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DETECTING FIVE YEAR WISE RAINFALL TRENDS OF KALAYAN KARNATAKA, INDIA

VISHWANATH* AND G.V. VENKATARAMANA

Department of Studies in Environmental Science, University of Mysore, Mysore 570 005, Karnataka, India

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Key words : *Annual rainfall, Statistical analysis, Trend and Sen's slope*

Abstract–An attempt was made to study the five year wise rainfall trends of Kalayan Karnataka. The study period spans for a period of 50 years from 1971-2020 which was divided into ten periods comprising each 5-year moving average to detect long term trends and further a linear tend was added as parametric test. Long term changes in rainfall characteristics were determined by both parametric and non-parametric tests. The analysis revealed that the period from 1991-1995 was found to be highest mean rainfall receiving period for the Bidar (1078.9 mm), Kalaburgi (976.7 mm) districts whereas for the Yadgir (1171.1mm) district it was from 1986-1990. However for Raichur (875.5 mm) and Koppal (670.7 mm) districts the period from 2001-2005 was found to be highest mean rainfall receiving period whereas 1971-1975 was found to be for Ballari (705.7 mm) district. The highest CV was recorded during the period from 1981-1985, 1976-1980, 1976-1980, 2016-2020, 1976-1980 and 2006-2010 from Bidar (34.5%), Kalaburgi (36.8%), Yadgir (43.3%), Raichur (39.7%), Koppal (30.9%) and Ballari (30.8%) respectively indicating higher variability and lesser dependability. Sen's slope estimator showed that there is a positive trend for the Bidar, Raichur and Koppal rainfall pattern. However, Kalaburagi, Yadgir and Ballari exhibited a decreasing trend.

INTRODUCTION

Climate change has been a prominent issue in the last decade. Climate change on a global scale does not necessarily have the same effect in different regions. Rainfall is a crucial weather element related to climate change. Rainfall trends analysis is an appropriate step in assessing the impact of climate change on water availability and food security (Aditya *et al.,* 2021).

Some studies have documented the rainfall variability in India like Rajendran *et al.* (2016) studied rainfall variation and frequency analysis for Dharmapuri district. Aditya *et al.* (2021) studied rainfall variations and changes at West Kalimantan, focusing on Mempawah and Kubu Raya from 2000-2019. The findings revealed that the annual rainfall pattern prevailed in all locations. Mempawah region tends to experience a downward trend, while Kubu Raya had an upward trend. However, a significant trend (at 95% confidence level) was identified in Sungai Kunyit with a slope value of -33.20 mm/year. This trend indicates that Sungai Kunyit will become drier in the future. The results of monthly rainfall analysis showed that significant upward and downward trends were detected in eight locations. Rainfall trends indicate that climate change has occurred in this region.

Deka *et al.* (2016) investigated Spatio-temporal variability of rainfall regime in the Brahmaputra valley of North East India. Kumar *et al.* (2021) studied rainfall trend, variability and changes over the state of Punjab, India from 1981–2020 by a geospatial approach. Bora *et al.* (2022) analyzed the variability and trends in annual as well as seasonal rainfall in the seven states of North East India for the period 1901–2020. In this context, a similar attempt was made to detect five year wise rainfall trends of Kalayan Karnataka.

MATERIALS AND METHODS

Study area and Data used

Kalyana Karnataka is a region located in north-eastern part of Karnataka. The region comprises 6 districts namely Bidar, Kalaburagi, Yadgir, Raichur, Koppal and Ballari as presented in Fig. 1. The rainfall data of 50 years from 1971-2020 was

collected from Economics and Statistics Department, Bengaluru.

Statistical analysis of rainfall

Rainfall characteristics like, mean, standard deviation (SD), range, CV and percentage departure were computed for five year rainfall period. The 50 years rainfall data is divided into ten periods comprising each 5-year moving average to find long term trends and further a linear tend was added as parametric test. The departure from the mean rainfall is calculated as follows: Departure % = (actual rainfall– mean rainfall)/mean rainfall) x 100

