Studies on Variability of Rainfall over North - Eastern Dry Zone of Karnataka: a statistical analysis

Abstract

The mean annual rainfall over different stations of North Eastern dry zone of Karnataka varied between 630.1 mm to 744.3 mm. The mean annual rainfall received relatively more at North side and middle of the zone in comparison to south side lying stations within the North Eastern dry zone of Karnataka.The percentage of seasonal rainfall contribution towards annual rainfall varied between 66-74%, 16-20% and 10-14% for *Kharif*, *rabi* and summer seasons respectively. The drought characterization revealed that, out of 35 years (1986-2020) of study period, all the stations have experienced one or the other kind of drought situation during 17 to 20 years which accounts for 49 to 57 per cent, which means, most of the stations have experienced either mild or moderate drought conditions for 50% of the years.

Keywords: North Eastern dry zone, Annual rainfall, Seasonal rainfall, Karnataka and drought.

1. INTRODUCTION

The success or failure of crops particularly under rainfed conditions is closely linked with the rainfall pattern.Three main characteristics of rainfall are its amount, frequency and intensity, the values of which vary from time to time[1]. Precise knowledge of these three main characteristics is essential for planning of its full utilization for agricultural production.India receives adequate amount of rainfall annually through the four different types of weather phenomena, South-West monsoon, North-East monsoon, winter and summer seasons[2][3]. The distribution in time and space is erratic, thus resulting in a limitation on the length of crop-growing periods or the occurrence of floods. Rainfall is one of the most important natural resource for human beings. The rainfall and its distribution throughout the year are important for every cultivator, both for deciding the cropping pattern and for providing irrigation[4].

Rainfall is the single most important factor in crop production planning in rainfed ecologies. The information on annual, seasonal, monthly and weekly rainfall of a region is useful for planning agricultural operations like field preparation, seeding, irrigation, fertilizer application and overall activities related to field crop planning. Around 60% of the Indian agriculture is rain-dependent, diverse, complex, under-invested, risky, distress prone and vulnerable[5].Climate change and dryland agriculture are interrelated processes. Variable climate and uncertain rainfall, high inter and intra seasonal variability, frequent occurrence of mid-season and terminal droughts, water scarcity, more unstable yield linked with poverty and vulnerable livelihoods are the characteristics of dryland agriculture[6][7]. It is the most impacted by climate change due to rainfall variability and reduction in number of rainy days and small and medium dryland farmers are highly vulnerable to climate change and to a greater extent. The Indian monsoon rainfall shows an inter-annual variability [8]. There is a need to quantify regional climate variability to assess its effect on crop productivity [2]. The climatological data of a location is of utmost importance towards minimizing production risk [9].

The studies of variability of annual and seasonal rainfall, frequency of dry and wet spells on monthly and weekly basis will provide useful information for determining the climate potential for agricultural development and for evolving suitable cropping pattern [10]. The information on annual, seasonal, monthly and weekly rainfall of a region is useful for planning agricultural operations like field preparation, seeding, irrigation, fertilizer application and overall activities related to field crop planning [11].The success or failure of crops particularly under rainfed conditions is closely linked with the rainfall pattern. Coincidence of dry spells with the sensitive phenological stages of the crop causes damage to the crop development. Hence, simple criteria related to sequential phenomenon like dry and wet spells and prediction of probability of onset and termination of the wet season could be used to obtain specific information needed for crop planning and for carrying out agricultural operations [12].

The dry land watersheds are faced with the following serious handicaps for which possible but simple remedies are required.Rainfall factors: intensity and erratic distribution, causing floods or droughts, etc., rainfall data is analyzed to attack the problem systematically[13].Timeliness of crop production activity: package of practices and technology is to be identified[14].Mechanical manipulations: for soil management, anti-erosion terracing, ravine protection and disposal of drainage water, practices have to be identified[15].Agricultural input factor availability of inputs must be taken into account before recommending cropping systems[9].Out of these, the rainfall factors have to be analyzed systematically before attacking any of the later problems.

Based on the rainfall pattern, topography, soil type and cropping pattern, Karnataka state is divided into 10 Agro-climatic zones[16][17]. In the present study, the second zone of Karnataka, i.e. North Eastern dry zone of Karnataka has been selected to study the variations in the rainfall pattern over different stations, within the agro-climatic zone. The zone comprises of parts of Kalaburgi, Yadgir and Raichur districts. Rainfall ranges between 650 – 790 mm. The soils vary from black soils to deep black soils and also some portion of red soils. The major dryland crops are jowar, redgram, chickpea, cotton and other pulses and oil seeds. Realizing the importance of analyzing the variations of rainfall distribution within the particular agro-climatic zone, the present study was carried out with the an analysis of rainfall pattern over North-Eastern dry zone of Karnataka and meteorological drought characterization and analysis of dry and wet spells.

2. MATERIAL AND METHODS

2.1.Location and extent of the study area

Based on the rainfall pattern, topography, soil type and cropping pattern, Karnataka state is divided into 10 Agro-climatic zones. A taluka has been taken as a smallest unit in this zoning. Presently, we have selected North Eastern Dry zone of Karnataka (Zone - II out of ten zones of agro-climatic zones in Karnataka). The details of North eastern Dry zone of Karnataka are summarized below.This zone comprises of Kalaburgi, Afzalpur, Chitapur, Jewargi, Sedam taluks of Kalaburgi district;Shorapur, Yadgir and Shahpur taluks of Yadgir district and Devadurga, Manvi and Raichur taluks of Raichur district. The total geographical area of this zone is 17,62,640 ha accounting to 9.25 per cent of the TGA of the state. The elevation of the taluks ranges from 300 to 450 metres in all taluks. The average annual rainfall ranges from 640 to 810 mm. The soils of the zone are deep to very deep black clay soils in major areas. Shallow to medium black soils in minor pockets. Rabi jowar, kharif jowar, gram, tur, other pulses, small millets, bajra, groundnut, oilseeds, paddy, cotton and chillies are grown in this zone. The rainfall analysis was carried out over the different stations of North Eastern dry zone of Karnataka such as Afzalpur, Kalaburgi, Sedam, Yadgir, Shorapur, Devadurga, Manvi and Raichur. The three stations (taluks) were not included for analysis as they are close (Chitapur is close to Sedam; Jewargi is close to Kalaburgi; Shahpur is close to Yadgir and Shorapur) to other taluks which lies within 0.5° x 0.5° (Approximately 53 km x 53 km) range by distance.

The various stations selected for the study purpose are presented in Fig. 1 and the geographical locations of the stations are presented in Table 1. The eight stations were selected for the study, which are spread over entire North Eastern dry zone of Karnataka.

2.2.Collection of the data

For the proposed study, the daily rainfall data of 35 years (1986–2020) was collected from "National Aeronautics and Space Administration" website (https://power.larc.nasa.gov: NASA Power / Prediction of Worldwide Energy Resources) at spacing of 0.5° x 0.5° (Approximately 53 km x 53 km) range by distance. The total of eight stations (Afzalpur, Kalaburgi, Sedam, Yadgir, Shorapur, Devadurga, Manvi and Raichur) were selected which are geographically well distributed representing North Eastern dry zone of Karnataka[18].

Table 1: Details of geographical location of various stations in Ballari district

Sl. No.	Station Name	Latitude(°N)	Longitude(°E)

1	Afzalpur	17.2026° N	76.3578°E
2	Kalaburgi	17.3297° N	76.8343°E
3	Sedam	17.1784° N	77.2873°E
4	Yadgir	16.7626° N	77.1442°E
5	Shorapur	16.5217° N	76.7611°E
6	Devadurga	16.4235° N	76.9355°E
7	Manvi	15.9951° N	77.0478°E
8	Raichur	16.2160° N	77.3566°E

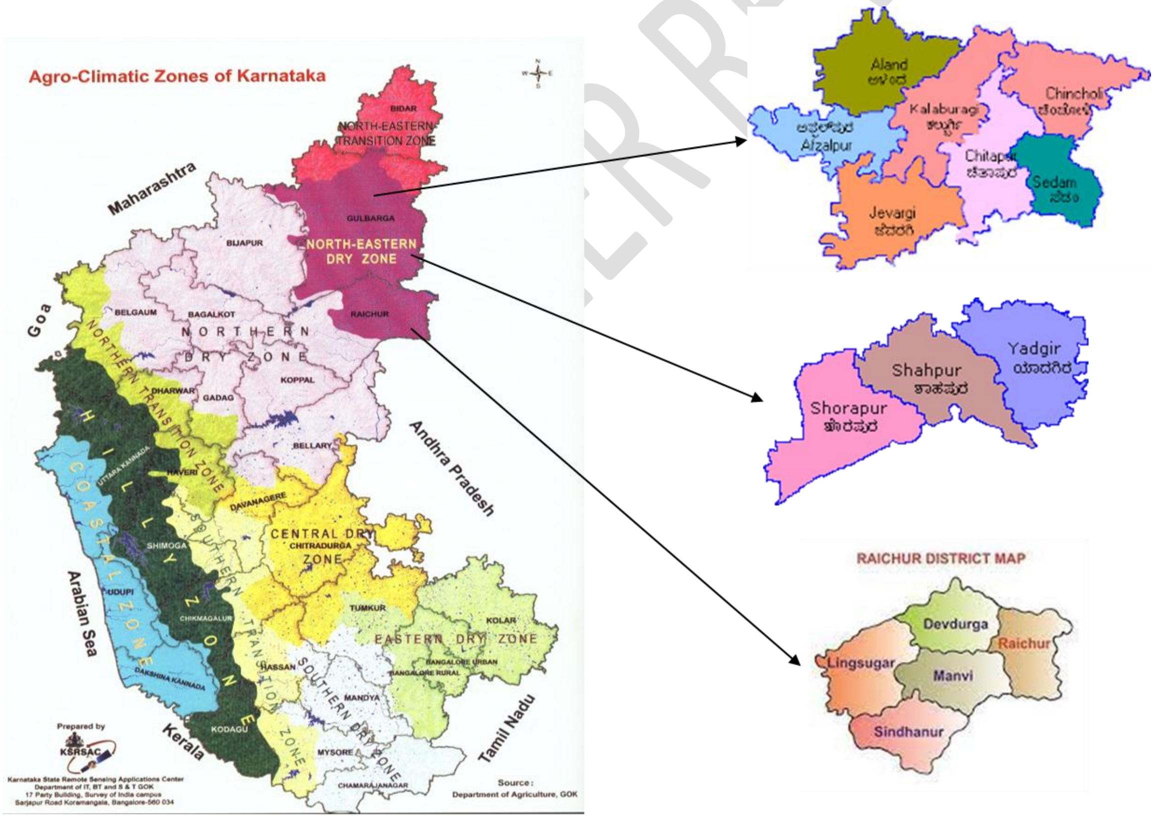

Fig. 1: Location of various stations over North eastern dry zone of Karnataka

2.3.Statistical analysis of rainfall

The statistical behaviour of any hydrological series can be described on the basis of certain parameters. Generally mean, standard deviation, coefficient of variation and skewness coefficient are taken as measures of variability of any hydrologic series[19][20]. All these parameters have been used to describe the variability of rainfall in the present study. The rainfall for all the stations were analysed statistically on annual, seasonal, monthly and weekly basis.

