Mysore J. Agric. Sci., 50 (3) : 535-540, 2016

Study of Variations in Annual Rainfall Across Rain Gauge Stations in Mandya District

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Abstract

A study of variation in annual rainfall (mm) across different rain gauge stations (RGS) located in Mandya district was considered for a period of 50 years from 1964 – 2013. The results revealed that the central part of Mandya district covering most of the RGS stations coming under Nagamangala, Mandya and Pandavapura taluks received below average (<700 mm) rainfall, whereas, RGS stations located in Maddur and Malavalli taluks towards east as well as K.R Pet and Srirangapatna taluk towards western parts of Mandya district received above average (>700 mm) rainfall during the study period. The significance of trend assessed by Mann-Kendall test revealed that only five RGS stations *viz.,* Seelunere, Halagur, Lingarajachatra, Honakere and Melkote had significant linear trend. Further, Seelunere and Halagur showed decreasing trend, while, Lingarajachatra, Honakere and Melkote showed an increasing trend in annual rainfall over the years.

Rain is an important natural phenomenon which can influence the human life. There are many factors which influence the rainfall, such as geographical position, monsoon, topography and other factors. These factors could collaborate in complex manner to contribute the rainfall.

India's climate is dominated by monsoons. Monsoon is a term derived from the Arabic word "Mausim", meaning season. It was used to describe the seasonal winds of Arabian Sea. The winds blow from the North-east for one half of the year and from the South-west for the other half of the year. North-east monsoon is the main period of rainfall activity over south peninsular India, particularly in the eastern half comprising of subdivisions of Coastal Andhra Pradesh, Rayalaseema, Tamil Nadu and Pondicherry. For Tamil Nadu, North-east monsoon is the main rainy season accounting for about 48 per cent of the annual rainfall. Coastal district gets the annual rainfall of about 60 per cent and the interior district get annual rainfall of about 40-50 per cent. Though South-west monsoon is the main rainy season for interior Karnataka, Kerala and Lakshadweep, rainfall continues till December in these sub divisions. The period October – December (North-east Monsoon) contributes about 20 per cent of annual total rainfall.

The Karnataka state is located within 74^0 East and 78^0 30' East longitude and $11^0$30' North and 18^0 30' North latitudes. It extends to about 400 km from east to west and about 750 km from north to south. It has a vivid agro climatic condition. The agriculture in Karnataka is mainly dependent on rainfall and most of it is dependent on the South–west Monsoon. Only 26.5 per cent of sown area is subjected to irrigation and the rest of the cultivable land entirely depends on rainfall. The climate of Karnataka varies with the season. The winter season starts from January to February and is followed by summer season which starts in the month of March to till the end of May and the monsoon season starts in two phases South-west monsoon (June to September) and post monsoon (October to December) and the South-west monsoon brings major rainfall to Karnataka state.

There are many studies reported on variation in annual rainfall. Sen and Balling (2004) analyzed the daily rainfall data of 129 stations and found general increasing trend in a contiguous region extending from the North-western Himalayas and decreasing values in the eastern part of the Gangetic Plains and parts of Uttarakhand. Deka *et al.* (2008) used data from seven stations of the Brahmaputra Valley of Assam for evaluation of variability in rainfall and temperature regimes. Pal and Al-Tabbaa (2009) found that winter and post monsoon extreme rainfall having an increasing tendency and decreasing trends in spring seasonal extreme rainfall. Longobardi and Villani (2010) made an attempt to analyze time series data on rainfall over

a wide time interval and a wide area, detecting potential trends and assessing their significance. Abdulharis *et al.* (2010) investigated rainfall and temperature trends at four stations representing three agro-ecological zones of Bihar using 45 years data. Ranabir Singh *et al.* (2012) made a study on trends in climate variability over Himachal Pradesh during 1969-87. Amrutha and Shreedhar (2014) studied rainfall variability for Belgaum district. In the present study, the nature of variations in annual rainfall across rain gauge stations located in Mandya district were identified.