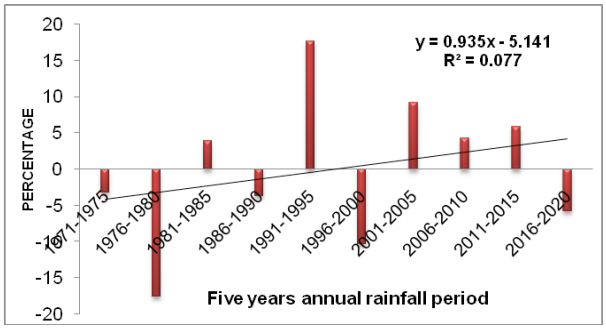

Fig. 2. Five years annual rainfall percent departure of Bidar

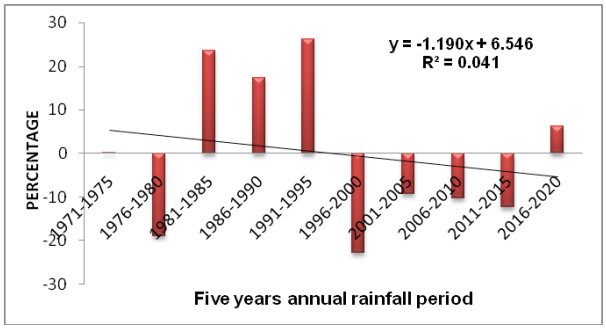

Fig. 3. Five years annual rainfall percent departure of Kalaburgi

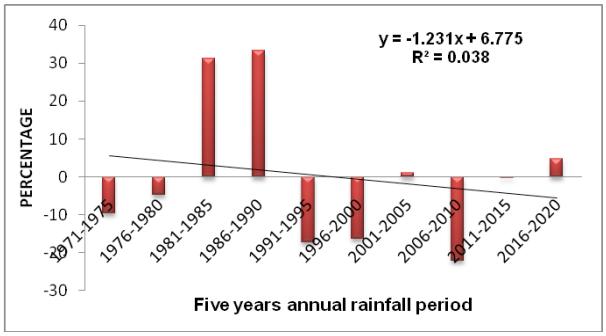

Fig. 4. Five years annual rainfall percent departure of Yadgir

RESULTS AND DISCUSSION

The trend analysis for five year rainfall was carried out to know the significant increasing or decreasing trend of rainfall over six districts of Kalyana Karnataka are represented in Fig. 2–7. The significant increase or decrease was considered at R^2 value of 0.1 (10 % reliability). The positive slopes and negative slopes of regression lines indicate increasing and decreasing trends respectively. From regression analysis, it was found that, the slopes of regression line are positive at Bidar, Raichur and Koppal. This shows that these districts have

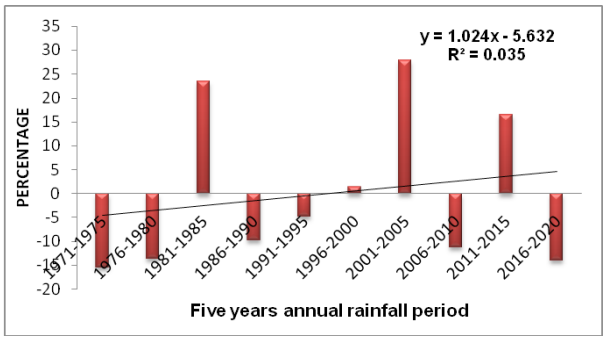

Fig. 5. Five years annual rainfall percent departure of Raichur

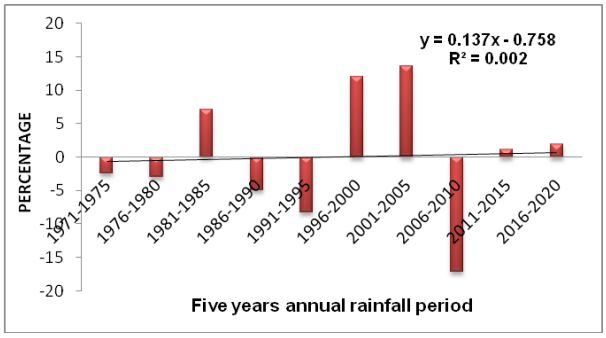

Fig. 6. Five years annual rainfall percent departure of Koppal

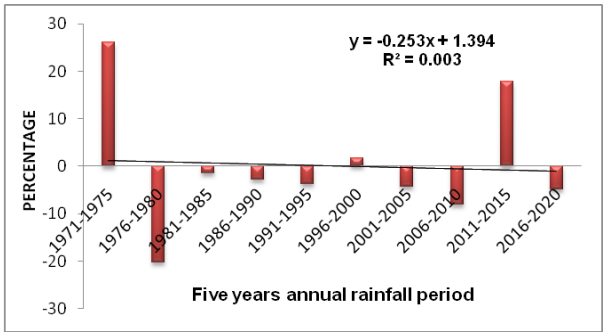

Fig. 7. Five years annual rainfall percent departure of Ballari

increasing rainfall trend. The remaining districts (Kalaburgi, Yadgir and Ballari) showed negative slope of regression line indicating decreasing trend of five year rainfall.