2.3.1. Mean

Mean represents measure of central tendency. Mean of a series is equal to the sum of all variables divided by their number.

Mean for the series, $\overline{X}$

$$\overline{X} = \frac{1}{N}\sum_{i=1}^{N} X_i \quad \text{---(1)}$$

2.3.2. Standard deviation

Standard deviation is the best measure of dispersion. It gives more weight to extreme items and less to those which are near the mean.

Standard deviation, σ

$$\sigma = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(X_i - \bar{X})^2} \quad \text{---(2)}$$

2.3.3. Coefficient of variation

Coefficient of variation is the "percentage variation in the mean, the standard deviation being treated as the total variation in the mean".

Coefficient of variation, (CV)

$$CV = \frac{\sigma}{\bar{x}}100 \quad \text{--- (3)}$$

Where

σ Standard deviation,

$\overline{X}$,mean

This measure is indicative of dependability of rainfall expressed in percentage. The threshold levels for CV for any interpretation are <25, <50, <100, <150 and <250 per cent for yearly, seasonal, monthly, weekly and daily rainfall respectively.

2.3.4. Skewness

Skewness is opposite of symmetry and its presence indicates that a particular series is not symmetrical. The measure of skewness indicates whether the dispersal of values from an average is symmetrical or asymmetrical. Asymmetrical may be positively skewed or negatively skewed. In case of positively skewed series, mean > median > mode. Whereas in case of negatively skewed series, mode > median > mean. The value greater than three indicates high degree of skewness.

Skewness, C_s

$$C_S = \frac{N(N-2)}{N-1}\sum_{i=1}^{N}\left(\frac{Xi-\overline{X}}{\sigma}\right)^3 \qquad \text{--- (4)}$$

Where,

Xi = variables

$\overline{X}$ = mean

N = total number of variables

σ = standard deviation

CV = coefficient of variation

C_S = skewness.

Along with statistical parameters, the maximum and minimum values of the series were also presented. The maximum and minimum value of a series indicates the highest and lowest variables in a series.

2.4. Trend analysis

Computation of trend values provides with a tool to ascertain, if a locality is getting drier or wetter. In case the rainfall series show a positive trend, the area would be considered to be getting wetter year–by–year or month–by–month. If it is negative, they would imply possible approach of drier conditions [21]. The regression equations were developed and the slopes of the regression lines were compared to know the increasing or decreasing trend of the rainfall. The correlation coefficient values (R^2) of the developed regression equations were critically analyzed to know the significant increasing or decreasing trends at the critical limit value of 0.1 (10 %) of correlation coefficient.

2.5.Meteorological drought analysis as per IMD criteria

The annual rainfall over different stations were classified as no drought, moderate drought and severe drought based on percentage deviation of rainfall towards negative side from mean rainfall. The meteorological drought classification based on IMD criteria is presented in Table2, if the deviation is less than 0 to –25 % then it is considered as mild drought. If deviation lies between –25 to –50 % it is designated as moderate drought year, if the deviation lies between–50 to –75% it is considered as severe drought and if the deviation is more than –75% it is considered as extreme drought. The difference between annual rainfall and mean rainfall divided by mean rainfall is an indicator for drought [22].

Table 2: Drought characterization through IMD criteria[23]

Deviation from normal rainfall (%)	Drought intensity
0 to –25 %	Slight drought
–25 to –50 %	Moderate drought
–50 to –75%	Severe drought
> –75 %	Extreme drought

3. RESULTS AND DISCUSSION

The study has been undertaken with the objective of characterizing various rainfall parameters over different stations of North Eastern dry zone of Karnataka. For this study, mean daily rainfall data for a period of 35 years (1986-2020) has been collected from NASA larc website and used in this study.An attempt has been made to analyze rainfall pattern on annual, seasonal, monthly and weekly basis. The meteorological drought characterization has been carried out. The initial and conditional probabilities of dry spells have been determined. The continuous dry and wet spell probabilities were obtained by Markov-chain process.

3.1.Analysis of rainfall pattern over different station of North Eastern dry zone of Karnataka

Rainfall being the only source of water under dryland agriculture, a more complete and quantitative understanding of this natural resource, provides a lot more insight for proper planning with respect to crop production. The daily rainfall data were analyzed for annual, seasonal, monthly and weekly basis and the results are presented as under:

3.1.1. Statistical Analysis of Annual Rainfall

Annual rainfall data of the selected stations were analyzed statistically and the statistical parameters like mean, maximum, minimum, standard deviation (SD), coefficient of variation (CV) and coefficient of skewness (C_S) are presented in Table 3.

Table 3: Annual rainfall parameters over North-Eastern dry zone of Karnataka

Station	Mean (mm)	Max (mm)	Min (mm)	SD (mm)	CV (%)	Skewness
Afzalpur	680.1	1100.8	419.7	161.0	23.7	0.4
Kalaburgi	744.3	1165.9	461.9	166.7	22.4	0.3
Sedam	796.9	1174.1	467.7	169.8	21.3	0.2
Yadgir	734.5	1119.8	411.9	162.9	22.2	0.2
Shorapur	684.2	1103.0	408.1	152.4	22.3	0.4
Devadurga	630.1	1013.7	346.0	143.3	22.7	0.5
Manvi	635.5	995.1	310.9	151.6	23.9	0.6
Raichur	676.8	1041.4	348.1	159.1	23.5	0.4

From table 3, it is revealed that, the highest mean annual rainfall was received at Sedam (796.9 mm) followed byKalaburgi(744.3 mm).The lowest mean annual rainfall was received at Devadurga(630.1 mm). The mean annual rainfall received relatively more at North side and middle of the zone in comparison to south side lying stations (Devadurga, Manvi and Raichur) within the North Eastern dry zone of Karnataka[24].The highest maximum annual rainfall was received at Sedam (1174.1 mm) followed by Kalaburgi (1165.9 mm). The lowest maximum annual rainfall was observed at Manvi (995.1 mm).

The minimum average annual rainfall was observed at Manvi (310.9 mm) followed by Devadurga(346.0 mm).

The standard deviation (SD) and coefficient of variation (CV)reveals that,the coefficient of variation (CV) was minimum at Sedam (21.3%) followed by Yadgir(22.2%). The CV varied between 21.3%(Sedam) to 23.9%(Manvi). From the skewness analysis, it was observed that, skewness varied from 0.2 to 0.6 at various stations of North Eastern dry zone of Karnataka. At all the eight stations, positive skewness was observed and skewness was not much and it varied between 0.2 to 0.6 only. If the CV of annual rainfall is within the threshold limits (<25%) of variability, it is considered that, the rainfall is highly dependable [25][26]. It was observed that all the stations are above 20% CV value and nearer to threshold limit (< 25%). But, there are within threshold limit (25%) for annual rainfall is concerned. So, annual rainfall is not much erratic and within 25% variation from mean annual rainfall over various stations of North Eastern dry zone of Karnataka.

The mean annual rainfall over different stations of North Eastern dry zone of Karnataka varied between 630.1 mm (Devadurga) to 744.3 mm (Sedam). The coefficient of variation (CV) of annual rainfall varied between 21.3% (Sedam) to 23.9% (Manvi). Since, CV is within threshold limits (<25%) for annual rainfall, it can be considered as highly dependable rainfall over mean annual rainfall across various stations of North Eastern dry zone of Karnataka. The skewness of annual rainfall was observed to be comparatively less and varied between 0.2 to 0.6. The positive skewness was observed over various stations[27].

3.1.2. Trend of annual rainfall

Computation of trend values provides with a tool to ascertain, if a locality is getting drier or wetter. In case the rainfall series show a positive trend, the area would be considered to be getting wetter year-by-year. If it is negative, they would imply possible approach of drier conditions [21]. The trend analysis of annual rainfall over various stations of North Eastern dry zone Karnataka are presented in figure 2-9.