Material and Methods

Mandya district with a geographical area of 4.98,244 hectares lies in the southern part of Karnataka State between 76^0 19' and 77^0 20' East Longitude and 12^0 13' and 13^0 04' North Latitude as depicted. The population is about 19.25 lakhs. The district comprises seven taluks, thirty one Hoblis and 1,369 villages. The district is considered as one of the most agriculturally prosperous districts in the state. With the advent of irrigation from the K. R. Sagar reservoir (1930's), there was substantially marked transformation in cropping pattern, composition of crops, better grown yield level, ultimately leading to better economic conditions of the people. The total irrigated area is 1,16,901, ha, out of which, around 88,000 ha is being irrigated by K. R. Sagar and around 16,000 ha by Hemavathi reservoir. The rest of the land is irrigated by other sources like tanks, wells and bore wells. The major geographical area of Mandya district is covered by Cauvery basin and agriculture in the district is classified under agro- climatic zone 6, *i.e.,* Southern dry zone. The crop sowing periods are early kharif, late kharif and summer. The average annual rainfall was 700 mm. The district gets a bimodal distribution of rainfall. Generally, the first peak is during April, May and the second during September, October. The month of June is known for dry spell.Sub divisions of districts (talukas) are Mandya, Maddur, Malavalli, Srirangapatna, Pandavapura, K. R. Pet, and Nagamangala. In each of these seven taluks, thirty two rain gauge stations are located as noted below:

Krishnarajapet Taluk : Akkihebbal, Krishnarajpet, Kikkeri, Santebachahalli and Seelunare.

Maddur Taluk : Koppa, Kowdle (Bolare), Maddur and Kestur.

Malavalli Taluk: Halagur, Malavalli and Shiva samudra.

Mandya Taluk: V.C. farm, Basaralu, Lingarajachatra, Mandya taluk office, Mandya SF, Kottatti, Keragodu and Dudda.

Nagamangala Taluk: Bellur, Bindiganavile, Devalapura, Honakere and Nagamangala.

Pandavapura Taluk: Chinkurli, Pandavapura and Melkote.

Srirangapatna Taluk: Krishnarajasagar dam, Krishnarajasagar KERS, Srirangapatna and Arakere.

For the present study, daily rainfall data pertaining to 32 RGS stations covering all 7 taluks of Mandya district for a period of 50 years from 1964 to 2013 were considered.

The descriptive statistics on rainfall such as Maximum, Minimum, Mean, Standard Deviation, Coefficient of Variation and Skewness were computed to study the variation of rainfall across different RGS. The stations were classified according to below normal, normal and above normal rainfall. Further, the trend in rainfall pattern was assessed using Mann Kendall test.

Results and Discussion

Table I shows descriptive statistics of annual rainfall for different rain gauge stations located at Mandya district. The average annual rainfall was found to be maximum for Keragodu (793.5 mm) followed by Koppa station (777.4 mm), whereas, it was minimum for Devalapura (395.4 mm) followed by Honakere station (483.9 mm). The coefficient of variation in annual rainfall across stations ranged from 23.4 per cent (at Arakere station) to 47.8 per cent (at Devalapura station). Further, compared to other taluks of the district, Srirangapatna taluk had low coefficient of variation (Fig. 1).

Table II shows the level of annual rainfall across different RGS stations during the study period. The table reveals that Devalpura station had below normal (< 700mm) rainfall for maximum number of years (44 years) followed by Honkere station (35 years)

TABLE I

Descriptive statistics of annual rainfall (mm) for different RGS during the study period (1964 – 2013)

