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RESEARCH PAPER

Annual and seasonal rainfall analysis for 2013-2023 period in Gadag district, Karnataka

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Abstract: The present study assesses the variability of rainfall trends across the Hoblis of Gadag district. The required data for this study were collected from the Karnataka State Natural Disaster Monitoring Centre (KSNDMC), Bengaluru, Government of Karnataka, for the period from 2013 to 2023. The rainfall variability analysis at hobli level for Gadag district depicts low variability in the annual (34.42%) and South West monsoon (34.49%) rainfall data, while high variability was found in the pre-monsoon and NE monsoons. The annual rainfall and seasonal rainfall for SW monsoon and NE monsoon during past 10 years (2013-2023) at hoblis of Gadag district has shown increasing trend in the rainfall amount (17%) and rainy days (+ 23%). Among the hoblis, Gadag hobli received the highest amount of annual rainfall (687.97 mm) and recorded the highest rainy days (58 days) with lower variability (33.16%) which supports greater stability for cultivation. While, Konnur and Mundaragi hoblis received the lowest amount of annual rainfall (533.31 and 521.66 mm) and rainy days (47 days), suggesting the need for having more water harvesting structures and advanced water management strategies to reduce the risk of frequent crop failures.

Key words: Rainfall, Rainy days, Seasonal distribution, Variability

Introduction

Rainfall is a crucial climatic factor, and disparities in the amount and pattern can directly or indirectly affect agriculture production, human lifestyle, water resources management, and ecosystem function and structure (Kumar and Gautam, 2014). However, on set of monsoon and the distribution of rainfall varies over the years and across the season. Crop production activities are governed by the time of occurrence and spatial variability of rainfall. During the crop season, variations in seasonal rainfall make it difficult for farmers to choose the crop, variety and best time to sow crop seeds, apply agricultural inputs and management. The spatial and temporal variation in monsoon can be observed at regional, zonal, district, taluk and even at hobli level. However, it's the variation at the smallest unit that directly affects farmers' decision.

Agro-ecologically, Gadag district lies in the hot semi-arid Eco-Sub Region of the Deccan Plateau and Agro-climatically lies in Northern Dry Zone (zone-3) and region-2 of Karnataka State. Gadag district receives average annual rainfall of 640 mm with a history of occurrence of agricultural droughts at a probability of 70 per cent. Long dry spells in *kharif* season and receding soil moisture in *rabi* season are the main characteristics of agricultural droughts and contraints productivity (Anon., 2022). Gadag district has semi undulating to undulating topography within the watershed of Krishna River, while Malaprabha and Tungabhadra rivers are the tributaries of Krishna and passes through the outer edges of the district *i.e.* Ron and Mundargi talukas, respectively (Anon., 2022).

The district has a total cropped area of 5.5 lakh hectares accounting for 84.24 per cent of total geographical area. Net sown area is 4.04 lakh hectares, of which 1.65 lakh hectare is sown more than once with a cropping intensity of 143.6 per cent. The district has an irrigated area of 99,353 hectares (24.56%) and it is mainly confined to Naragund and Ron taluks which get protective irrigation from Malaprabha Reservoir (Anon., 2022). About 46.1 per cent of soil is of medium black clay soil followed by 40.7 per cent deep black clay soil. Rest of the soil type is red sandy soils as well as red and black mixed soil.

Few studies have been conducted on seasonal variations and trends in rainfall patterns of Gadag district based on a gridded rainfall data. Especially at hobli level, not many studies taken up. This study analyze variability of rainfall trends across the hoblis of Gadag district. The main objective of this study was to use recent decade rainfall data (2013-2023), to evaluate the mean rainfall and seasonal variability *i.e.*, Winter, Pre-Monsoon, South West Monsoon and North East Monsoon rainfall at hobli level for Gadag district.

Material and methods

Study area

Fig.1 depicts the location of Gadag district, located in central part of North Interior Karnataka, between 15°15' and 15° 45' North latitude and 75°20' and 75°47' East longitudes. The district is divided into seven taluks, of which five taluks fall under Northern dry zone of Karnataka (Gadag, Mundargi, Nargund, Ron, and Gajendragad) and two taluks under Northern Transition Zone of Karnataka (Laxmeshwar and Shirahatti). The district is divided into a total of 11 Hoblis namely, Betageri, Gadag, Dambal, Mundaragi, Konnur, Naragund, Holealur, Naregal, Ron, Lakshmeshwar and Shirahatti.