The five year rainfall analysis was presented in the Table 1 to 7 for all the districts of Kalyana Karnataka. The analysis for the Bidar district revealed that the period from 1991-1995 was found to be highest mean rainfall receiving period where as the highest CV was during the period from 1981-1985 indicating higher variability and lesser dependability. From among all the ten periods the lowest CV was recorded during 1971-1975 indicating least variability and more dependability. The analysis for the Kalaburgi district revealed that the period from 1991-1995 was found to be highest mean rainfall receiving period where as the highest CV was during the period from 1976-1980 indicating higher variability and lesser dependability. From among all the ten periods the

Table 1. Five years annual rainfall variability and percent departure of Bidar

Period	Year	Range (mm)	Mean (mm)	SD (mm)	CV (%)	Departure (%)
I	1971-1975	831.0-954.7	888.0	51.3	5.8	-3.24
II	1976-1980	396.6-1039.0	756.5	241.9	32.0	-17.57
III	1981-1985	562.1-1445.6	953.2	328.7	34.5	3.86
IV	1986-1990	693.7-1143.3	883.0	176.2	19.9	-3.79
V	1991-1995	770.5-1362.6	1078.9	289.9	26.9	17.56
VI	1996-2000	624.2-1250.6	822.7	247.2	30.0	-10.36
VII	2001-2005	774.4-1259.3	1002.2	188.2	18.8	9.20
VIII	2006-2010	721.0 - 1127.6	957.0	170.4	17.8	4.27
IX	2011-2015	792.8 - 1182.7	971.5	160.0	16.5	5.85
X	2016-2020	624.3 - 1135.9	864.8	242.9	28.1	-5.77
	1971-2020	396.6 - 1445.6	917.8	220.0	24.0	-

Table 2. Five years annual rainfall variability and percent departure of Kalaburgi

Period	Year	Range (mm)	Mean (mm)	SD (mm)	CV (%)	Departure (%)
I	1971-1975	607.1 - 858.7	775.3	111.4	14.4	0.24
II	1976-1980	358.7 - 942.8	626.4	230.4	36.8	-19.01
III	1981-1985	626.5 - 1295.1	955.6	282.4	29.6	23.55
IV	1986-1990	561.1 - 1232.1	907.4	300.1	33.1	17.32
V	1991-1995	820.0 - 1292.4	976.7	182.2	18.7	26.28
VI	1996-2000	409.5 - 930.4	596.9	202.5	33.9	-22.83
VII	2001-2005	533.5 - 979.7	701.3	175.3	25.0	-9.33
VIII	2006-2010	521.8 - 879.1	694.1	150.1	21.6	-10.26
IX	2011-2015	559.6 - 793.5	678.7	85.9	12.7	-12.25
X	2016-2020	679.3 - 1100.2	822.0	172.3	21.0	6.28
	1971-2020	358.7 - 1295.1	773.5	223.1	28.8	-

Table 3. Five years annual rainfall variability and percent departure of Yadgir

Period	Year	Range (mm)	Mean (mm)	SD (mm)	CV (%)	Departure (%)
I	1971-1975	598.8 - 999.8	793.2	164.3	20.7	-9.64
II	1976-1980	424.3 - 1335.5	836.8	362.7	43.3	-4.67
III	1981-1985	594.5 - 1587.1	1151.7	384.4	33.4	31.20
IV	1986-1990	634.0 - 1618.6	1171.1	371.2	31.7	33.41
V	1991-1995	512.6 - 874.1	726.9	145.1	20.0	-17.19
VI	1996-2000	515.2 - 1116.7	733.5	232.0	31.6	-16.44
VII	2001-2005	718.0 - 1085.3	887.3	169.1	19.1	1.08
VIII	2006-2010	523.1 - 939.4	683.2	188.3	27.6	-22.17
IX	2011-2015	727.3 - 1097.6	875.2	169.2	19.3	-0.30
X	2016-2020	547.0 - 1224	919.2	276.6	30.1	4.72
	1971-2020	424.3 - 1618.6	877.8	286.4	32.6	-

lowest CV was recorded during 2011-2015 indicating least variability and more dependability.