Taluk	Annual rainfall (mm)						
	Rain Gauge Stations	Min.	Max.	Mean	SD	CV (%)	Skewness
Krishnarajpet	Akkihebbal	152.2	1394.0	671.3	263.5	39.3	0.4
	Krishnarajpet	344.9	1069.7	729.2	200.4	27.9	- 0.03
	Kikkeri	109.3	1026.6	647.4	218.2	33.7	- 0.4
	Santebachahalli	265.2	1403.1	692.9	234.1	33.8	0.3
	Seelunare	265.2	1761.1	720.4	256.2	35.6	1.3
Maddur	Koppa	299.7	1767.2	777.4	296.5	38.1	1.4
	Kowdle (Bolare)	343.8	1474.6	740.9	235.3	31.8	0.8
	Maddur	387.2	1321.2	750.0	207.2	27.6	0.1
	Kestur	323.2	1761.1	743.9	241.2	32.4	1.5
Malavalli	Halagur	112.0	1427.6	710.4	243.7	34.3	- 0.07
	Malavalli	275.8	1216.2	699.5	220.5	31.5	0.5
	Shiva samudra	356.5	1326.7	726.5	190.7	26.2	0.5
Mandya	V C farm	298.5	1341.3	654.1	242.4	37.1	0.4
	Basaralu	134.4	1176.8	600.2	229.9	38.3	0.2
	Lingarajachatra	117.7	995.0	518.5	227.4	43.9	0.0
	Mandya taluk office	231.6	1541.3	693.1	233.7	33.7	0.9
	Mandya SF	227.0	1175.4	610.6	234.9	38.5	0.02
	Kottatti	212.0	1311.5	623.9	272.3	43.6	0.3
	Keragodu	378.0	1338.2	793.5	249.2	31.4	0.6
	Dudda	210.5	1045.9	589.3	200.5	34.0	0.3
Nagamangala	Bellur	169.8	1051.0	533.1	222.6	41.7	0.03
	Bindiganavile	115.4	993.2	554.5	214.1	38.6	- 0.05
	Devalapura	158.2	1171.0	395.4	189.1	47.8	1.5
	Honakere	162.9	885.0	483.9	176.2	36.4	0.1
	Nagamangala	284.3	1324.5	760.4	220.6	29.0	0.2
Pandavapura	Chinkurli	101.0	1051.2	541.1	244.3	45.1	0.1
	Melkote	253.0	1319.7	702.4	253.9	36.1	0.4
	Pandavapura	286.4	1235.2	686.4	224.2	32.7	0.2
Srirangapatna	Krishnarajsagar dam	266.6	1603.3	714.6	251.9	35.2	1.4
	Krishnarajsagar KERS	431.0	1316.0	734.9	202.8	27.6	0.8
	Srirangapatna	260.3	1019.0	646.5	170.5	26.4	- 0.3
	Arakere	439.8	1099.3	7 23.1	169.0	23.4	0.4

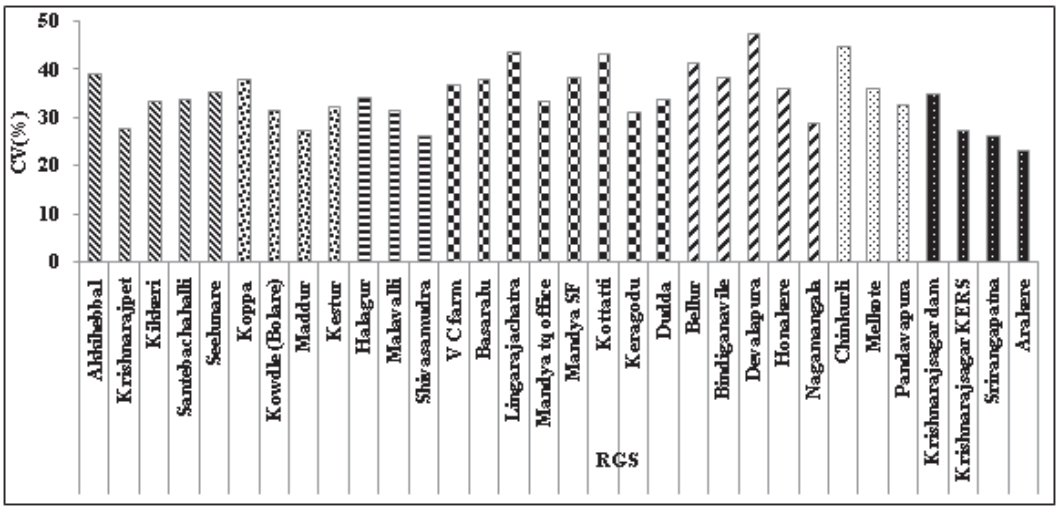

Fig.1: Coefficient of Variation in Annual Rainfall across RGS

TABLE II

Classification of rainfall in different rain gauge stations during the study period (1964-2013)

