Vol III Issue X April 2014 ISSN No :2231-5063

International Multidisciplinary Research Journal

Golden Research Thoughts

Chief Editor
Dr.Tukaram Narayan Shinde

Publisher
Mrs.Laxmi Ashok Yakkaldevi

Associate Editor
Dr.Rajani Dalvi

Honorary
Mr.Ashok Yakkaldevi

Welcome to GRT

RNI MAHMUL/2011/38595 **ISSN No.2231-5063**

Golden Research Thoughts Journal is a multidisciplinary research journal, published monthly in English, Hindi & Marathi Language. All research papers submitted to the journal will be double - blind peer reviewed referred by members of the editorial board.Readers will include investigator in universities, research institutes government and industry with research interest in the general subjects.

International Advisory Board

Flávio de São Pedro Filho
Federal University of Rondonia, Brazil

Kamani Perera
Regional Center For Strategic Studies, Sri Lanka

Janaki Sinnasamy
Librarian, University of Malaya

Romona Mihaila
Spiru Haret University, Romania

Delia Serbescu
Spiru Haret University, Bucharest, Romania

Anurag Misra
DBS College, Kanpur

Titus PopPhD, Partium Christian University, Oradea,Romania

Mohammad Hailat
Dept. of Mathematical Sciences, University of South Carolina Aiken

Abdullah Sabbagh
Engineering Studies, Sydney

Catalina Neculai
University of Coventry, UK

Ecaterina Patrascu
Spiru Haret University, Bucharest

Loredana Bosca
Spiru Haret University, Romania

Fabricio Moraes de Almeida
Federal University of Rondonia, Brazil

George - Calin SERITAN
Faculty of Philosophy and Socio-Political Sciences Al. I. Cuza University, Iasi

Hasan Baktir
English Language and Literature Department, Kayseri

Ghayoor Abbas Chotana
Dept of Chemistry, Lahore University of Management Sciences[PK]

Anna Maria Constantinovici
AL. I. Cuza University, Romania

Horia Patrascu
Spiru Haret University, Bucharest,Romania

Ilie Pintea,
Spiru Haret University, Romania

Xiaohua Yang
PhD, USA

.....More

Editorial Board

Pratap Vyamktrao Naikwade
ASP College Devrukh,Ratnagiri,MS India

R. R. Patil
Head Geology Department Solapur University,Solapur

Rama Bhosale
Prin. and Jt. Director Higher Education, Panvel

Salve R. N.
Department of Sociology, Shivaji University,Kolhapur

Govind P. Shinde
Bharati Vidyapeeth School of Distance Education Center, Navi Mumbai

Chakane Sanjay Dnyaneshwar
Arts, Science & Commerce College, Indapur, Pune

Awadhesh Kumar Shirotriya
Secretary,Play India Play,Meerut(U.P.)

Iresh Swami
Ex - VC. Solapur University, Solapur

N.S. Dhaygude
Ex. Prin. Dayanand College, Solapur

Narendra Kadu
Jt. Director Higher Education, Pune

K. M. Bhandarkar
Praful Patel College of Education, Gondia

Sonal Singh
Vikram University, Ujjain

G. P. Patankar
S. D. M. Degree College, Honavar, Karnataka

Maj. S. Bakhtiar Choudhary
Director,Hyderabad AP India.

S.Parvathi Devi
Ph.D.-University of Allahabad

Sonal Singh,
Vikram University, Ujjain

Rajendra Shendge
Director, B.C.U.D. Solapur University, Solapur

R. R. Yalikar
Director Managment Institute, Solapur

Umesh Rajderkar
Head Humanities & Social Science YCMOU,Nashik

S. R. Pandya
Head Education Dept. Mumbai University, Mumbai

Alka Darshan Shrivastava
Shaskiya Snatkottar Mahavidyalaya, Dhar

Rahul Shriram Sudke
Devi Ahilya Vishwavidyalaya, Indore

S.KANNAN
Annamalai University,TN

Satish Kumar Kalhotra
Maulana Azad National Urdu University

Address:-Ashok Yakkaldevi 258/34, Raviwar Peth, Solapur - 413 005 Maharashtra, India
Cell : 9595 359 435, Ph No: 02172372010 Email: ayisrj@yahoo.in Website: www.aygrt.isrj.net

Golden Research Thoughts
ISSN 2231-5063
Volume-3 | Issue-10 | April-2014
Available online at www.aygrt.isrj.net

ANALYSIS OF TREND IN RAINFALL DATA FOR INDIA

Shesabhare Sudhir Yashwant and Kalange Dhananjay Narayan

Assistant Professor in Economics, A.C.S. College, Palus.
Assistant Professor in Statistics,A.C.S. College, Palus.

