STUDY OF RAINFALL TRENDS AND VARIABILITY FOR BELGAUM DISTRICT

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Abstract

Rainfall patterns usually have spatial and temporal variability. This variability affects the agricultural production, water supply, transportation, the entire economy of a region, and the existence of its people. Agriculture would be seriously affected by increased variability and trends in the seasonal characteristics of rainfall in an environment where one of the major limiting factors of agricultural production is the amount of water available through rainfall. This dissertation work is an analysis of variations and trends in rainfall for Belgaum district, Karnataka. Some parts of Belgaum district receive annual rainfall less than 750 mm and hence are drought prone. To study the phenomenon of low rainfall in the district, statistical analysis of annual rainfall data from 42 rain gauge stations located in the district will be carried out. The length of data, for stations varies from 25 years to 33 years. The analysis is based on the series of tests designed to determine if the annual rainfall data is consistent, random and trend free. The trend in the data is determined by various methods such as Linear regression method etc. The different variability will be determined for stations. The Standard Precipitation Index (SPI) method will be used in this study to analyze Drought. Athani which is located in the north western part of Belgaum district is taken as the area of study because the area experiences frequent droughts and very few studies have been carried out for Athani before. The study concludes with the description of the structural characteristics and temporal and spatial variations of the annual rainfall data in Belgaum district.

Keywords: *Belgaum, Trends, Drought, Athani.*

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1. INTRODUCTION

1.1 General

Rainfall is an end product of a number of complex atmospheric processes, and it forms the input to all the hydrological studies. Rainfall patterns usually have temporal and spatial variability. This temporal and spatial variability of rainfall is due to seasonal atmospheric phenomenon and geographical (topographical) factors respectively.

In this direction, an attempt has been made to study the spatial and temporal behavior of rainfall in the Belgaum districts of Karnataka state. This has been achieved by considering historical data of 40 rain gauge stations which are situated in this region.

World Meteorological Organization (2000) has recommended a number of statistical techniques for climatological analysis. Using some of these methods, rainfall in the Belgaum district has been analyzed to study presence of any trend in the rainfall series.

Rainfall forms the input of all hydrological studies. Apart from the quantum of rainfall, its time distribution plays a critical role in the planning and management of water resources. Peak rainfall data are used in designing storm water management systems and in determining the flooding potential of various storm events. Daily or hourly data are required in continuous hydrologic simulation procedures. Monthly and seasonal data are used in determining supplementary irrigation water requirements, and in engineering studies related to storage analyses, water supply, and reservoir management.

The variability in rainfall may affect the agricultural production, water supply, transportation, the entire economy of a region, and the existence of its people. In regions where the year-to-year variability is high, people often suffer great calamities due to floods or droughts. The damage due to extremes of rainfall cannot be avoided completely, a fore-warning could certainly be useful and it's possible from analysis of rainfall data.

1.2 Importance of Analysis of Rainfall

1.2.1 Agricultural Planning

Agricultural production is controlled by monsoon rainfall, which is the primary source for soil moisture for dry land crops. In Agricultural Planning, rainfall variability analysis aids to take farm decisions on times of sowing, inter culture operations, fertilizers application etc.

The economy of the country depends upon the agricultural production. Since Variation of the yields of most of the major crops to a large extent is due to the variations of the rainfall amounts and of their distribution in time, studies of rainfall variability are of great importance.

1.2.2 In Design of Storage Structures

Statistical and probability analysis of rainfall occurrences is usually carried out for planning and design of water conservation and recharge structures.

Though rainfall pattern is erratic and varies temporally and spatially, it is predictable with reasonable amount of certainity for certain return periods that helps to design water conservation/recharge structures in particular area.

Frequency analysis of rainfall is necessary and useful tool for solving various water management problems like planning and designing of structures for water conservation and recharge purpose.

1.2.3 Study the Trends in Rainfall Series

Water resources systems are designed and operated on assumption of stationary hydrology. Existence of trends and other changes in the data invalidates this assumption, and detection of the changes in hydrological time series should help us revise the approaches used in assessing, designing and operating our systems. Also the trend and step change studies help us understand the impact of man's activities (e.g. Urbanization, deforestation, dam construction, agricultural activities, etc.) on the hydrological cycle.