Taluk	Rain Gauge Stations	Level of Rainfall (Normal = 700mm)					
		Below normal < (Mean - SD)		Normal (Mean ± SD)		Above normal > (Mean + SD)	
		No. of years	Per cent	No. of years	Per cent	No. of years	Per cent
Krishnarajpet	Akkihebbal	18	36	16	32	16	32
	Krishnarajpet	13	26	16	32	21	42
	Kikkeri	17	34	18	36	15	30
	Santebachahalli	16	32	13	26	21	42
	Seelunare	12	24	19	38	19	38
Maddur	Koppa	8	16	19	38	23	46
	Kowdle (Bolare)	11	22	19	38	20	40
	Maddur	11	22	12	24	27	54
	Kestur	8	16	21	42	21	42
Malavalli	Halagur	8	16	23	46	19	38
	Malavalli	18	36	13	26	19	38
	Shivasamudra	9	18	20	40	21	42
Mandya	V C farm	20	40	18	36	12	24
	Basaralu	21	42	21	42	8	16
	Lingarajachatra	27	54	15	30	8	16
	Mandya taluk office	12	24	21	42	17	34
	Mandya SF	22	44	14	28	14	28
	Kottatti	20	40	16	32	14	28
	Keragodu	9	18	18	36	23	46
	Dudda	23	46	18	36	9	18
Nagamangala	Bellur	28	56	13	26	9	18
	Bindiganavile	26	52	16	32	8	16
	Devalapura	44	88	4	8	2	4
	Honakere	35	70	11	22	4	8
	Nagamangala	12	24	14	28	24	48
Pandavapura	Chinkurli	32	64	9	18	9	18
	Melkote	15	30	14	28	21	42
	Pandavapura	17	34	14	28	19	38
Srirangapatna	Krishnarajsagar dam	12	24	24	48	14	28
	Krishnarajsagar KERS	10	20	18	36	22	44
	Srirangapatna	14	28	22	44	14	28
	Arakere	9	18	21	42	20	40

whereas, Maddur station had above normal (> 700 mm) rainfall for maximum number of years (27 years) followed by Koppa and Keragodu stations (23 years). The Krishnarajsagar dam had normal rainfall for maximum number of years (24 years) followed by Srirangapatna station (22 years). The result further reveals that the annual rainfall varied over a wide range across different RGS stations. The stations coming under Nagamangala taluk had below normal rainfall as compared to other taluks of Mandya district. It is very clear from Table II that Devalpura and Honakere stations had below normal rainfall ie, 88 per cent and 70 per cent, respectively. The map showing the rainfall distribution across RGS of Mandya district is presented in Fig. 2.

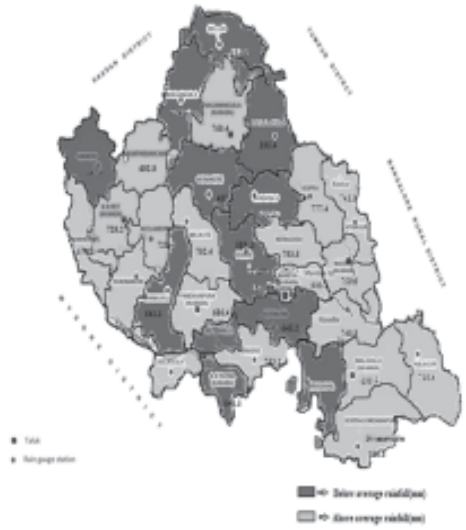

Fig. 2: Rainfall distribution at different RGS of Mandya district

The RGS stations like, Akkihebbal, Krishnarajpet, Santebachahalli, Seelunare, Koppa, Kowdle (Bolare), Maddur, Kestur, Halagur, Malavalli, Shivasamudra, Mandya taluk office, Keragodu, Nagamangala, Melkote, Pandavpura, Krishnarajsagar dam, Krishnarajsagar KERS and Arakere stations recorded above average annual rainfall, whereas, below average annual rainfall was found in stations like Kikkeri, V.C. farm, Basaralu, Lingarajachatra, Mandya SF, Kottati, Dudda, Bellur, Bindiganavile, Devalapura, Honakere, Chinkurli and Srirangapatna.

Majority of the RGS stations received normal rainfall during the study period except for Devalapura and Honakere stations belonging to Nagamangala taluk of Mandya north district which received below normal rainfall. However, Maddur station belonging to Maddur taluk had rainfall exceeding the normal limit.