The statistical analysis of five years annual rainfall for the Yadgir district revealed that the period from 1986-1990 was found to be highest mean rainfall receiving period where as the highest CV was during the period from 1976-1980 indicating higher variability and lesser dependability. From among all the ten periods the lowest CV was recorded during 2001-2005 indicating least variability and more dependability. The analysis for the Raichur district revealed that the period from 2001-2005 was found to be highest mean rainfall receiving period where as the highest CV was during the period from 2016-2020 indicating higher variability and lesser dependability. From among all the ten periods the lowest CV was recorded during 1971-1975 indicating least variability and more dependability.

The analysis for the Koppal district revealed that the period from 2001-2005 was found to be highest mean rainfall receiving period where as the highest CV was during the period from 1976-1980 indicating higher variability and lesser dependability. From among all the ten periods the lowest CV was recorded during 1971-1975 indicating least variability and more dependability. The analysis for the Ballari district revealed that the period from 1971-1975 was found to be highest mean annual rainfall receiving period where as the highest CV was during the period from 2006-2010 indicating higher variability and lesser dependability. From among all the ten periods the lowest CV was recorded during 1991-1995 indicating least variability and more dependability.

The trend analysis for five year rainfall was carried out to know the significant increasing or decreasing trend of rainfall over six districts of Kalyana Karnataka are represented in Fig. 2–7. The significant increase or decrease was considered at R^2 value of 0.1 (10 % reliability). The positive slopes and negative slopes of regression lines indicate increasing and decreasing trends respectively. From regression analysis, it was found that, the slopes of regression line are positive at Bidar, Raichur and Koppal. This shows that these districts have increasing rainfall trend. The remaining districts (Kalaburgi, Yadgir and Ballari) showed negative

Table 4. Five years annual rainfall variability and percent departure of Raichur

Period	Year	Range (mm)	Mean (mm)	SD (mm)	CV (%)	Departure (%)
I	1971-1975	484.7 - 634.4	578.2	74.2	12.8	-15.52
II	1976-1980	386.2 - 860.9	591.5	190.0	32.1	-13.58
III	1981-1985	560.6 - 1320.8	845.3	304.1	36.0	23.51
IV	1986-1990	388.5 - 823.7	616.7	204.7	33.2	-9.89
V	1991-1995	547.3 - 826.1	651.1	117.1	18.0	-4.87
VI	1996-2000	508.8 - 950.2	693.8	180.2	26.0	1.37
VII	2001-2005	585.6 - 1055.3	875.5	203.3	23.2	27.92
VIII	2006-2010	445.0 - 722.2	606.7	113.9	18.8	-11.35
IX	2011-2015	572.8 - 936.3	796.7	187.9	23.6	16.41
X	2016-2020	342.2 - 875.3	588.6	233.7	39.7	-14.00
	1971-2020	342.2 - 1320.8	684.4	204.3	29.9	-

Table 5. Five years annual rainfall variability and percent departure of Koppal

Period	Year	Range (mm)	Mean (mm)	SD (mm)	CV (%)	Departure (%)
I	1971-1975	451.7 - 741.3	575.7	113.9	19.8	-2.48
II	1976-1980	370.7 - 831.7	572.6	177.0	30.9	-3.01
III	1981-1985	403.3 - 862.5	632.2	180.6	28.6	7.09
IV	1986-1990	454.7 - 747.7	561.5	113.6	20.2	-4.89
V	1991-1995	385.4 - 714.2	541.9	153.1	28.3	-8.21
VI	1996-2000	453.2 - 906.2	661.4	162.1	24.5	12.04
VII	2001-2005	503.1 - 901.3	670.7	158.2	23.6	13.61
VIII	2006-2010	314.4 - 651.0	489.0	142.1	29.1	-17.17
IX	2011-2015	325.1 - 720.6	597.0	161.5	27.1	1.13
X	2016-2020	422.3 - 843.0	601.5	167.8	27.9	1.89
	1971-2020	314.4 - 906.2	590.3	149.4	25.3	-

slope of regression line indicating decreasing trend of five year wise rainfall.