Data collection and analysis

The required data for this study were collected from the Karnataka State Natural Disaster Monitoring Centre

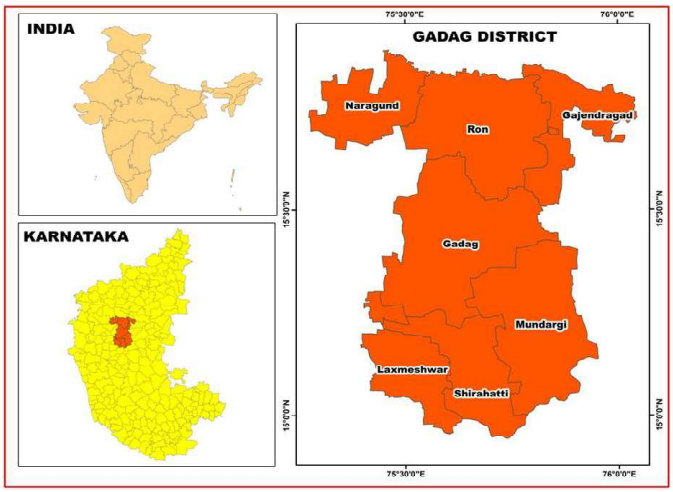

Fig 1. Study location map of Gadag district with taluk boundaries

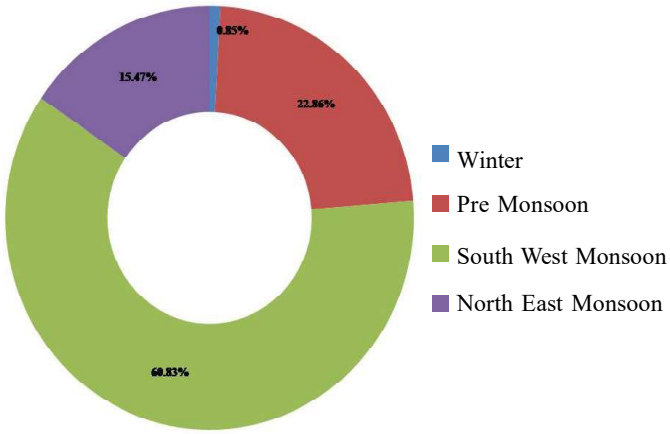

Fig 2. Seasonwise percent distribution of annual rainfall of Gadag district

(KSNDMC), Bengaluru, Government of Karnataka, for the period from 2013 to 2023. KSNDMC utilizes 132 telemetric raingauages located across various gram panchayats of Gadag district. The mean value from all grid point data was taken to calculate daily rainfall of Gadag district. The daily rainfall data for the year was classified as annual rainfall. Then the annual rainfall was further divided into four seasons; January to February month rainfall as winter season rainfall, March to May month rainfall as pre-monsoon season rainfall, June to September rainfall as south west monsoon season rainfall and October to December month rainfall as north east monsoon season. Annual and seasonal rainfall data were analyzed statistically and the statistical parameters like mean, maximum, minimum, standard deviation and coefficient of variation were studied for Gadag district.

Results and discussion

Annual and seasonal distribution of rainfall and it's variability

Variation in the seasonal as well as annual rainfall adversely affects the yield of crops. Table 1 displays descriptive statistics for Gadag distrct's annual and seasonal rainfall of the past 10 years. The annual rainfall is divided into four categories: winter, pre monsoon, south west monsoon (SW monsoon) and north east monsoon (NE monsoon). Table 1 includes the minimum and maximum values, mean, standard deviation, coefficient of variation (C.V) and seasonal contribution to annual rainfall. Gadag district rainfall varies throughout the year, with different seasons adding different amounts of rain to the total rainfall. Annual mean rainfall for the district was 585.34 mm for the past decade and out of those10 years, five years were below-average. It means that, on average, the district receives moderate rainfall annually. However, there is a significant variation in rainfall from year to year, as evidenced by the higher deviation of 201.5 mm for the total of 585.34mm. It means that some years can be much wetter or drier compared to the average. The recorded maximum and minimum annual rainfall values were 1008.95 mm in 2022 and 348.05 mm in 2016, respectively, under scoring the large variation in annual rainfall in 10 years period, thus increasing the risk for farming community.

Gadag district received the most rain during the SW monsoon season (June - September) (356.04 mm; 60.83%), but in 6 out of 10 years, rainfall was below the mean value. The deviation of 122.81 mm suggests more variation in rainfall from year to year, but not as much as in the annual category (201.5 mm). During NW monsoon season (October - December), Gadag district received 90.56 mm rainfall (15.47%), but in 5 out of 10 years, rainfall was below the mean value (90.56 mm). During pre monsoon season, Gadag district received 133.80 mm rainfall (22.56%) with a deviation of 74.68 mm. The higher amount of rainfall received during pre monsoon season requires to be properly harvested through proper land management and in-situ moisture conservation practices, which help to recharge the soil profile and facilitate early or timely sowing of *kharif* crops, especially greengram which is a major crop of Gadag district (Subbulakshmi, 2021).