1.2.5 Planning and Management of the Regional Water Resources

For proper planning and management of water resources in a basin there is a need to constantly update the knowledge of temporal variability of rainfall in the basin.

1.2.6 Implications for Cropping

Some crops vary in plant water requirements (drought tolerance) and growing season (time of sowing and maturity duration). Better choices on which crop should be grown can be made with rainfall probability information. Information on rainfall probability is also important to make the choice to not grow a crop at all, due to potential seasonal conditions which would produce crop failure.

1.2.7 Study the Occurrences of Droughts and Floods

Frequency analysis of Rainfall can help to predict the occurrences of drought or floods with certain return period.

1.3 Structural Characteristics of Annual Rainfall

Rainfall records in a geographical region show a complex structure. Basic statistical information such as average, standard deviation, skewness, correlation structure, median value, and range can be computed in a simple way from the rainfall records.

Additionally, structural characteristics of the time series can be derived. These characteristics include consistency, independence, randomness, and homogeneity as well as the presence of trends and jumps.

Structural characteristics of hydro-meteorological variables (Rainfall) are important in modeling studies. For instance, if an autoregressive (AR) type model is to be applied to the observed time series of the variable, then the removal of any trend is required before applying the model. AR-type models, and many others, require the data to obey a predefined probability distribution function, such as a normal distribution.

Information on the structural characteristics of precipitation data can also identify a climate change or variability signal. Such information can be exported from the trend analysis and/or jump analysis of the precipitation record.

1.4 Temporal Variations of Rainfall

Point precipitation records exhibit great variation from hour to hour, week to week and even from year to year. Therefore, in practice for hydrological purposes the analysis of rainfall data is often based on the statistical properties of observed rainfall time series. This variation in rainfall records mainly incorporates three time series components: stochastic, periodic and secular. Stochastic variations result from the probabilistic or random nature of precipitation occurrence, and may be so great that they effectively dominate the time series. Periodic or cyclic variations are related, for example, to astronomical cycles such as the diurnal and annual cycles. Finally, secular or long-term variations, which are often referred to as climatic change, may incorporate both cyclic or trend characteristics.

The reason for the great variability in rainfall can be seen in if one looks at the frequency distribution of rainfall, since it is apparent that a small proportion of storms or rain days in the course of a year may provide a disproportionate amount of the total rainfall. The presence or absence of only a small number of storms may therefore have a considerable effect upon the total precipitation. The variability of annual rainfall is greater for areas with low annual precipitation, where rain may fall only occasionally, than for, say, equatorial regions where rain may fall on nearly every day. In addition to rainfall amounts, the time intervals between storms are of great interest to the hydrologist, especially in the drier parts of the world. The timing and magnitude of individual storms is largely stochastic in nature, and the number of studies, have represented parameters such as the time interval between storms, the storm duration and the precipitation depths by statistical frequency distributions.

The periodic variations are regular cyclic variations with rainfall minima and maxima recurring after approximately equal time intervals.. The annual cycle is the most obvious weather cycle and results from the regular seasonal shifts in the zones of atmospheric circulation in response to the changes in the heating patterns. There is ample evidence that climate has changed in the past and no reason to suppose that it will not change in the future. The question of whether such secular, or long-term, changes in climate are cyclic in pattern remains a controversial topic in hydrology.

2. LITERATURE REVIEW

2.1 General

Literature referred during the preparation of this thesis is mainly regarding the statistical methods available for rainfall analysis; it mainly includes the trend tests like Spearman rho test and Mann Kendall test. The research papers also included the statistical tests and Rainfall probability analysis.