Table III shows the linear trend analysis for the annual rainfall across different rain gauge stations for

TABLE III

Estimates of linear trend in annual rainfall across RGS of Mandya district

Taluk	Rain Gauge Stations	Intercept	Coefficient	F value	Mann-Kendall *t*	P value
Krishnarajpet	Akkihebbal	746.4	-2.94	1.31 NS	-0.089	0.366
	Krishnarajpet	673.7	2.17	1.23 NS	0.117	0.235
	Kikkeri	619.9	1.08	0.24 NS	0.007	0.935
	Santebachahalli	631.5	2.41	1.10 NS	0.066	0.503
	Seelunare	856.4	-5.34	4.87 *	-0.215	0.028
Maddur	Koppa	696.3	3.18	1.20 NS	0.259	0.118
	Kowdle (Bolare)	644.0	3.79	2.18 NS	0.117	0.235
	Maddur	708.8	1.61	0.62 NS	0.066	0.503
	Kestur	819.5	-2.96	1.59 NS	-0.073	0.277
Malavalli	Halagur	842.3	-5.04	5.22 *	-0.195	0.046
	Malavalli	738.8	-1.54	0.50 NS	-0.073	0.462
	Shivasamudra	642.9	3.27	3.21 NS	0.169	0.085
Mandya	V C farm	746.2	-3.17	2.10 NS	-0.153	0.120
	Basaralu	555.4	1.75	0.60 NS	0.081	0.412
	Lingarajachatra	343.5	6.86	11.51**	0.287	0.003
	Mandya tq office	727.5	-1.35	0.34 NS	-0.030	0.763
	Mandya SF	602.3	0.32	0.01 NS	-0.001	1.000
	Kottatti	706.7	-3.23	1.48 NS	-0.149	0.128
	Keragodu	847.2	-2.11	0.73 NS	-0.078	0.427
	Dudda	553.6	1.39	0.50 NS	0.123	0.210
Nagamangala	Bellur	473.4	3.08	2.38 NS	0.138	0.160
	Bindiganavile	481.5	2.86	1.89 NS	0.123	0.210
	Devalapura	425.0	-1.16	0.39 NS	-0.042	0.670
	Honakere	378.4	4.14	6.37 **	0.215	0.028
	Nagamangala	692.3	2.66	1.53 NS	0.136	0.165
Pandavapura	Chinkurli	573.5	-1.06	0.20 NS	-0.103	0.296
	Melkote	545.8	6.10	6.71**	0.233	0.018
	Pandavapura	639.6	1.83	0.69 NS	0.068	0.493
Srirangapatna	Krishnarajsagar dam	708.1	0.25	0.01 NS	0.053	0.592
	Krishnarajsagar KERS	696.0	1.52	0.58 NS	0.109	0.269
	Srirangapatna	569.0	3.04	3.47 NS	0.184	0.061
	Arakere	672.6	1.98	1.43 NS	0.115	0.242

** Significant at 1% level * Significant at 5% level NS: Not significant

the period 1964-2013. The statistical significance of trend was assessed by Mann-Kendall test. It was found that only five rain gauge stations *viz.,* Seelunere, Halagur, Lingarajachatra, Honakere and Melkote had significant linear trend. Further, Seelunere and Halagur showed decreasing trend, while, Lingarajachatra, Honakere and Melkote showed an increasing trend in annual rainfall over the years.

From the above investigation, it is observed that the central part of Mandya district covering most of RGS stations coming under Nagamangala, Mandya and Pandavapura taluks had received below average (< 700 mm) rainfall, whereas, RGS stations located in Maddur and Malavalli taluks towards east as well as K.R Pet and Srirangapatna taluk towards western parts of Mandya district had received above average (> 700 mm) rainfall during the study period. It was found that only five rain gauge stations *viz.,* Seelunere, Halagur, Lingarajachatra, Honakere and Melkote had significant linear trend. Further, Seelunere and Halagur showed decreasing trend, while, Lingarajachatra, Honakere and Melkote showed an increasing trend in annual rainfall over the years. The present study will help the farmers to plan their crops suitably.

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(*Received :* July, 2015 *Accepted :* May, 2016)