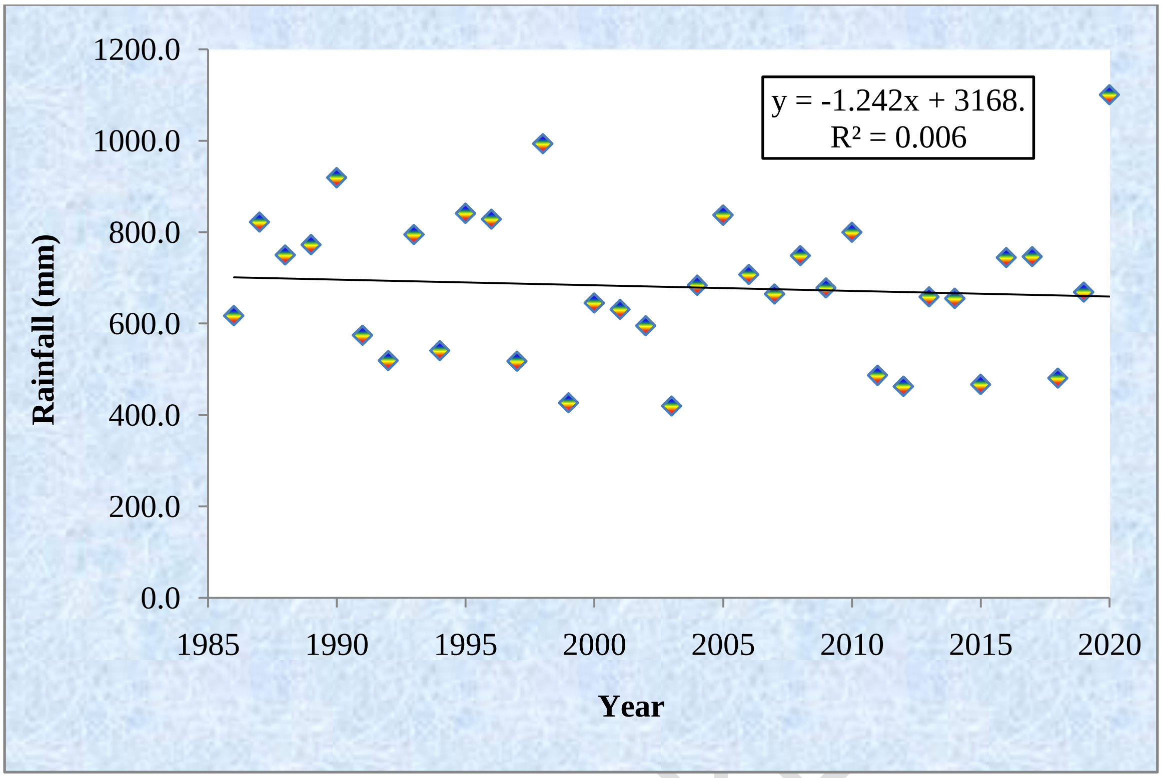

Fig 2:Trend analysis of annual rainfall over Afzalpur

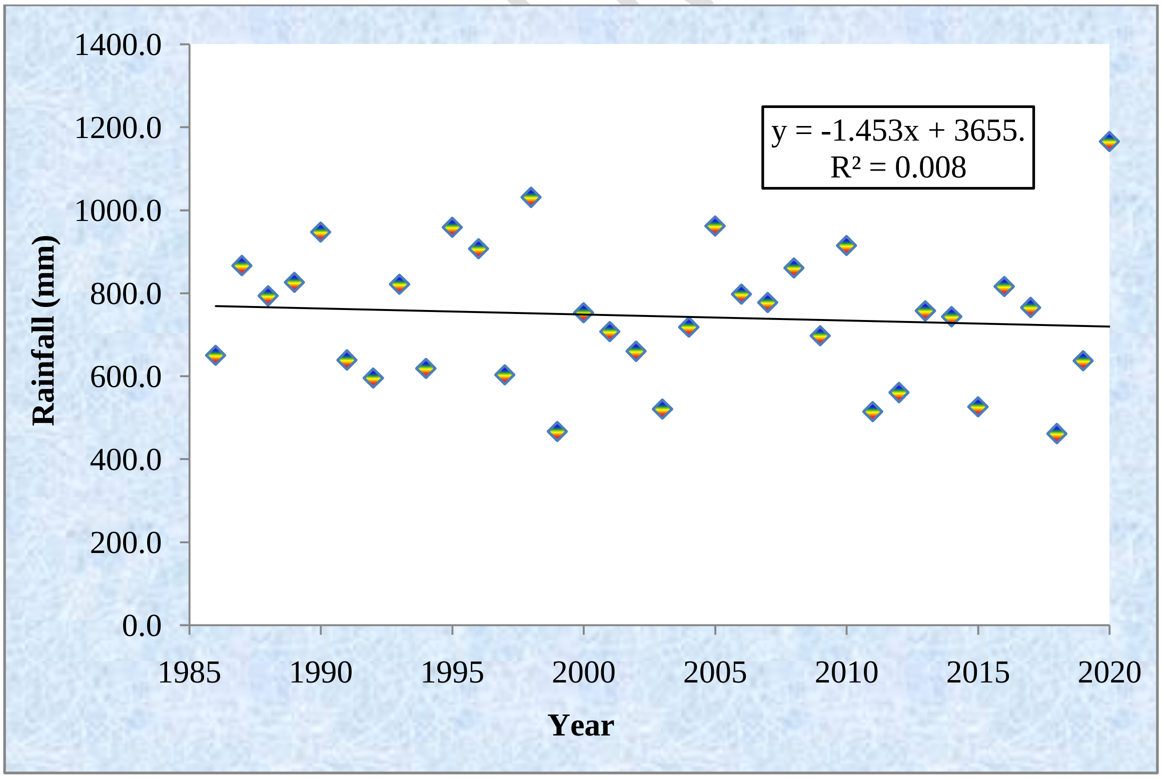

Fig 3:Trend analysis of annual rainfall over Kalaburgi

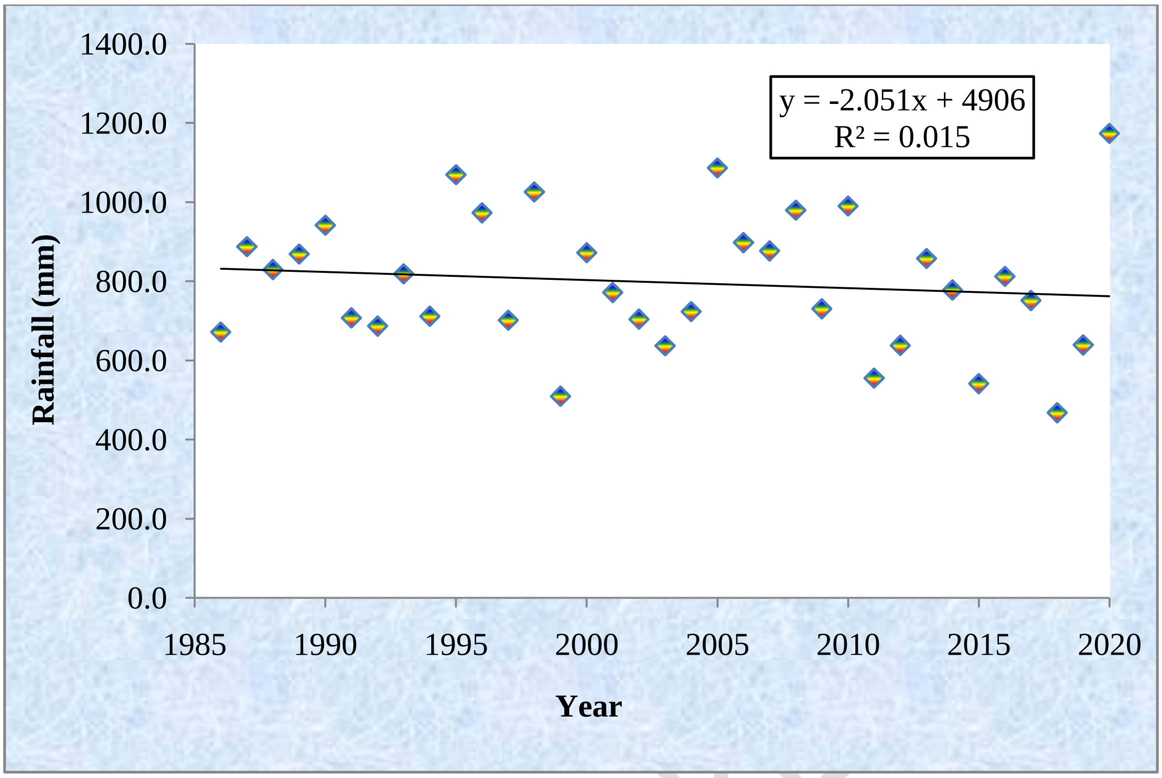

Fig 4: Trend analysis of annual rainfall over Sedam

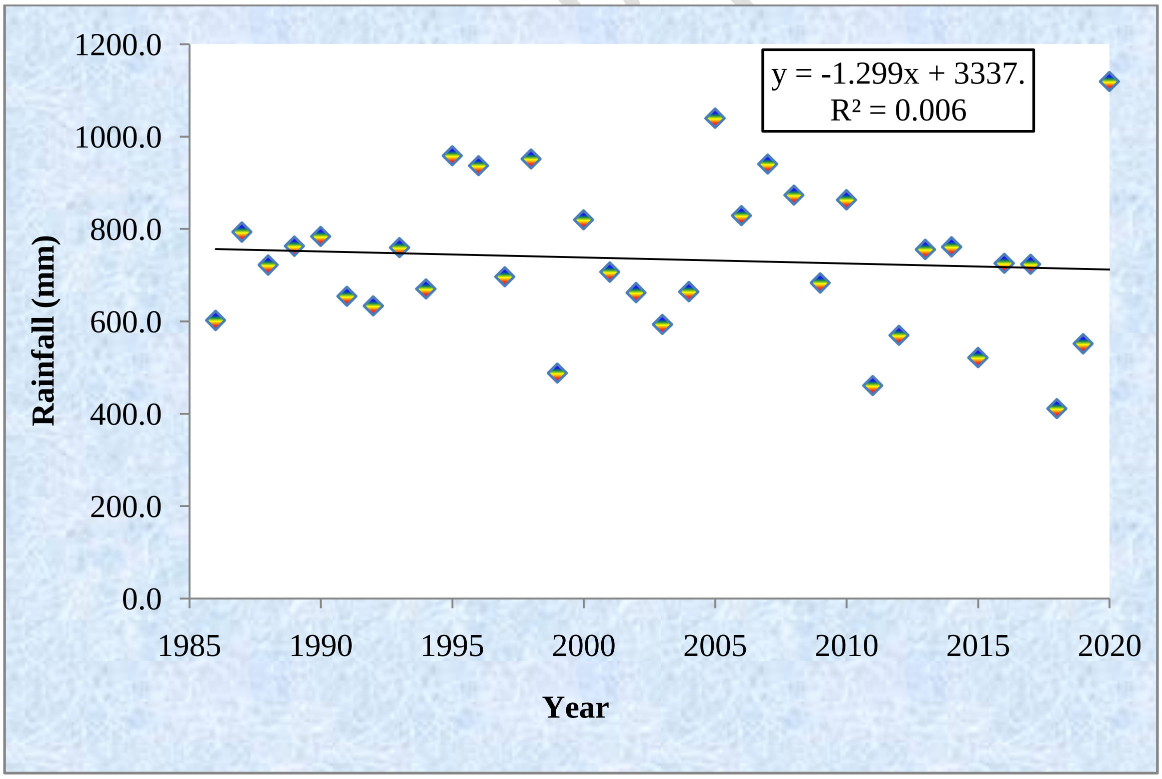

Fig 5: Trend analysis of annual rainfall over Yadgir

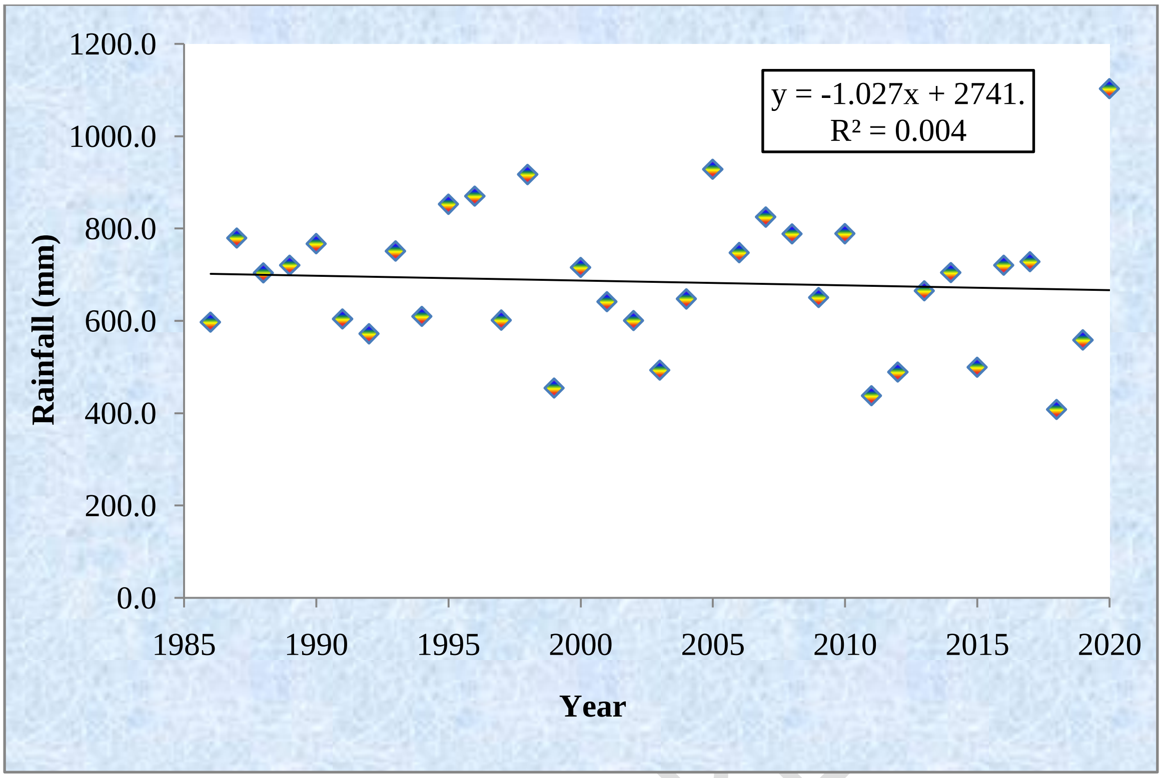

Fig 6: Trend analysis of annual rainfall over Shorapur

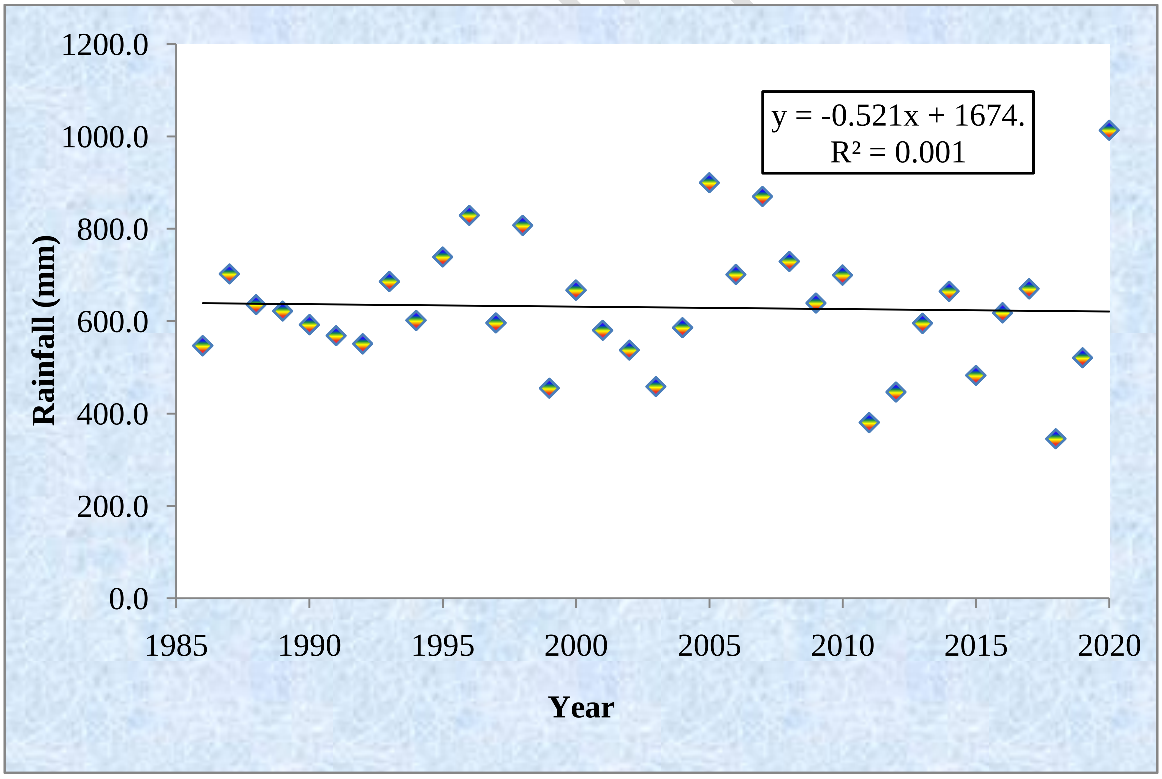

Fig 7: Trend analysis of annual rainfall over Devadurga

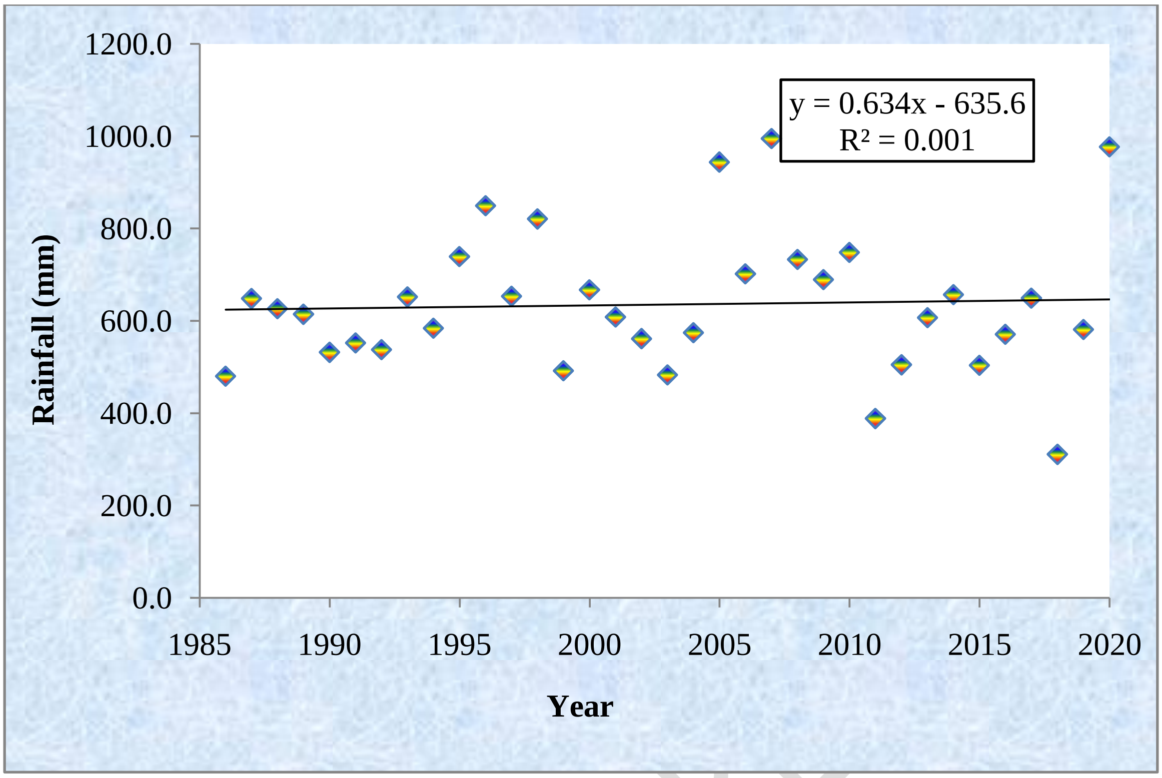

Fig 8: Trend analysis of annual rainfall over Manvi