Abstract:- In the present study, exploratory analysis of rainfall data is performed. This study aims to determine trends in annual, monsoon month-wise and meteorological region-wise in India. The data used consists of mean month-wise and region-wise rainfall for the period 1901-2010. Non-parametric statistical tools such as Sen's estimator of slope and Mann-Kendall trend test was used to estimate the magnitude of trend. The rainfall in the monsoon months: July, August and September showed downward trend. Out of four meteorological regions, three regions showed downward trend. The downward as well as upward trends were observed to be statistically insignificant.

Keywords: Rainfall, Trend analysis, Time series, Mann-Kendall Test, Sen's estimate of slope.

1.INTRODUCTION

India is home to an extraordinary variety of climatic regions. In south India the climate is tropical while in the Himalayan north, it is alpine. The elevated regions in the Himalayan north receive sustained winter snowfall. The average annual rainfall across the regions in India is between 750-1500 mm (30-59 in). The most precipitation in India falls on Tamil Nadu after beginning the dry northeast monsoon in September. Many parts of the nation are entirely dependent on rains for recharging its water resources. Failures of monsoon lead to acute water scarcity and severe drought. India's agriculture sector, food security and energy security crucially depends on the monsoon rainfall. Thus, monsoon rainfall plays an important role in the national policies of India.

The purpose of present study is to investigate the variations in the monsoon rainfall in India by detecting the precipitation changes in the temporal and spatial structure for the period 1901 to 2010. The present paper consists of five sections. The first section introduces the paper and motives of the work. The second section deals with survey of literature with special reference to Indian rainfall data. The third section describes study area, methodology and statistical techniques used for analysis. The fourth section discusses results and its discussion while the fifth one outlines concluding remarks.

2.SURVEY OF LITERATURE

Many climatic change studies have been reported in the literature. These studies aim to identify and determine the climatic changes in various contexts. Here, we take brief review of some of the research studies conducted in the context of trend analysis of Indian monsoon rainfall data. Kumar et al (2010a) studied monthly, seasonal and annual trends of rainfall using monthly data series of 135 years (1871–2005) for 30 sub-divisions (sub-regions) in India. Half of the sub-divisions showed an increasing trend in annual rainfall, but for only three (Haryana, Punjab and Coastal Karnataka), this trend was statistically significant. Similarly, only one sub-division (Chhattisgarh) indicated a significant decreasing trend out of the 15 sub-divisions showing decreasing trend in annual rainfall. They have also reported that during June and July, the number of sub-divisions showing increasing rainfall is almost equal to those showing decreasing rainfall. In August, the number of sub-divisions showing an increasing trend exceeds those showing a decreasing trend, whereas in September, the situation is the opposite. The majority of sub-divisions showed very little change in rainfall in non-monsoon months. The five main regions of India showed no significant trend in annual, seasonal and monthly rainfall in most of the months. For the whole of India, no significant trend was detected for annual, seasonal, or monthly rainfall. Annual and monsoon rainfall decreased, while pre-monsoon, post-monsoon and winter rainfall increased at the national scale.

The rivers in India are sources of potable water, irrigation, industrial requirements, sources for hydro-power projects, etc. Kumar and Jain (2010b) have conducted study to determine trends in annual and seasonal rainfall and rainy days over

different river basins across India. They have used data of daily gridded rainfall at 1° x 1° resolution for the period 1951-2004. Among 22 basins studied by them, 15 showed a decreasing trend in annual rainfall; only one basin showed a significant decreasing trend at 95% confidence level. Of the 6 basins showing an increasing trend, 1 basin showed a significant positive trend. The monsoon rainfall increased over 6 basins, decreased over 16 basins and a decreasing trend for 2 basins was found statistically significant. They have observed that all river basins, except Ganga and Brahmaputra, experienced the same direction of trend in monsoon and annual rainfall. Four river basins experienced increasing (non-significant) trend in annual rainy day three basins did not show any change in annual rainy days whereas 15 basins have shown a decreasing trend in annual rainy days. The decreasing trend in three basins was statistically significant. Most of the basins have shown the same direction of trend in rainfall and rainy days at the annual and seasonal scale. Rainfall is subject to strong seasonality in tropical monsoonal climate.

