	PRM - PRM				
	1	2	3	4	5
IITM	0.32	0.15	-0.17	-0.06	-0.05
KSNDMC	0.3	0.15	-0.23	0.08	0.09

Table 6: Year wise lag relationship between PRM - SWM

YEAR LAG RELATIONSHIP	PRM - SWM				
	1	2	3	4	5
IITM	0.11	-0.1	0.08	-0.16	-0.13
KSNDMC	0.15	-0	-0.07	-0.25	-0.12

Table 7: Year wise lag relationship between PRM - NEM

YEAR LAG RELATIONSHIP	PRM -NEM				
	1	2	3	4	5
IITM	-0	-0.1	0.04	0.07	0.27
KSNDMC	-0	0.08	0.02	0.01	0.12

III. MODELLING:

The region of coastal Karnataka that is affected by the southwest monsoon season is being taken into consideration for some additional work. Each of the three seasons is presented above in its own right, along with the fundamental particulars of the data for the time period (1960-2010). Every single piece of information was obtained from the data bank of the Karnataka State Natural Disaster Monitoring Centre (KSNDMC) and the Indian Institute of Tropical Meteorology (http://www.tropmet.res.in). To get around the problems described above, we have implemented the Artificial Neural Network (ANN) technique. This is due to the fact that it demonstrates a non-linear relationship and a modest correlation. Unstructured non-relationships can be managed by the application of the ANN technique, which makes it convenient for forecasting.

Rainfall prediction is very challenging task and plays an important role for survival of farmers and all living beings. By using machine learning with different techniques, rainfall data can be predicted. In this paper, Artificial Neural Network (ANN) with backpropagation algorithm was used for data prediction. ANN is flexible model in which the model learns from past data and makes predictions on the current data. The prediction accuracy is measured using Root mean squared error (RMSE). The number of input nodes to be considered based on the root mean squared error for the further work. The results show that the prediction model based on ANN indicates acceptable accuracy. Here we have are deciding number of input nodes based on RMSE value. With the help MATLAB, we have trained the neural network for 12 input nodes, 5 hidden nodes and 1 output nodes. The basic statistical comparison for the region of coastal Karnataka during south- west monsoon between actual rainfall data and predicted rainfall data is tabulated in Table 8 and the data comparison have also shown in the Fig 5.

Table 8: Basic statistical comparison between actual rainfall data and predicted rainfall data

	ACTUAL RAINFALL DATA	PREDICTED RAINFALL DATA
LPA (m_R cm)	296.50	295.33
LPD (σR cm)	52.64	46.91
SKEWNESS	1.04	0.84
KURTOSIS	4.55	4.21

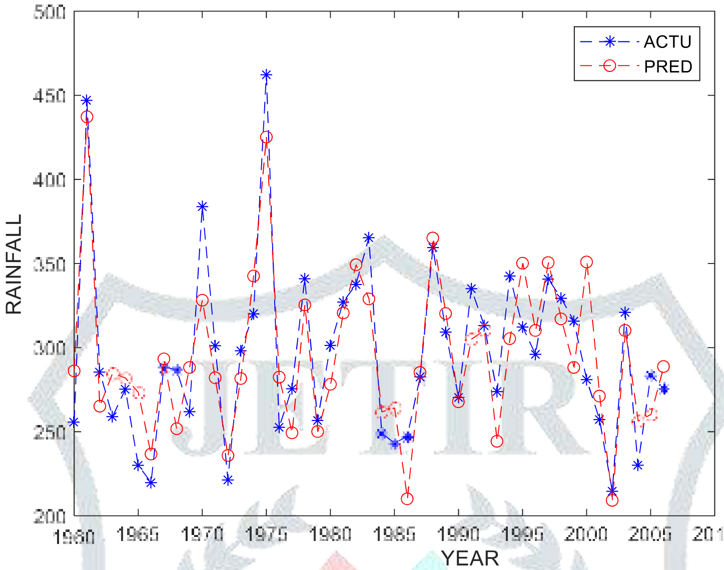

Fig 5: Comparison between actual rainfall data and the predicted rainfall data (in cm) SWM during 1960 – 2006

IV. SUMMARY AND CONCLUSION:

A fundamental statistical analysis and the variability of the rainfall time series are both demonstrated by the findings of this study. It is important to take into account the variability of rainfall while attempting to anticipate and build new models for rainfall forecasting in the future. The rainfall time series data that was used in the past has been observed to be mostly focused on the broad regions of India and its subdivisions. Initially, the work that Kokila Ramesh and Iyengar (2017) have done is that they have constructed an artificial neural network (ANN) model that incorporates both intra seasonal variability and inter annual variability through the utilization of a back propagation technique. Both the long-term and the short-term scales of Karnataka require the development of the same model for our research. If it is possible to construct new statistical models on lower spatial and temporal scales, it will be of greater use to research. Predicting the variability of the Indian Monsoon on a district and taluk level within the state of Karnataka would be the primary objective of this piece of endeavor. For the purpose of pursuing the research effort, such as training the network and extended to construct probabilistic models also for one step forecasting in any time scale, the fundamental analysis of the data for the brief number of stations that were given will supply us with the clue that we need.

V. Acknowledgment

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