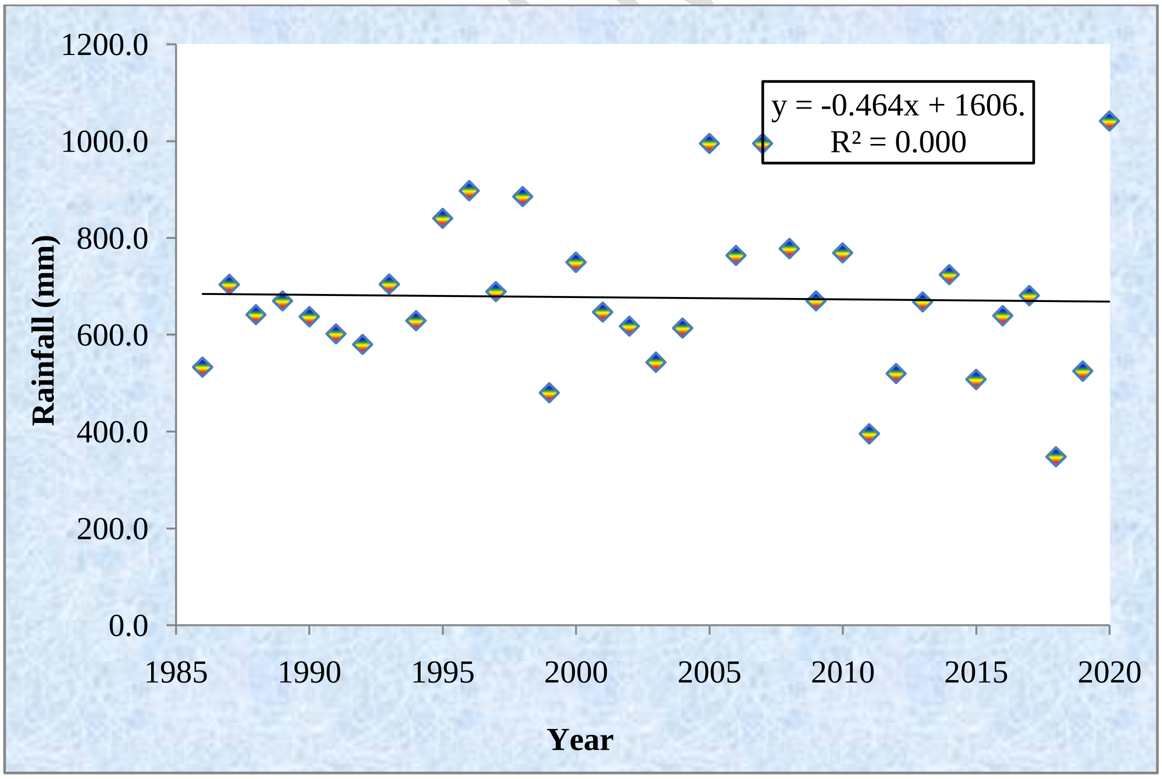

Fig 9: Trend analysis of annual rainfall over Raichur

The trend of annual rainfall was found to be non-significant for all stations (< 0.1 = 10% variation). From regression analysis, it was found that, the slopes of regression line of annual rainfall were observed to be positive slopes for seven stations and only one station (Manvi) showed negative slope. But the slopes are not significant for all the locations indicating there is no significant increase or decreasing trend of annual rainfall. The correlation coefficient values (R^2) of developed regression equations were found to be very low (< 0.1) and were found to be non significant over all the stations.