2.2 Review of Literature Vance, et al (2004).

In their study, the analysis was done to determine the annual and monthly rainfall in Cambodia, the aim was to aid farmers when making choices as to which crops to grow apart from rice. Daily records of rainfall data in the three provinces of Battambarg, Kampong Cham and Takeo were analyzed to:

- Calculate the monthly rainfall totals,
- Determine the variability in annual rainfall,
- Determine if the total rainfall in the month of March or April might give an indication of the potential rainfall for the remaining season, and determine if the drought periods in the June and July are consistent in each year, and if they may be predicted,
- Predict for Battambarg the break of season for field crops.

Jayawardene H.K. et al**.,(2005)** In their study, an analysis was carried out to extract the trends of rainfall depth in Sri Lanka over the last century. The work discussed in this paper focuses of extracting the trends and seasonal patterns of rainfall on a set of selected weather stations by utilizing statistical techniques. The work was carried out with monthly and annual rainfall data recorded on 15 stations within a time span of 98 to 130 years. Emphasis is given to find out whether there is any significant change in the rainfall time series records over the years.

Among the statistical tests available to detect trend in a time series, the Mann Kendall rank statistic, the Spearman rank statistic and the least-square regression were chosen for their work. The results obtained from the tests were discussed.

Wing H Cheung et al**., (2008)** studied and investigated the temporal dynamics of rainfall and its spatial distribution within Ethiopia. Changes in rainfall were examined using data from 134 stations in 13 watersheds between 1960 and 2002. The variability and trends in seasonal and annual rainfall were analyzed at the watershed scale. Similar analyses were also performed at the gauge, regional, and national levels. The gauge level analysis showed that certain gauge stations experienced recent changes in rainfall; these trends are not necessarily reflected at the watershed or regional levels.

From the review of literature it is evident that several studies have been undertaken to characterize trends in rainfall time series at various locations across the globe. These studies have adopted several statistical techniques to quantify increasing or decreasing trends in annual rainfall. Most commonly adopted trend detection techniques were Mann Kendall, Spearman rho test and linear regression test. However, few studies seem to have been undertaken to understand rainfall trends and variability with regard to Asian monsoon phenomenon. Studies on trend analysis in this region are crucial for sustainable water resources development and utilization.

Also it is evident that less work has been carried out on variability of rainfall and probability analysis of rainfall. Therefore, the present study seeks to study the temporal variability of rainfall and employ popular statistical techniques to characterize trends in annual rainfall series of Belgaum district, Karnataka.

3. DESCRIPTION OF STUDY AREA

Belgaum is among the 30 districts of Karnataka, situated in the Northwest part of the state. The district is bordered by Maharashtra state to the North, Bagalkot district in the East, Dharwad and Uttar Kannada districts in the South, Goa and Maharashtra state in the west. There are ten taluks in the district namely Athani, Bailhongal, Belgaum,

Chikkodi, Hukkeri, Khanapur, Raibag, Ramdurg and Saundatti.

The district of Belgaum geographically comes in Malnad region and receives an average annual rainfall of nearly 2000 mm. Agro-climatologically the district can be divided into three zones i.e. high rainfall “Hilly zone”, “Northern transitional zone” and “Northern dry zone”.

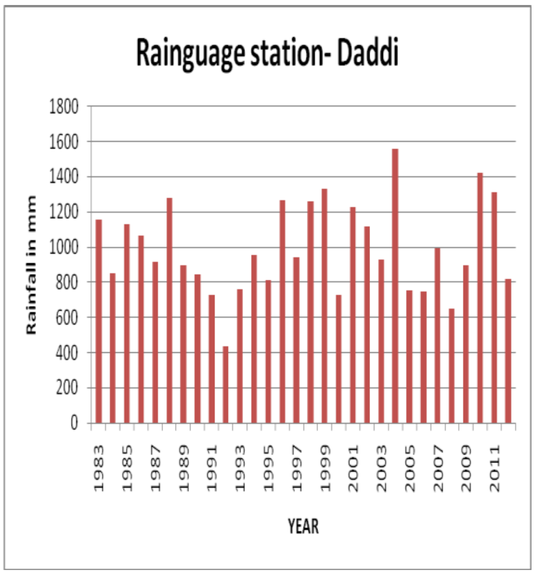
The district lies between 15°00’ and 17°00’ north latitudes and between 74°00 and 75°30’ east longitudes. It is situated near the foothills of the Sahyadri mountain range (Western Ghats) and about 100km from the Arabian Sea. The population was about 42 lakhs at the last census and the area of the district is about 13,415 km^2. Of the total geographical area, 1927 km^2 is under forest ,and 6273 km^2 is nearly about 50% of the geographical area is normally under crops.