The coefficient of variation (C.V) is used to assess the degree of variability in the rainfall data (Bharath *et al*. 2023 & Kumar *et al*. 2023). Table 1 here shows the C.V values for different rainfall variables across various seasons. The annual rainfall has a C.V of 34.42%, indicating medium variability. The SW monsoon season also shows lower variability with a C.V of 34.49%. In contrast, the NE monsoon and pre-monsoon

Table 1. Descriptive analysis of rainfall variability in Gadag district (2013-2023)

Categories	Mean	Standard Deviation	C.V (%)	Max (mm)	Min (mm)	% of total
South West Monsoon	356.04	122.81	34.49	615.38	174.8	60.83
Pre-Monsoon	133.80	74.68	55.81	278.47	20.06	22.86
North East Monsoon	90.56	50.64	55.91	195.43	6.08	15.47
Winter	4.95	9.79	197.85	31.64	0.04	0.85
Annual	585.34	201.50	34.42	1008.95	348.05	100

Table 2. Seasonal and annual distribution of rainfall (mm) at hoblis across Gadag District for the period 2013-2023.

	Gadag	Lakshmeshwar	Shirahatti	Naregal	Betageri	Ron	Dambala	Naragund	Holealur	Konnur	Mundaragi
Annual (mm)	687.97	612.89	611.30	602.05	593.88	581.58	570.31	569.41	545.12	533.31	521.66
C.V (%)	33.16	40.50	42.35	32.16	31.65	34.25	37.80	35.78	34.38	35.82	33.53
SW Monsoon (mm)	408.89	354.67	356.11	375.10	368.38	375.43	324.29	342.31	334.99	325.85	314.59
C.V (%)	33.63	35.09	39.43	29.15	31.45	34.00	37.39	39.30	33.63	33.90	31.58
NE Monsoon (mm)	126.03	113.49	115.88	112.86	102.54	96.78	111.78	111.63	102.04	101.07	109.95
C.V (%)	70.57	68.96	70.65	58.37	65.85	67.30	61.42	64.35	60.38	61.99	66.43
Pre Monsoon (mm)	148.00	133.85	132.59	113.07	119.94	106.91	127.88	111.37	106.17	104.02	93.02
C.V (%)	56.83	74.13	77.27	49.74	46.29	53.39	58.34	65.22	53.41	56.93	58.62
Winter (mm)	5.05	10.88	6.72	1.03	3.02	2.46	6.37	4.10	1.92	2.37	4.11

season exhibit very high variability, reflected by 55.91 and 55.81% C.V, respectively. Similarly, winter season rainfall displays significant variability, with 197.85% C.V, but it's contribution to annual rainfall is negligible (< 1%). Overall, the analysis demonstrates the variability of seasonal rainfall. Season wise percent contribution to the total annual rainfall in the district is presented in Fig-2. SW monsoon (June - September) rainfall accounts for 61%, NW monsoon (October - December) rainfall accounts for 15%, Pre monsoon (March - May) rainfall accounts for 23% and winter (January - February) rainfall accounts < 1% (0.85%) of the total annual rainfall.

Low variability in the annual and SW monsoon rainfall is obvious for the district because of the fact that maximum amount of annual rainfall is contributed by SW monsoon. Lower variability provides better reliability and stability, but the higher variability in NE monsoon and pre-monsoon season calls for effective rain water harvesting and advanced water management strategies and infrastructure development for assured crop yield. Policy maker and stake holders need to consider long-term planning to cope with potential water scarcity and agricultural challenges arising out of these fluctuations in seasonal rainfall patterns.

Distribution of rainfall among Hoblis of Gadag district for the period (2013- 2023)