3.1.3. Analysis of seasonal rainfall

The seasonal rainfall (*Kharif* – 23^{rd} to 39^{th} SMW; *Rabi* – 40^{th} to 08^{th} SMW and Summer – 09^{th} to 22^{nd} SMW) analysis was carried out at various stations to know the contribution of seasonal rainfall towards the mean annual rainfall. The results are presented in Fig.10-17.

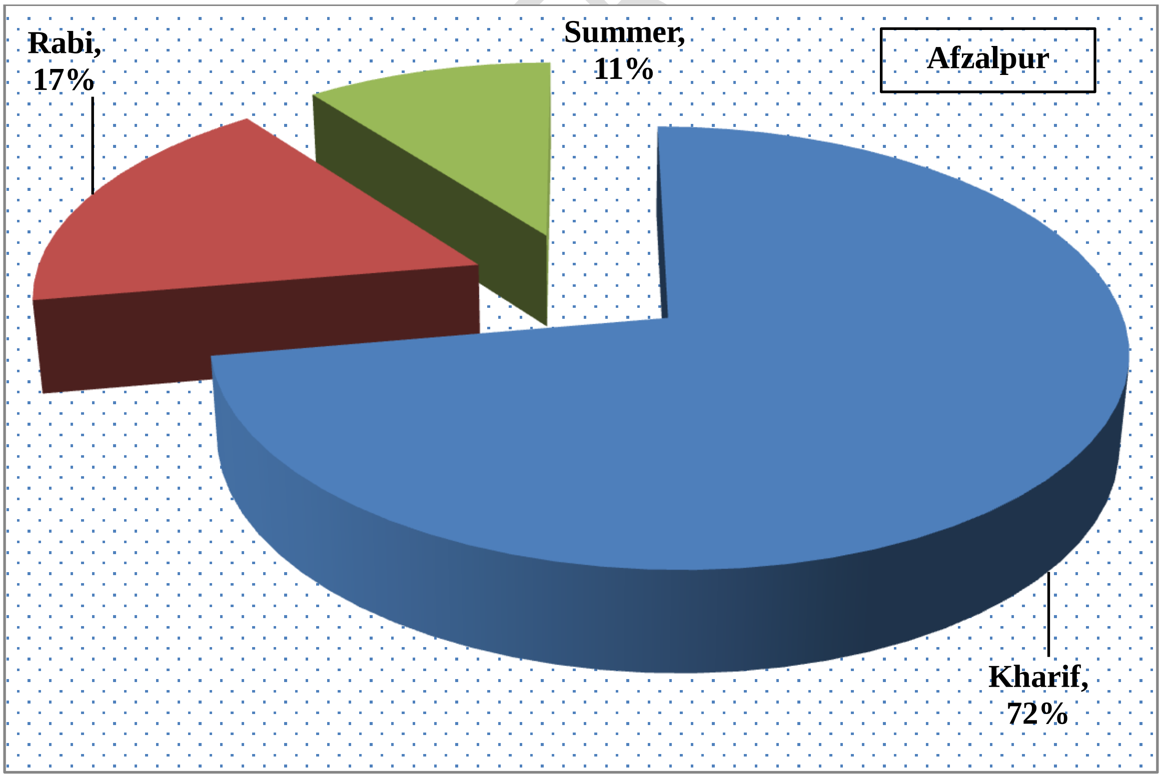

Fig 10: Seasonal distibution of rainfall over Afzalpur

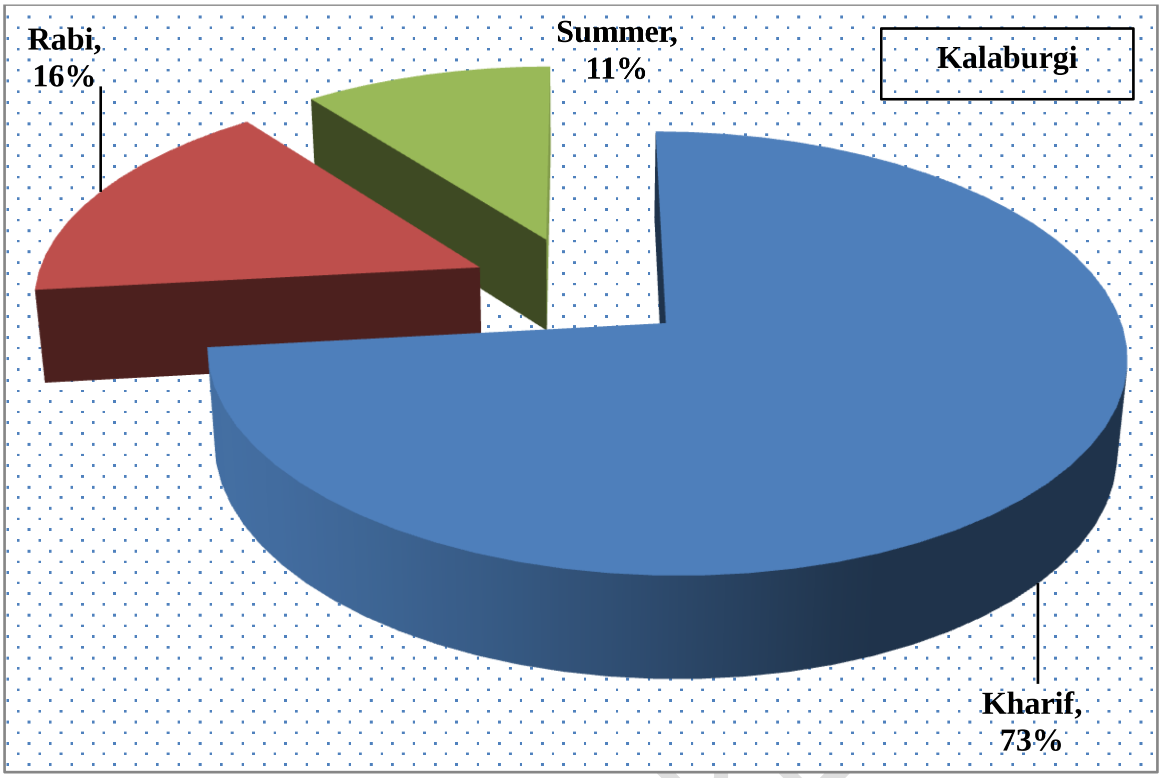

Fig 11: Seasonal distibution of rainfall over Kalaburgi

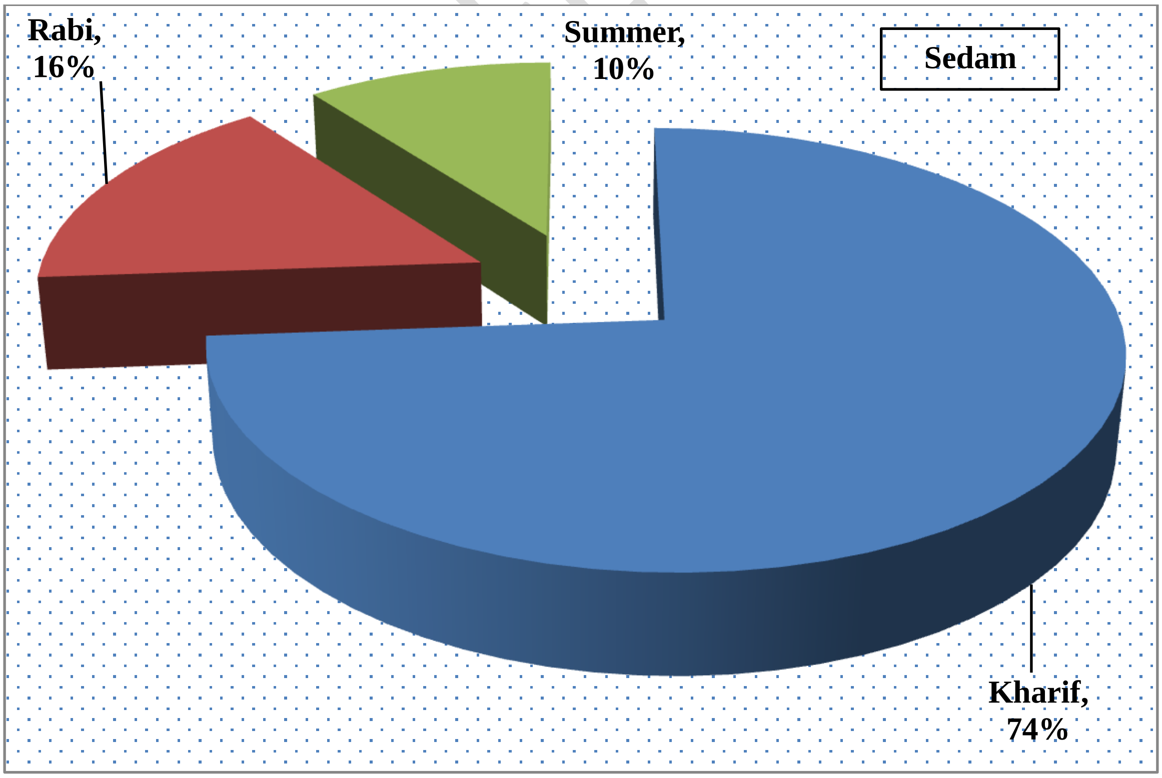

Fig 12: Seasonal distibtion of rainfall over Sedam

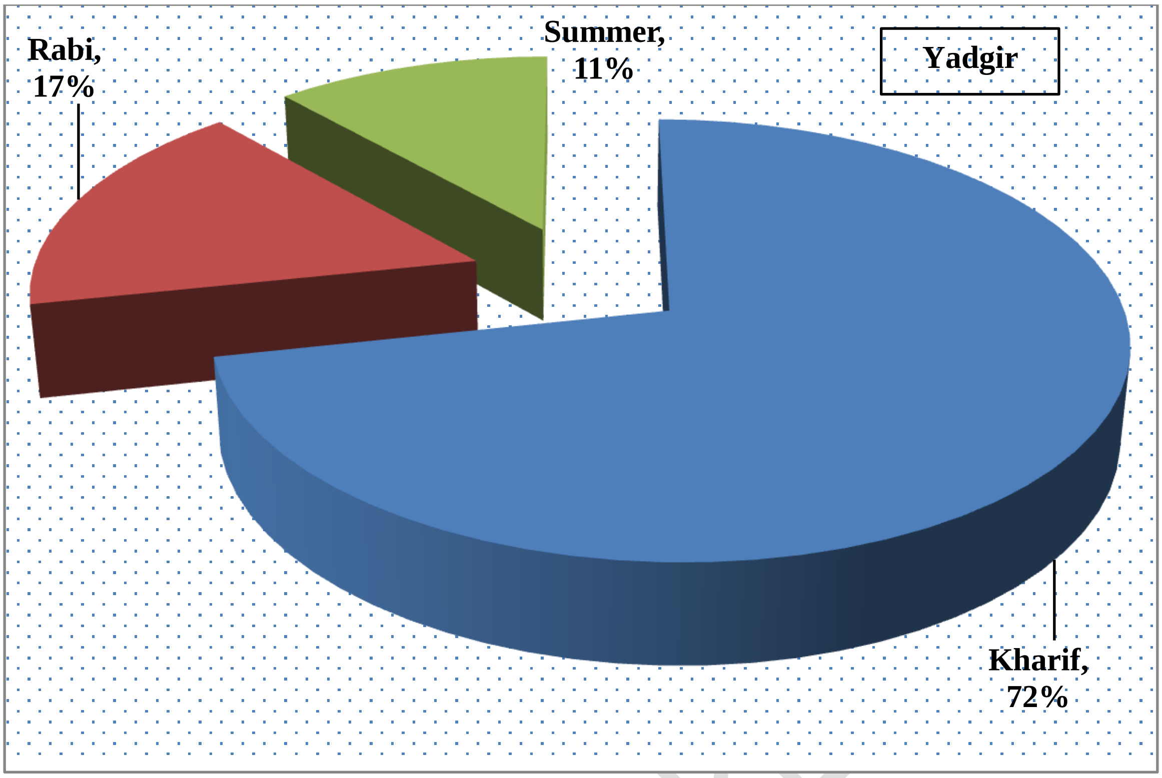

Fig 13: Seasonal distibtion of rainfall over Yadgir

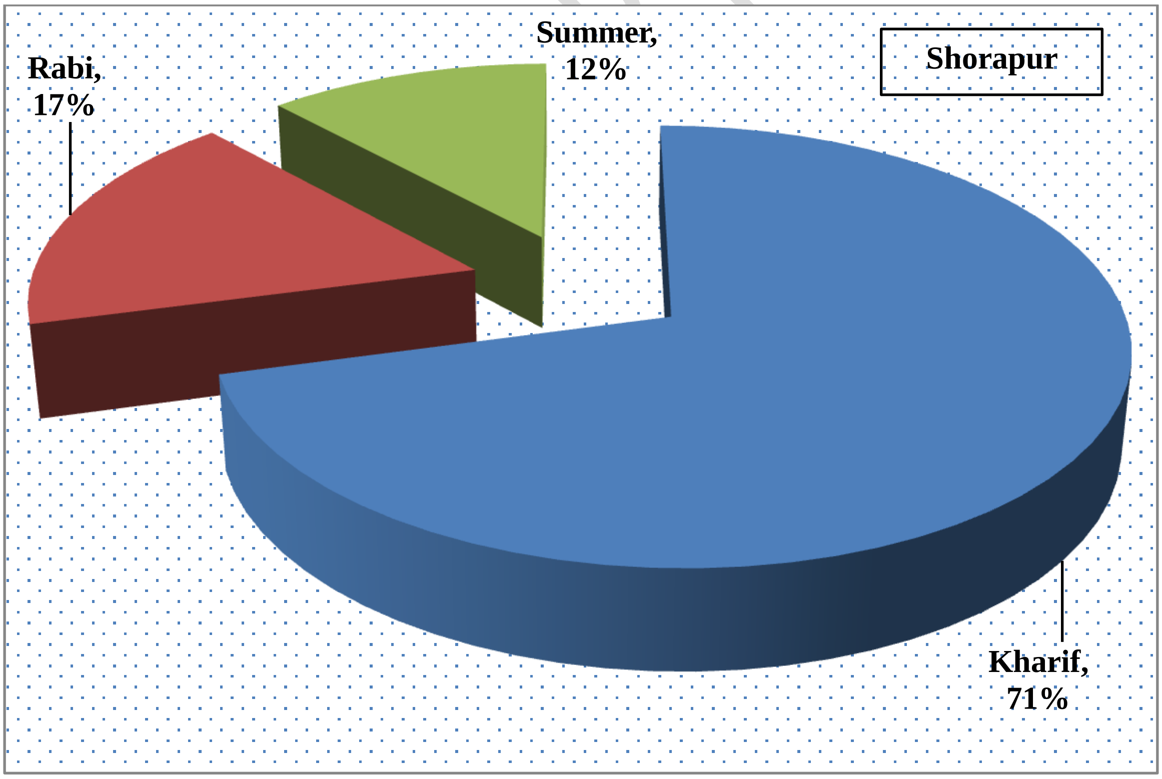

Fig 14: Seasonal distibtion of rainfall over Shorapur

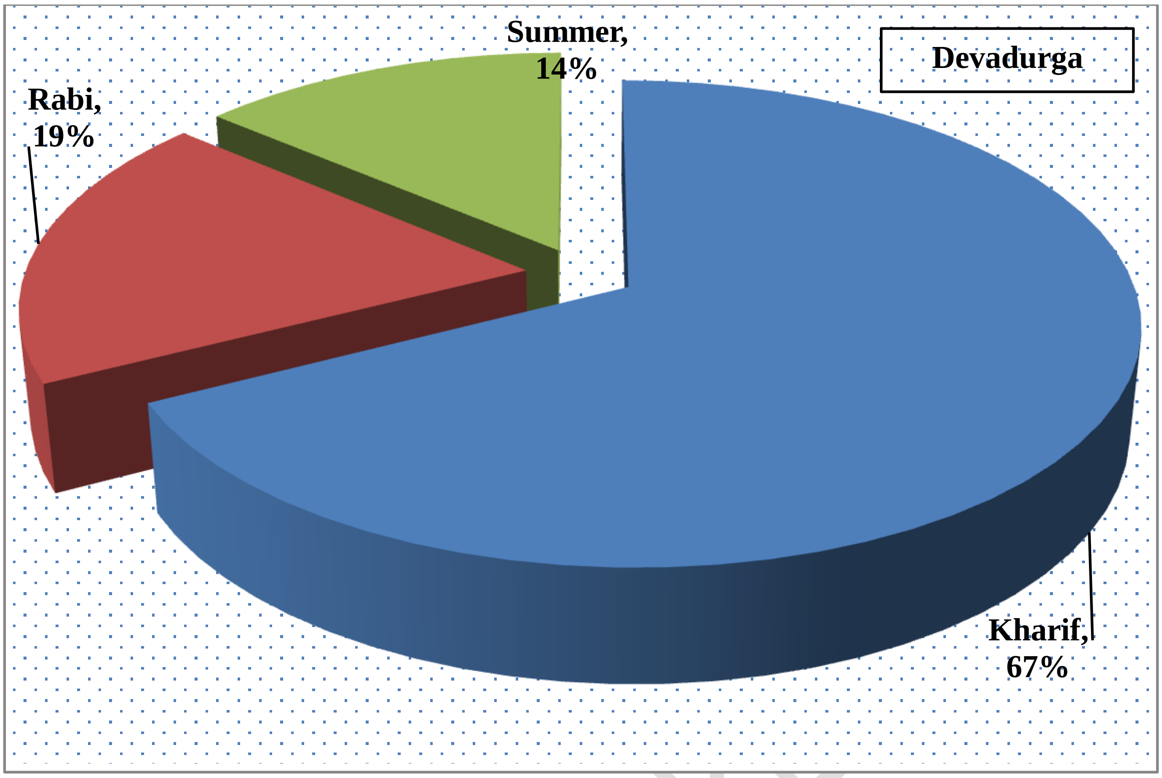

Fig 15: Seasonal distibtion of rainfall over Devadurga

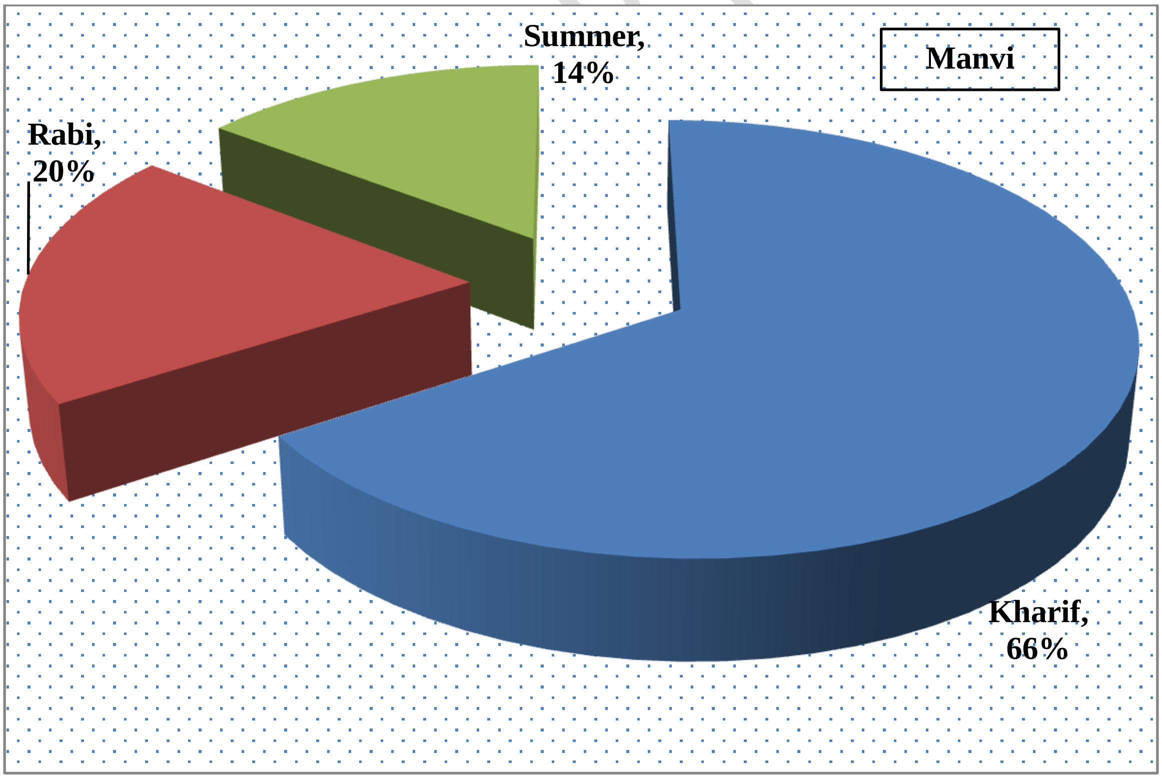

Fig 16: Seasonal distibtion of rainfall over Manvi

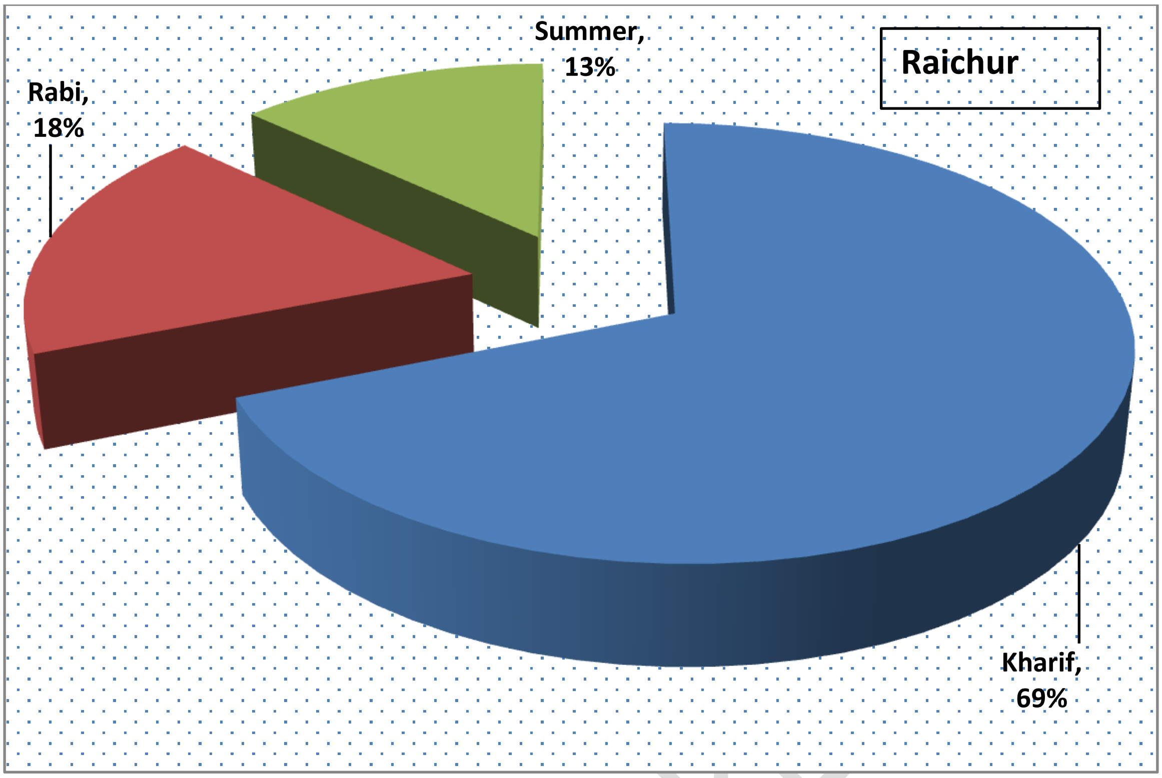

Fig17: Seasonal distibtion of rainfall over Raichur

The results revealed that, the contribution of *kharif* season (23rd to 39th SMW) rainfall varied from 66% (Manvi) to 74 % (Sedam). The *rabi* season (40th to 08th SMW) rainfall contribution varied from 16% (Sedam and Kalaburgi) to 20% (Manvi). The summer rainfall which includes free monsoon season contributed >10% of mean annual rainfall over all stations. The summer rainfall contribution varied from 10% (Sedam) to 14% (Manvi and Devadurga).

The percentage of seasonal rainfall contribution towards annual rainfall varied between 66-74%, 16-20% and 10-14% for *kharif*, *rabi* and summer seasons respectively over various stations of North Eastern dry zone of Karnataka. The mean, maximum, minimum, SD,CV and skewness analysis of *kharif*, *rabi* and summer season are presented in table 4,5 and 6 respectively. From *kharif* season(Table 4)rainfall analysis, it revealed that the mean *kharif* season rainfall varied from 418.4 mm (Manvi) to 588.7 mm (Sedam). The CV for *kharif* season was found to be within threshold limit (<50%) for all the eight stations over North Eastern dry zone of Karnataka[1], [10], [11], [19]. The skewness varied from 0.1 (Afzalpur, Kalaburgi and Manvi) to 1.0 (Manvi). All the stations showed positive skewness.