The five year rainfall analysis was presented in the Table 1 to 7 for all the districts of Kalyana Karnataka. The analysis for the Bidar district revealed that the period from 1991-1995 was found to be highest mean rainfall receiving period where as the highest CV was during the period from 1981-1985 indicating higher variability and lesser dependability. From among all the ten periods the lowest CV was recorded during 1971-1975 indicating least variability and more dependability. The analysis for the Kalaburgi district revealed that the period from 1991-1995 was found to be highest mean rainfall receiving period where as the highest CV was during the period from 1976-1980 indicating higher variability and lesser dependability. From among all the ten periods the lowest CV was recorded during 2011-2015 indicating least variability and more dependability.

The statistical analysis of five years annual rainfall for the Yadgir district revealed that the period from 1986-1990 was found to be highest mean rainfall receiving period where as the highest CV was during the period from 1976-1980 indicating higher variability and lesser dependability. From among all the ten periods the lowest CV was recorded during 2001-2005 indicating least variability and more dependability. The analysis for the Raichur district revealed that the period from 2001-2005 was found to be highest mean rainfall receiving period where as the highest CV was during the period from 2016-2020 indicating higher variability and lesser dependability. From among all the ten periods the lowest CV was recorded during 1971-1975 indicating least variability and more dependability.

The analysis for the Koppal district revealed that the period from 2001-2005 was found to be highest mean rainfall receiving period where as the highest CV was during the period from 1976-1980 indicating higher variability and lesser dependability. From among all the ten periods the lowest CV was recorded during 1971-1975 indicating least variability and more dependability. The analysis for the Ballari district revealed that the period from 1971-1975 was found to be highest mean annual rainfall receiving period where as the highest CV was during the period from 2006-2010 indicating higher variability and lesser dependability. From among all the ten periods the lowest CV was recorded during 1991-1995 indicating least variability and more dependability. Sen's slope estimator showed that there is a positive trend for the Bidar, Raichur and Koppal rainfall pattern. However, Kalaburagi, Yadgir and Ballari exhibited a decreasing trend.

Table 6. Five years annual rainfall variability and percent departure of Ballari

Period	Year	Range (mm)	Mean (mm)	SD (mm)	CV (%)	Departure (%)
I	1971-1975	460.0 - 868.5	705.7	174.4	24.7	26.05
II	1976-1980	340.5 - 633.7	445.9	114.9	25.8	-20.35
III	1981-1985	363.0 - 760.2	551.4	140.8	25.5	-1.51
IV	1986-1990	381.1 - 734.5	543.6	163.2	30.0	-2.90
V	1991-1995	421.5 - 632.5	539.2	85.6	15.9	-3.69
VI	1996-2000	375.5 - 721.0	569.5	131.6	23.1	1.73
VII	2001-2005	410.2 - 668.4	535.7	111.9	20.9	-4.31
VIII	2006-2010	341.7 - 684.5	514.4	158.6	30.8	-8.12
IX	2011-2015	484.7 - 957.9	660.2	199.1	30.2	17.93
X	2016-2020	452.4 - 776.3	532.8	138.1	25.9	-4.83
	1971-2020	340.5 - 957.9	559.8	149.0	26.6	-

Table 7. Results of Trend Analysis

District	Linear Regression	Trend	Sen's Slope
Bidar	$y = 0.935x - 5.141$ $R^2 = 0.077$	⚜	+0.13
Kalaburagi	$y = -1.190x + 6.546$ $R^2 = 0.041$	-	"0.22
Yadgir	$y = -1.231x + 6.775$ $R^2 = 0.038$	-	"0.36
Raichur	$y = 1.024x - 5.632$ $R^2 = 0.035$	⚜	+0.21
Koppal	$y = 0.137x - 0.758$ $R^2 = 0.002$	⚜	+0.11
Ballari	$y = -0.253x + 1.394$ $R^2 = 0.003$	-	"0.04

CONCLUSION

The investigation showed a long term insignificant decline trend of Kalaburgi, Yadgir and Ballari districts, where as an increasing trend in Bidar, Raichur and Koppal districts from five year wise rainfall analysis. The Sen's slope estimator showed the same result. The analysis revealed that the highest CV was recorded during the period from 1981-1985, 1976-1980, 1976-1980, 2016-2020, 1976-1980 and 2006-2010 for Bidar (34.5%), Kalaburgi (36.8%), Yadgir (43.3%), Raichur (39.7%), Koppal (30.9%) and Ballari (30.8%) respectively indicating higher variability and lesser dependability.

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