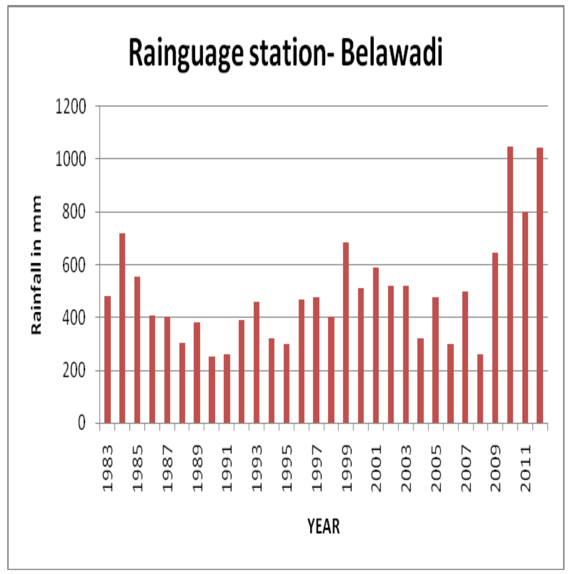
The Belgaum district is Semi-arid in parts of Athani, Raibag, Gokak, Bailhongal, Ramdurg and Saudatti taluks. Climate in rest of the district ranges from sub-humid to humid towards west.

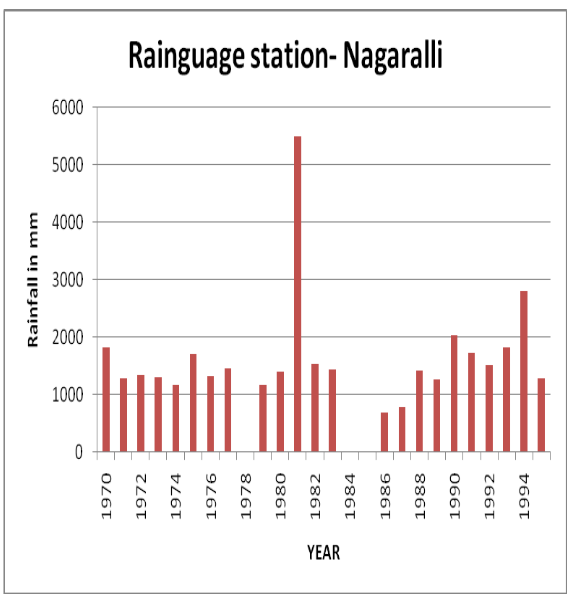
Nearly 95 percent of the annual rainfall is received during the period April to October, because of the South-west monsoon. Most of the remaining rainfall is received during November and December under the influence of Northeast monsoon. The district has two major river systems Ghataprabha and Malaprabha which are tributaries of river Krishna. The other rivers Hiranyakesi and Markandeya are tributaries to Ghataprabha. There are two dams, on Ghataprabha at Hidkal and on Malaprabha at Naviluteerth.

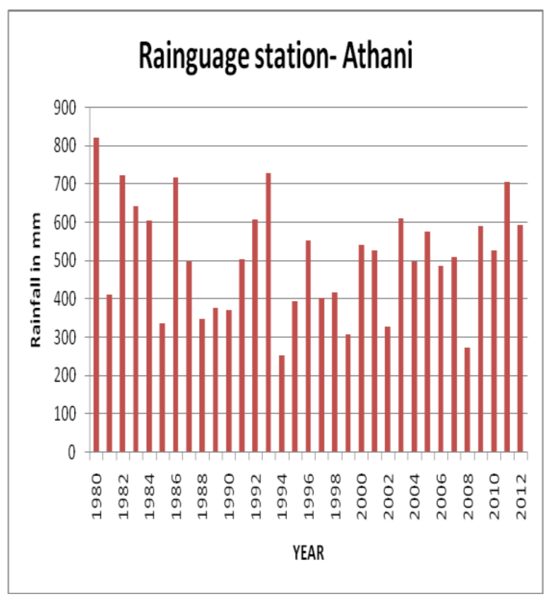
4. RAINFALL STATISTICS FOR THE BELGAUM DISTRICT:

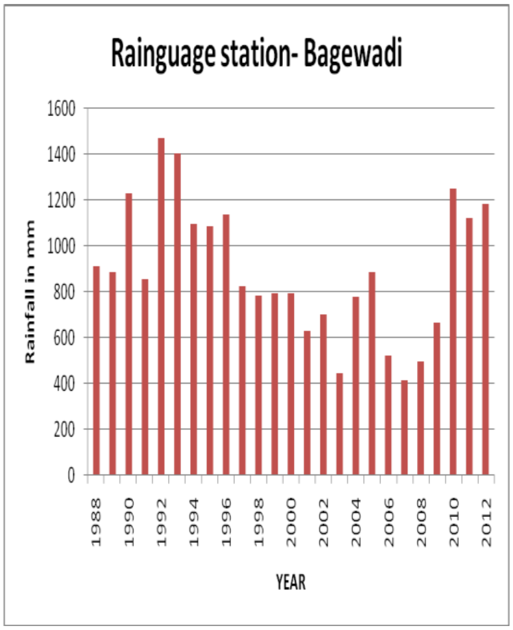
The annual series of the rainfall for all stations considered for the analysis are plotted. From the figures the variation of annual rainfall over the years for the data period can be easily seen. Some of the rainfall statistics of Belgaum district is shown below