There are spatial and temporal variations in various attributes of the rainy season such as starting date, ending date, durability, etc. Numerous notions of rainy season exist in the real world and the literature, e.g. green season, growing season, wet season, monsoonal rainy season and wet period. Ranade et al (2008) have studied a hydrological wet season (HWS) by taking into consideration important parameters such as starting and ending dates and duration, seasonal rainfall/rainwater and surplus rainfall/rainwater potential. They have performed analysis for the 11 major and 36 minor rivers basins as well as the West Coast Drainage System (WCDS) and the whole country using highly quality-controlled monthly rainfall from well-spread network of 316 rain-gauge stations from earliest available year (sometimes going back to 1813) up to 2006. They have observed declining tendency in the HWS rainfall/rainwater and surplus rainfall/HRWP over most of the minor basins in the CMRR in recent years/decades

The state-wise analyses of rainfall have also been reported in the literature. Krishnakumar et al (2009) have studied temporal variation in monthly, seasonal and annual rainfall over Kerala, India, during the period from 1871 to 2005. Their analysis revealed significant decrease in southwest monsoon rainfall while increase in post-monsoon season over the State of Kerala which is popularly known as the 'Gateway of summer monsoon'. Rainfall during winter and summer seasons showed insignificant increasing trend. Rainfall during June and July showed significant decreasing trend while increasing trend in January, February and April. Hydro-power generation and water availability during summer months are the concern in the State due to rainfall decline in June and July, which are the rainiest months. At the same time, majority of plantation crops are likely to benefit due to increase in rainfall during the post-monsoon season if they are stable and prolonged. As it can be seen from the above survey, previous studies have been conducted either river basin wise or state-wise. None of the study deals with month-wise and/or meteorological region-wise analysis of Indian rainfall data.

3.METHODOLOGY

3.1 STUDY AREA

This study is conducted considering whole India as a study area. The meteorological department of India has divided whole nation into four homogeneous regions according to the monsoon rainfall. These

Figure : Meteorological Region of India (source: google maps)

regions are: Northwest India (NWI), Central India (CI), Northeast India (NEI) and South Peninsular India (SPIN).

3.2 MATERIAL AND METHODS:

The data used for this study is secondary data. The data obtained from the official website of Indian Meteorological Department (http://www.imd.gov.in). The data include the records of mean annual rainfall during four monsoon moths and according to the homogeneous regions. The rainfall records include observations spanning from 1901 to 2010 and cover a period over 110 years. The period of time series is long enough to carry out statistical analysis. As many hydrological time series data are not normally distributed, non-parametric tests were preferred over parametric tests. We have adopted methodology used by previous studies such Abdul-Aziz et al (2013), Jain and kumar (2012), etc.

3.2.1 Sen's slope Estimator:

Previous studies have used different methodologies for trend detection. Trend analysis of a time series consists of the magnitude of trend and its statistical significance. In general, the magnitude of trend in a time series is determined either using parametric tests such as regression analysis or using non-parametric method such as Sen's estimator method. Both these methods assume a linear trend in the time series. Sen's slope estimator has been widely used for determining the magnitude of trend in hydro-meteorological time series. In this method, the slopes (Tk) of all data pairs are first calculated by:

$$T_k = \frac{x_j - x_i}{j - i} \qquad for\ k = 1,2,\ldots..,N$$

where x_j and xi are data values at time j and i (j > I)
The median of these N values of T_k is Sen's estimator of slope which is calculated as:

$$\beta = \begin{cases} T_{\frac{N+1}{2}} & N\ is\ odd \\ \frac{1}{2}\left(T_{N/2} + T_{(N+1)/2}\right) & N\ is\ even \end{cases}$$

A positive value of β indicates an upward (increasing) trend and a negative value indicates a downward (decreasing) trend in the time series.

3.2.2 Mann-Kendal Test:

The MK test checks the null hypothesis of no trend versus the alternative hypothesis of the existence of increasing or decreasing trend. i.e., H0: There is no trend in the data values versus H1: There exists trend in the data values.