Table 4: *Kharif*seasonal(23 – 39thSMW) rainfall parameters over North Eastern dry zone of Karnataka

Station	Mean (mm)	Max (mm)	Min (mm)	SD (mm)	CV (%)	Skewness
Afzalpur	491.6	765.9	268.9	138.1	28.1	0.1
Kalaburgi	545.4	840.5	319.1	141.5	26.0	0.1
Sedam	588.7	863.7	353.5	140.2	23.8	0.1
Yadgir	526.6	840.3	310.7	137.1	26.0	0.5
Shorapur	485.0	791.8	287.4	130.4	26.9	0.4
Devadurga	425.3	744.0	233.1	123.6	29.1	0.7
Manvi	418.4	820.7	225.8	132.4	31.6	1.0
Raichur	466.8	860.2	262.4	137.1	29.4	0.8

Table 5: *Rabi* seasonal (40 – 8thSMW) rainfall parameters over North Eastern dry zone of Karnataka

Station	Mean (mm)	Max (mm)	Min (mm)	SD (mm)	CV (%)	Skewness
Afzalpur	118.1	273.4	17.3	65.0	55.0	0.7
Kalaburgi	121.4	301.7	22.1	67.8	55.8	0.9
Sedam	126.0	326.3	28.0	73.4	58.2	1.0
Yadgir	123.1	315.5	28.1	70.0	56.8	0.9
Shorapur	118.3	289.5	27.7	63.2	53.4	0.7
Devadurga	117.8	278.3	24.5	59.5	50.5	0.6
Manvi	124.4	287.5	23.8	62.5	50.3	0.6
Raichur	121.7	301.2	25.1	66.1	54.3	0.8

Table 6: Summerseasonal (9 – 22nd SMW) rainfall parameters over North Eastern dry zone of Karnataka

Station	Mean (mm)	Max (mm)	Min (mm)	SD (mm)	CV (%)	Skewness
Afzalpur	70.5	144.2	8.6	33.0	46.8	0.5
Kalaburgi	77.6	158.9	8.0	37.4	48.2	0.7
Sedam	82.4	178.2	8.6	42.6	51.7	0.8
Yadgir	84.9	187.5	7.5	42.2	49.7	0.8
Shorapur	81.1	170.8	8.9	37.7	46.5	0.8
Devadurga	87.0	202.7	9.6	39.7	45.6	1.0
Manvi	92.7	219.9	5.2	45.4	48.9	1.0
Raichur	88.3	204.9	6.1	43.4	49.2	0.9

The mean rainfall during *rabi*season (Table 5) varied from 117.8 mm (Devadurga) to 126.0 mm (Sedam). The CV during *rabi* season was observed to be more than threshold limit (> 50%) for seasonal rainfall,for all the stations. The skewness ranged from 0.6 to 1.0 which showed positive skewness at all stations. Interestingly, during *rabi* season, it was observed that, the lowest skewness (0.6) was observed at lowest rainfall receiving stations (Devadurga and Manvi) and the highest skewness (1.0) was observed at highest rainfall receiving station (Sedam). Whereas, it was *vice-versa* in case *kharif* season rainfall[14], [15]. The mean rainfall during summer season (Table 6) varied from 70.5 mm (Afzalpur) to 92.7 mm (Manvi). The CV during summer season was observed to be within threshold limits (< 50%) for all the stations except Sedam. The skewness ranged from 0.5 (Afzalpur) to 1.0 (Devadurga and Manvi).