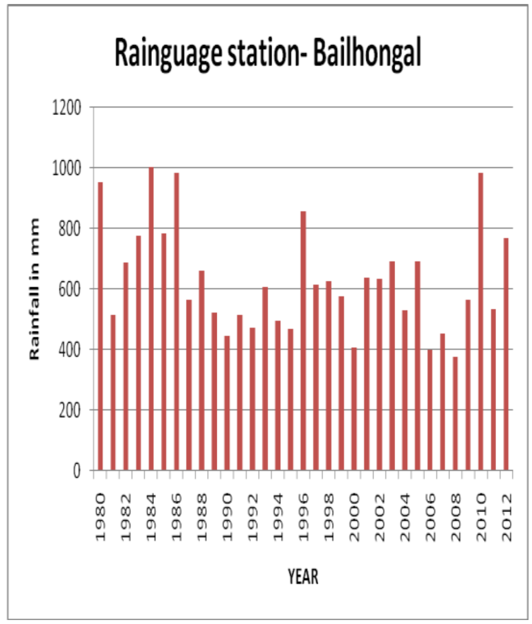


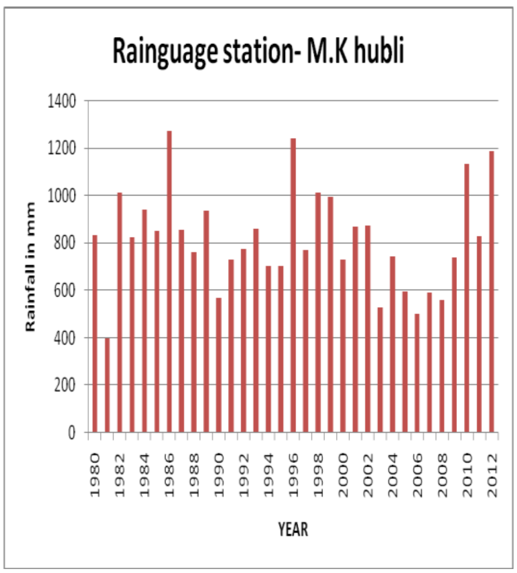


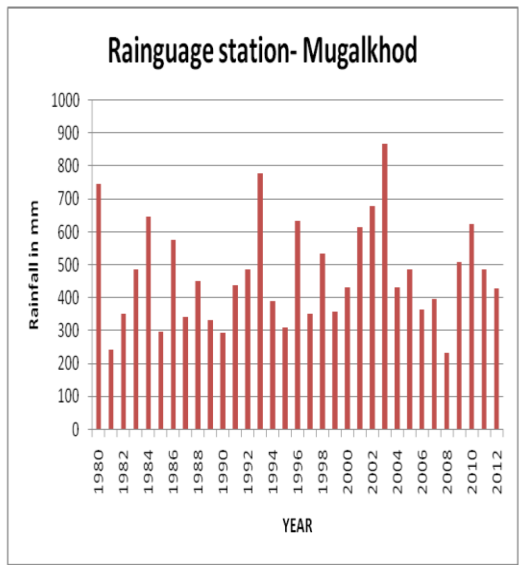





Rainguage station- Bagewadi
Rainfall in mm
0 200 400 600 800 1000 1200 1400 1600
1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012
YEAR


Rainguage station- Bailhongal
Rainfall in mm
0 200 400 600 800 1000 1200
1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012
YEAR


Rainguage station- M.K hubli
Rainfall in mm
0 200 400 600 800 1000 1200 1400
1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012
YEAR


Rainguage station- Mugalkhod
Rainfall in mm
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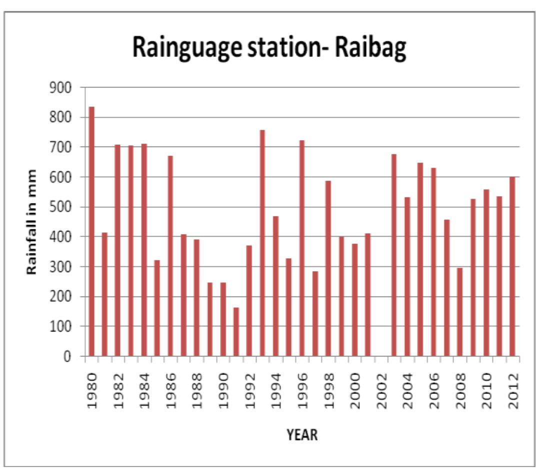
1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012
YEAR


Rainguage station- Raibag
Rainfall in mm
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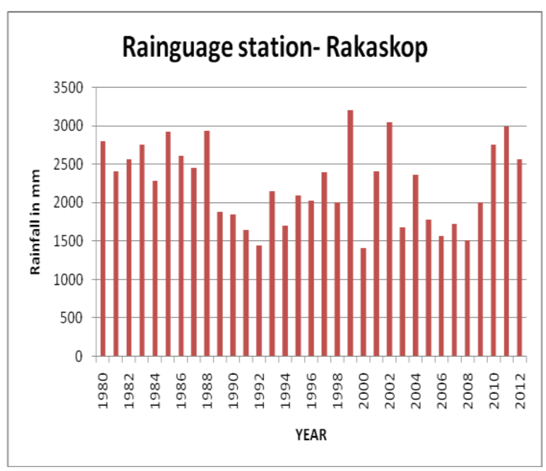
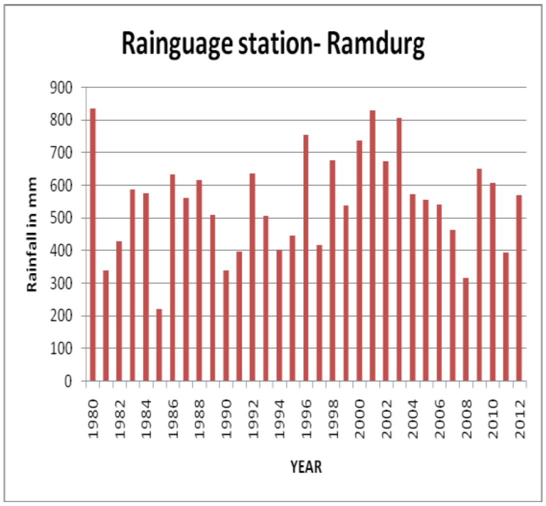
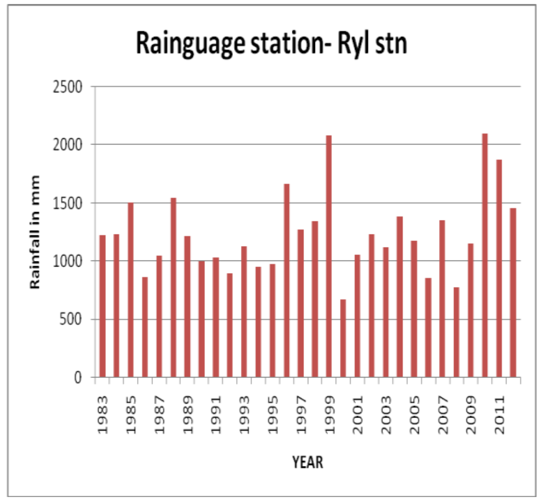
1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012
YEAR