The statistics (S) is defined as:

$$S = \sum_{i=1}^{N} \sum_{j=i+1}^{N-1} sgn(x_j - x_i)$$

where N is the number of data points. Assuming $(x_j - x_i) = \theta$, the value of sgn(θ) is computed as follows:

$$sgn(\theta) = \begin{cases} 1 & if\ \theta > 0 \\ 0 & if\ \theta = 0 \\ -1 & if\ \theta < 0 \end{cases}$$

For large N, the test is conducted using normal distribution with mean and variance as follows:

$$E(S) = 0$$

$$Var(S) = \frac{N(N-1)(2N+5) - \sum_{k=1}^{n}(t_k(t_k-1)(2t_k+5)}{18}$$

Where n is the number of tied groups and t_k the number of data points in the k^{th} tied group. The Standard Normal

Variate (S.N.V.) is then computed as:

$$Z = \begin{cases} \frac{S-1}{\sqrt{var(S)}} & if\ S > 0 \\ 0 & if\ S = 0 \\ \frac{S+1}{\sqrt{var(S)}} & if\ S < 0 \end{cases}$$

If the computed value of $|Z| > Z\alpha/2$, the null hypothesis (H0) is rejected at a level of significance, where $0 < a < 1$.

Table 1: Descriptive Statistics of overall and month-wise Monsoon Rainfall data

Month	N	Min	Max	Mean	S.D.
June	110	85.7	277.2	167.14	35.67
July	110	146.2	381.6	295.48	41.7
Aug.	110	189.8	348	261.67	37.66
Sept.	110	95.1	283.1	173.91	38.15
Annual	110	697.4	1124.2	898.69	93.42

Table2: Descriptive Statistics of region-wise Monsoon Rainfall data

Region	N	Min	Max	Mean	S.D.
NWI	110	345.4	1024.0	630.60	121.00
NEI	110	1043.7	1684.2	1351.20	131.10
CI	110	679.9	1349.4	980.60	131.60
SPIN	110	434.0	951.7	720.95	101.49

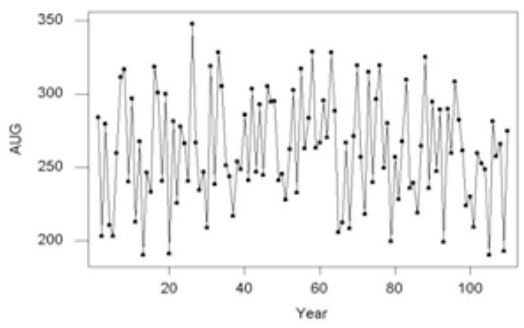

Figure 3: Rainfall time series plot for 'August'

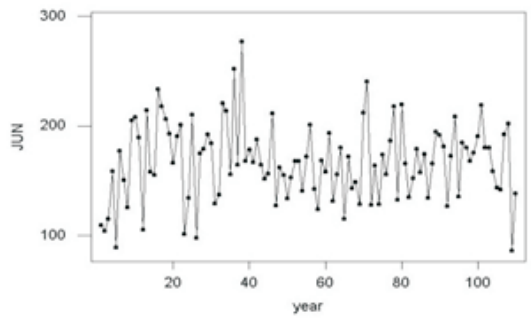

Figure 2: Rainfall Time series plot for month 'June'

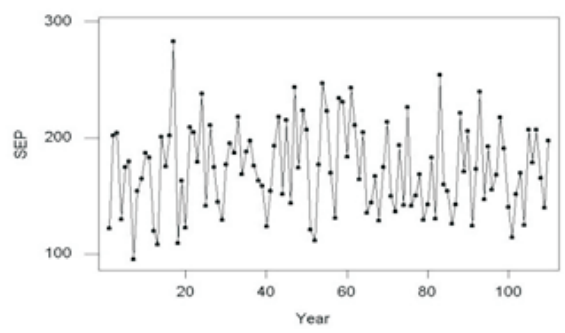

Figure 4: Rainfall time series plot for month 'Sept.'

4.RESULTS AND DISCUSSION:

The preliminary graphical inspection of the data under study is performed. Time series plots of the rainfall values for three of the monsoon month are shown in the figures 2, 3 and 4. The descriptive statistics such as Minimum, Maximum, Mean and Standard Deviations were computed for each of the four months and presented in the Table no. 1 and as well for four meteorological regions in the Table no. 2. It was observed that, on an average, maximum rainfall occurs in the month of July during the monsoon period. The maximum rainfall occurred in the meteorological region of Northeast India (NEI).