3.1.4. Monthly rainfall analysis

The statistical analysis of monthly rainfall was carried out and presented in tables1-8 of APPENDIX - I. The statistical parameters like mean, maximum, minimum, standard deviation, CV and Skewness are presented. It is revealed that, during rainy season months (June to September – South West monsoon and October to November – North East monsoon), the mean monthly rainfall varied from 78.7 mm (Manvi) to 113.2 mm (Sedam) in June month; 100.3 mm (Manvi) to 154.5 mm(Sedam) in July month; 113.7 mm (Manvi) to 175.7 mm (Sedam) in August month; 128.9 mm (Devadurga) to 153.4 mm (Kalaburgi) in September month; 84.8 mm (Devadurga) to 90.5 mm (Sedam) in October month and 18.0 mm (Afzalpur) to 24.3 mm (Manvi) in November months respectively[19], [28], [29].

From tables, it was observed that, the CV was found to be within the threshold limit (<100%) for June to September months (South-West monsoon period) for all the stations. During North-East monsoon period, the CV was observed to bewithin threshold limits (< 100%) for all the stations for October month and it exceeded threshold limits (>100%) for all the stations during November months which hints that, the mean rainfall during November month is not much reliable. Interestingly, April and May months, CV was also observed to be within threshold limits (< 100%) for all the stations, which is an indication that, there is more certaintyof getting rainfall (near to mean) during April and May months also. The skewness was found to be positively skewed for all the months at all stations. In case of positively skewed series, mean > median > mode. The skewness was observed to be more skewed (> 3.0) for most of the stations during March month except Afzalpur (which was 2.8 of course near to 3.0). The skewness was observed to be more (> 3.0) during January and December months at Afzalpur and Raichur regions respectively.