Rainguage station- Rakaskop
Rainfall in mm
0 500 1000 1500 2000 2500 3000 3500
1980 1982 1984 1986 1988 1990 1992 1994 1996 1998 2000 2002 2004 2006 2008 2010 2012
YEAR





5. BASIC STATISTICAL PARAMETERS OF INDIVIDUAL RAIN GAUGE STATION

SL.NO	NAME	NO.YEARS	MIN (MM)	AVG (MM)	MAX (MM)	SD (MM)	CV	KVRT	SKEW
1	Daddi	30	433	993	1559	255.444	25.724	-0.169	0.229
2	Belawadi	30	250	493.43	1045	202.124	40.962	2.209	1.415
3	Athani	33	251.6	508.29	822.4	125.837	24.576	-0.377	-0.458
4	Bagewadi	25	430	893.44	1471	287.209	32.146	-0.453	0.215
5	Bailhongal	33	372	629.4	1002.8	162.762	25.859	0.396	0.727
6	Arabhavi	33	141	481.39	797	144.781	30.075	-0.38	-0.152
7	Bidi	30	526	1103.27	1909	339.91	30.809	-0.242	0.616
8	Bugate alur	26	303	674.92	1640	321.629	47.654	3.6	1.913
9	Chapoli	33	1624.5	4724.34	7654.7	1259.072	26.65	0.305	0.657
10	Chikkanandi	30	219	569.1	957	191.611	33.669	-0.175	0.373
11	Chikkodi	33	306	691.06	1049	155.02	22.432	1.122	0.317
12	Dupadhal	25	218	473.08	774	130.043	27.488	1.035	0.469
13	Galatga	30	250	616.93	1171	185.47	30.063	1.791	0.605
14	Gokak	33	212	495.37	901.4	129.507	26.143	2.298	0.615
15	Hattargi	33	247	668.12	1147	184.703	27.645	0.89	0.127
16	Hidkal	33	326	625.15	822	118.543	18.962	0.9383	0.433
17	Hikkeri	33	319	660.44	1116.6	156.652	23.719	0.194	-0.286
18	Kanakumbi	30	3951.2	5976.02	8150.8	1160.572	19.47	-0.755	-0.037
19	Khanapur	33	1084	1853.44	3149.8	435.237	23.482	1.518	0.742
20	Kittur	29	430	900.45	1292	236.182	26.229	-0.387	-0.2408
21	Kulagod	26	249	463.92	781	131.726	28.393	0.033	0.804
22	MK hubli	33	397.6	815.35	1273.3	192.093	25.559	0.587	0.752
23	Mugalkhod	33	231	471.88	867	140.761	29.83	1.028	0.91
24	Raibag	33	0	484.82	836.4	176.002	36.306	0.437	-0.742
25	Rakaskop	33	1402	2239.64	3205	500.042	22.326	-0.8166	0.045
26	Ramdurg	33	316	549.66	836	135.672	24.682	0.3903	-0.148
27	Rly stn	30	671	1237.1	2079	347.326	28.075	1.032	0.988
28	Sambra	30	334	927.6	1329	233.868	25.212	0.126	-0.39
29	Sankeswar	33	438	867.43	1504	251.141	28.952	0.405	0.587