Table No. 3: Sen's Slope Estimate and Mann Kendall Test Results for month-wise data

Month	Sample	S-statistic	Z-value	P-value	β (mm/yr)
June	110	157	0.403	0.687	0.0395
July	110	-606	-1.5628	0.1181	-0.1844
August	110	-122	-0.3126	0.7546	-0.0421
Sept.	110	-84	-0.2144	0.8302	-0.0344
Over all	110	-291	-0.7491	0.4538	-0.2167

where β is Sen's estimate of slope

Table No. 4: Sen's Slope Estimate and Mann Kendall Test Results for Region-wise Data

Region	Sample	S-statistic	Z-value	P-value	β (mm/yr)
NWI	110	-602	-1.5524	0.1206	-0.6137
CI	110	-410	-1.0565	0.2908	-0.509
NEI	110	-10	-0.0232	0.9815	-0.0072
SP	110	220	0.5657	0.5716	0.1896

Further, rainfall time series data were analyzed with a Mann-Kendall test and Sen's slope estimate for each of months: June, July, August, September and meteorological regions: Northwest India(NWI), Northeast India(NEI), Central India(CI), South Peninsular India(SPIN) as well. Table No. 3 provides the computations of the Mann-Kendall Statistic, Sen's slope estimate and P-values for these four monsoon months. As it can be observed, upward trend is observed in the month of June while remaining three months (July, August and September) reveal downward trends. The observed trends are found to be statistically insignificant as evidenced from the P-values. Table No. 4 shows computations of Sen's estimate of slope, Mann-Kendall statistics and P-values for four meteorological regions. In case of these four meteorological regions, three regions i.e., NWI, NEI and CI revealed downward trends which were also statistically insignificant. But, the trend observed in the region SPIN was upward trend.

5.CONCLUSIONS

The study of trend analysis in the rainfall data is a basic and important requirement for the planning and management of water resources. The overall monsoon rainfall shows downward trend which is statistically insignificant. The downward trend identified in three meteorological regions. The decrease in rainfall occurred in overall monsoon period. However, this decrease was found to be statistically insignificant. Finally, it can be concluded that investigation of cyclical fluctuations should be done to throw more light on the hidden patterns in the Indian rainfall data.

REFERENCES

1.Abdul-Aziz A. R. et al(2013): Modeling and forecasting Rainfall Pattern in Ghana as a Seasonal Arima process, International Journal of Humanities and Social Sciences, 3(2), pp 224-233.
2.Jain S.K. and Kumar V. (2012): Trend analysis of rainfall and temperature data for India, Current Science, 102(1), pp- 37-48
3.Kumar, V., Jain S. K. and Singh, Y. (2010a): Analysis of Long-term rainfall trends in India. Hydrol. Sci. J. 55, pp. 484-496
4.Kumar, V. and Jain S.K. (2010b): Trend in seasonal and annual rainfall and rainy days in Kashmir valley in the last century, Quaty Intl., 212, pp 64-69
5.Krishnakumar, K. N., Rao, G.S., and Gopalkumar C.S. (2009): Rainfall trends in twentieth centuary over Kerala, India, Atmos. Environ. 43, pp. 1940-1944
6.Ranade A., Singh N., Singh H. N., and Sontakke, N. A. (2008): On variability of hydrological wet season, seasonal rainfall and rainwater potential of the river basins of India (1813-2006). J. Hydrol. Res. Dev., 23, 79-108.

Publish Research Article
International Level Multidisciplinary Research Journal
For All Subjects

Dear Sir/Mam,

We invite unpublished Research Paper,Summary of Research Project,Theses,Books and Book Review for publication,you will be pleased to know that our journals are

Associated and Indexed,India

- International Scientific Journal Consortium
- OPEN J-GATE

Associated and Indexed,USA

- EBSCO
- Index Copernicus
- Publication Index
- Academic Journal Database
- Contemporary Research Index
- Academic Paper Databse
- Digital Journals Database
- Current Index to Scholarly Journals
- Elite Scientific Journal Archive
- Directory Of Academic Resources
- Scholar Journal Index
- Recent Science Index
- Scientific Resources Database
- Directory Of Research Journal Indexing

Golden Research Thoughts
258/34 Raviwar Peth Solapur-413005,Maharashtra
Contact-9595359435
E-Mail-ayisrj@yahoo.in/ayisrj2011@gmail.com
Website : www.aygrt.isrj.net