3.1.5. Weekly rainfall analysis

The weekly rainfall data for all 52 standard meteorological weekswere analyzed to compute mean, maximum, minimum, SD, CV and skewness. Since CV gives an idea of variation of rainfall amount about its mean, the adequacy of the measure depends upon the use to which it is put. For modern agriculture, information on climatic features is required for a shorter period. Annual rainfall only indicates trends of certain climatic patterns, which may be useful to indicate agro-climatic homogeneous zones, but it does not give any picture as to the erratic behaviour of rainfall during the growing season, particularly in the different phenological stages of crop growth. Even the use of monthly rainfall data suffers from many shortcomings. Therefore, in this study weekly rainfall pattern is considered. The various weekly rainfall parameters are presented in tables 1-8 of APPENDIX - II. The results revealed that, the mean weakly rainfall during kharif season (23 to 39thSMW) varied from 14.8 mm(26thSMW) at Manvi to 42.4 mm(30thSMW) at Sedamregion respectively.

Analysis of weekly rainfall revealed that, during kharif season (23 to 39th SWM), the mean weekly rainfall was found to be more than 20mm in the all the weeks except25-27th SMW and 31st SMW at Manvi; 25-27th SMW at Devadurga and 26th SMW at Raichur regions respectively. The CV of weekly rainfall was critically analyzed and it was observed that, during kharif season (23 to 39th SWM), the mean weekly rainfall CV was found to be within threshold limits (< 150% for weekly rainfall) over all stations except during 25th SMW at Manvi and Raichur regions respectively. The CV within the threshold limit(<150%) for weekly rainfall gives us an idea about high dependable rainfall amounts during particular weeks. The skewness analysis revealed that, all the stations have positive skewness during all standard meteorological weeks in a year. However, few weeks at various stations showed more skewness (>3.0) indicating variations in rainfall distribution pattern. Other than kharif season (23-39thSMW), the detail description about various statistical parameters during various other standard meteorological weeks are also presented in the tables which shows erratic rainfall over the various stations of North-Eastern dry zone of Karnataka.

4. CONCLUSION

The precise knowledge on the rainfall characteristics and its distribution is very much essential for planning agricultural operations in dryland agriculture. Since, the primary source of water for dryland agriculture is rainfall, the rainfall amount and its distribution influences greatly on growth and development of a crop. Knowing the importance of rainfall analysis on regional basis, the study has been undertaken to analyze the rainfall pattern over North-Eastern dry zone of Karnataka. For this purpose, the daily rainfall data for a period of 35 years (1986-2020) was collected and used in the present study. The eight stations (Afzalpur, Kalaburgi, Sedam, Yadgir, Shorapur, Devadurga, Manvi and Raichur) spatially spread over entire North-Eastern dry zone of Karnataka are considered in the present study. The rainfall data were statistically analyzed based on annual, seasonal, monthly and weekly basis. The drought characterization has been carried out and dry and wet weeks probabilities were worked out to know the distribution of dry and wet spells over entire study area.

References

[1] U. K. Shanwad, I. Shankergoud, B. S. Janagoudar, A. G. Srinivas, and V. BIRADAR, “Influence of seasonal and annual rainfall variability on crop planning in north eastern dry zone (Zone-2) of Hyderabad Karnataka Region,” *Karnataka J. Agric. Sci*, vol. 28, no. 5, pp. 768–770, 2015.

[2] S. Jangra and M. Singh, “Analysis of rainfall and temperatures for climatic trend in Kullu valley,” *Mausam*, vol. 62, no. 1, pp. 77–84, 2011.

[3] J. K. Neelakanth, D. Tamilmani, I. Muthuchamy, and P. Balakrishnan, “Characterization of Agricultural Drought in Koppal District of Northeastern Parts of Karnataka, India,” *Clim. Chang. Impacts Water Resour. Syst.*, p. 50, 2015.

[4] S. U. Rani, N. P. Singh, P. Kumar, R. N. Padaria, and R. K. Paul, “Trend Analysis of Temperature and Rainfall across Agro Climatic Zones of Karnataka-A Semi Arid State in India,” 2022.

[5] L. Huggi, H. S. Shivaramu, M. H. Manjunataha, D. V Soumya, P. V. Kumar, and M. M. Lunagaria, “Agro-climatic onset of cropping season: A tool for determining optimum date of sowing in dry zones of southern Karnataka,” *J. Agrometeorol.*, vol. 22, no. 3, pp. 240–249, 2020.

[6] M. J. Madolli, P. S. Kanannavar, and R. Yaligar, “Spatial and Temporal Analysis

of Precipitation for the State of Karnataka, India," *Int. J. Agric. Sci. Res.*, vol. 5, no. 1, pp. 93–98, 2015.

[7] G. Mohapatra, V. Rakesh, S. Purwar, and A. P. Dimri, "Spatio-temporal rainfall variability over different meteorological subdivisions in India: analysis using different machine learning techniques," *Theor. Appl. Climatol.*, vol. 145, no. 1–2, pp. 673–686, 2021.

[8] R. H. Kripalani, A. Kulkarni, S. S. Sabade, and M. L. Khandekar, "Indian monsoon variability in a global warming scenario," *Nat. hazards*, vol. 29, pp. 189–206, 2003.

[9] R. P. Samui, R. Balasubramanian, and M. V Kamble, "Northeast monsoon rainfall and agricultural production in Tamil Nadu and Andhra Pradesh: II-Dry and wet spell and its impact on cropping pattern," *MAUSAM*, vol. 64, no. 3, pp. 489–500, 2013.

[10] J. SARKAR, K. Seetharam, and S. K. Shaha, "Climatology of dry and wet spell over Vidarbha region during monsoon months," *MAUSAM*, vol. 52, no. 2, pp. 365–370, 2001.

[11] H. C. Sharma, H. S. Chauhan, and S. Ram, "Probability analysis of rainfall for crop planning [India].," *J. Agric. Eng.*, 1979.

[12] M. L. Khichar, R. Niwas, and S. Pal, "Markov chain model for use in analysis of south west monsoon rainfall of arid zone in Haryana," *J. Appl. Hydrol.*, vol. 8, no. 3/4, pp. 60–65, 2000.

[13] S. Pradhan, V. K. Sehgal, D. K. Das, and R. Singh, "Analysis of meteorological drought at New Delhi using SPI," 2011.

[14] N. Kumar and J. G. Patel, "Analysis of regional droughts intensity and frequency over north Gujarat," *J. Agrometeorol.*, vol. 14, no. 1, pp. 95–96, 2012.

[15] D. Jhajharia, S. K. Shrivastava, P. S. Tulla, and R. Sen, "Rainfall analysis for drought proneness at Guwahati," *Indian J Soil Conser*, vol. 35, no. 2, pp. 163–165, 2007.

[16] M. Sagar, G. S. Mahadevaiah, S. Bhat, and H. V Kumar, "Rainfall variability and its influence on agricultural GDP in central dry zone of Karnataka: An econometric analysis," *Econ. Aff.*, vol. 63, no. 2, pp. 527–531, 2018.

[17] K. J. B. Siddharam, D. Basavaraja, M. Nemichandrappa, and A. T. Dandekar, "Assessment of long term Spatio-temporal variability and Standardized Anomaly Index of rainfall of Northeastern region, Karnataka, India," *Clim. Chang.*, vol. 6, no. 21, pp. 1–11, 2020.

[18] A. A. Haris and V. Chhabra, "Rainfall and temperature trends at three

representative agroecological zones of Bihar," *J. Agrometeorol.*, vol. 12, no. 1, pp. 37–39, 2010.

[19] R. Chand, U. P. Singh, Y. P. Singh, and P. A. Kore, "Analysis of weekly rainfall of different period during rainy season over Safdarjung airport of Delhi for 20th century–A study on trend, decile and decadal analysis," *Mausam*, vol. 62, no. 2, pp. 197–204, 2011.

[20] D. Barman, A. R. Saha, D. K. Kundu, and B. S. Mahapatra, "Rainfall characteristics analysis for jute based cropping system at Barrackpore, West Bengal, India," 2012.

[21] B. LAL and B. Lakshmanaswamy, "Does precipitation pattern foretell climatic shift over Punjab state?," *MAUSAM*, vol. 46, no. 3, pp. 325–332, 1995.

[22] P. G. Gore and K. C. S. RAY, "Droughts and aridity over districts of Gujarat," *J. Agrometeorol.*, vol. 4, no. 1, pp. 75–85, 2002.

[23] M. P. Akhtar, F. A. Faroque, L. B. Roy, M. Rizwanullah, and M. Didwania, "Computational Analysis for Rainfall Characterization and Drought Vulnerability in Peninsular India," *Math. Probl. Eng.*, vol. 2021, 2021, doi: 10.1155/2021/5572650.

[24] S. Ujwala Rani, N. P Singh, K. Pramod, R. Nath Padaria, and R. Kumar Paul, "Trend Analysis of Temperature and Rainfall across Agro Climatic Zones of Karnataka-A Semi Arid State in India," 2021.

[25] D. Sharma and V. Kumar, "Prediction of onset and withdrawal of effective monsoon dates and subsequent dry spells in an arid region of Rajasthan," *Indian J. Soil Cons*, vol. 31, no. 3, pp. 223–228, 2003.

[26] B. Geetha and Y. E. A. Raj, "A 140 year data archive of dates of onset and withdrawal of northeast monsoon over coastal Tamil Nadu: 1871-2010 (Re-determination for 1901-2000)," *Mausam*, vol. 66, no. 1, pp. 7–18, 2015.

[27] A. G. Dastidar, S. Ghosh, U. K. De, and S. K. Ghosh, "Statistical analysis of monsoon rainfall distribution over West Bengal, India," *Mausam*, vol. 61, no. 4, pp. 487–498, 2010.

[28] A. J. Dixit, S. T. Yadav, and K. D. Kokate, "The variabi1ity of rainfall in Konkan region," *J. Agrometeorol.*, vol. 7, no. 2, pp. 322–324, 2005.

[29] S. Bemal, D. Singh, and S. Singh, "Rainfall variability analysis over eastern agroclimatic zone of Haryana," *J. Agrometeorol.*, vol. 14, no. 1, pp. 88–90, 2012.