30	Shedabal	33	196.6	547.31	992	192.54	35.179	0.636	0.791
31	Telsang	33	147	569.76	974	191.56	33.622	0.148	-0.252
32	Ugar kh	30	185	494.5	799	157.503	31.851	-0.343	0.366
33	Yalaprattti	30	224	449.7	796	132.021	29.359	0.485	0.554
34	Yaragatti	33	258.3	530.43	946.3	172.902	32.596	0.642	0.616
35	Nippani	30	415.8	803.95	1250	195.753	24.349	-0.183	0.174
36	Soundatti	33	210	507.51	867	163.905	32.295	-0.422	0.136
37	Kudachi	30	210.6	469.49	1145	187.683	40.406	5.074	1.694
38	Navilthirtha	33	213.8	608.61	820.6	143.85	23.636	1.997	-1.152
39	Nesaragi	33	311	588.86	1023.5	164.035	27.856	0.357	0.382
40	Sadalga	32	395.4	624.57	1180	184.11	29.478	1.358	1.042
41	Hulagund	32	188.7	389.88	690.2	160.251	41.102	-0.964	0.224
42	sarapur	25	117	346.48	706	132.381	38.207	1.013	0.583

The basic statistical parameters relating to each rainfall stations have been given in table. The average annual rainfall of the raingauge stations in Belgaum district ranges from 346.48 mm (sarapur) to 5976.02 mm (kanakumbi) indicating a wide variation from one station to the another station.

From the table it can be seen that the maximum rainfall occurred at station chapoli with 7654.7 mm in the year 1987 in which the minimum occurred at the station sarapur with rainfall of 117 mm in the year 1988. The standard deviation varies between 118.543 mm to 1259.072 mm for station hidkal dam and the chapoli respectively.

It is observed that the maximum variation in the annual rainfall occurs at station Bugate alur with a coefficient of variation of 47% and minimum at the station hidkal dam with a coefficient of variation is around 18%. The average coefficient of variation is around 30% indicating the rainfall varies reasonably from one year to the next.

Most of the stations have kurtosis coefficient negative indicating that a distribution is more flat than the normal distribution. Only one station kudachi has a kurtosis coefficient greater than 5 indicating that low rainfall values are observed more often than high rainfall values.

The skewness coefficient for most of the stations are positive indicating that the low rainfall happens frequently whereas the high value rainfall happens rarely. For some of the stations the skewness coefficient is equal to or nearly equal to zero indicating the data follows a normal distribution.

6. METHODOLOGIES USED

6.1Structural Characteristics of Rainfall

- Consistency test
- Randomness test
- Serial correlation test

6.2Trend Analysis of Rainfall Data

- Mann-kendall test
- Spearman rho test
- Linear regression

6.3Trend Analysis of Rainfall Data

- Relative variability
- Co-efficient of variation
- Relative inter sequential variability

7. OBJECTIVES OF PRESENT STUDY

Thus the objectives of the present study are:

1. To apply statistical techniques to historical data and characterize rainfall occurrence in Belgaum district.
2. To carry out trend analysis of historical rainfall time series.
3. To study variability of annual rainfall in Belgaum district.
4. To obtain the rainfall probability charts for various rain gauge stations.

8. CONCLUSIONS

The work discussed in this paper focuses of extracting the trends and seasonal patterns of rainfall on a set of selected weather stations by utilizing statistical techniques. The work was carried out with annual rainfall data recorded on 42 stations. Emphasis is given to find out whether there is any significant change in the rainfall time series records over the years.

Most of the stations have kurtosis coefficient negative indicating that a distribution is more flat than the normal distribution. The skewness coefficient for most of the stations are positive indicating that the low rainfall happens frequently whereas the high value rainfall happens rarely

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