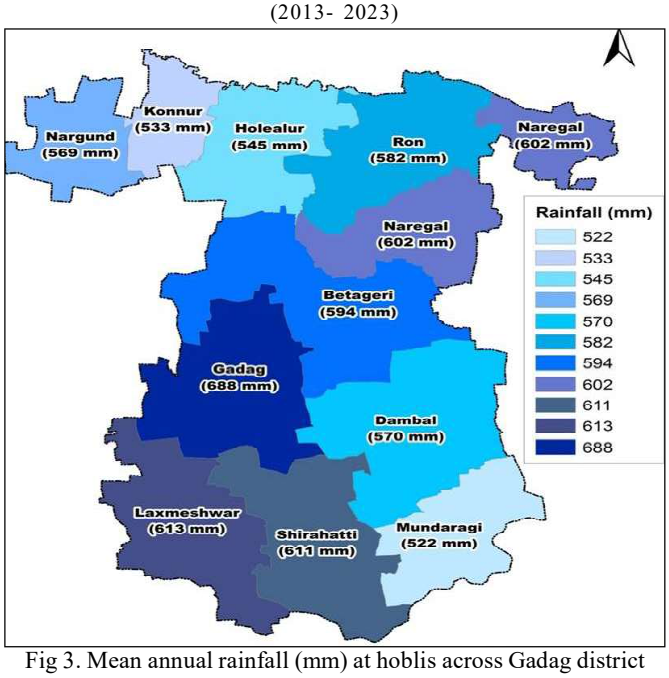

Fig 3. Mean annual rainfall (mm) at hoblis across Gadag district (2013-2023)

Annual and seasonal distribution of rainfall and their variability at hobli level

The mean annual rainfall for 11 hoblis of Gadag is furnished in Fig 3.On the basis of available data (2013-2023), the highest annual rainfall of 688 mm was observed for Gadag hobli followed by Laxmeshwara hobli (613 mm) and the lowest in Mundaragi hobli (522 mm). The difference between the maximum and the minimum rainfall at Hobli level is 166 mm.The annual rainfall received over the past 10 years period (2013-2023) at the Hoblis of Gadag district has shown increasing trend in the rainfall amount and the increment was to the tune of 160 mm (Fig. 5). The enhancement in the annual rainfall supplements moisture to the soil profile, which in turn extends the crop growing period. However, the hobli level annual rainfall is highly variable and the highest C.V was recorded for Shirahatti hobli (42.35%) followed by Laxmeshwara hobli (40.50%) and the lowest for Betageri hobli (31.65%), thus underlining the importance of in-situ rain water harvesting.

The mean rainfall and it's C.V during winter, pre monsoon, SW monsoon and NE monsoon at Hoblis of Gadag district are shown in the Table 2. The mean rainfall during pre monsoon (March - May) season was the highest in Gadag hobli (148 mm)

Distribution of rainy day's (2.5 mm) among Hoblis of Gadag district for the period (2013- 2023)

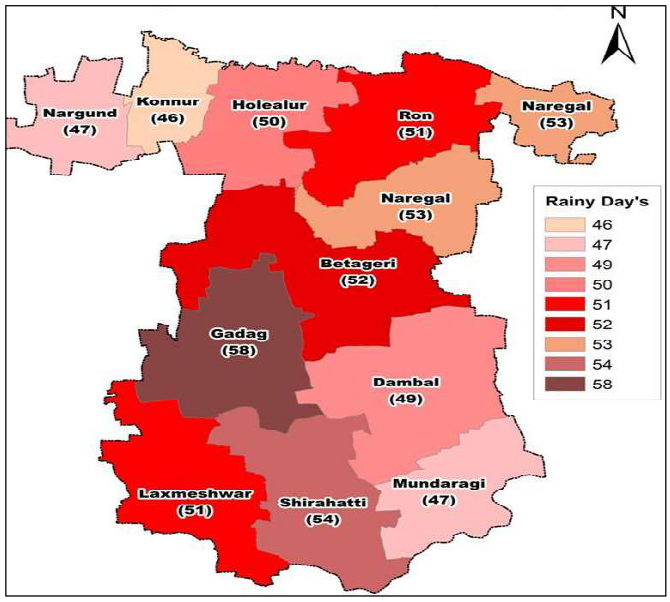

Fig 4. Mean annual rainydays (No.) at hoblis across Gadag district (2013-2023)

Table 3. Seasonal and annual distribution of rainy days at hoblis across Gadag District for the period 2013-2023.

	Gadag	Shirahatti	Naregal	Betageri	Lakshmeshwar	Ron	Holealur	Dambala	Konnur	Mundaragi	Naragund
Annual	58	53	53	52	51	51	50	49	47	47	46
SW Monsoon	36	34	35	33	31	33	32	30	29	30	29
NE Monsoon	10	9	8	8	9	8	8	9	8	9	8
Pre Monsoon	12	10	10	11	11	10	10	10	10	8	9
Winter	0	0	0	0	0	0	0	0	0	0	0

followed by Lakshmeshwara hobli (134 mm) and the lowest in Konnur hobli (104 mm). However, a minimum of 104 mm rainfall during March, April and May months is quite significant and very useful for land preparation and early sowing. During SW monsoon (June - September) season the highest mean rainfall was observed with Gadag hobli (409 mm) followed by Ron hobli (375 mm) and the lowest in Mundaragi hobli (315 mm). Whereas, during NE monsoon (October - December) season the highest mean rainfall was again observed with Gadag hobli (126 mm) followed by Shirahatti hobli (116 mm) and the lowest in Ron hobli (97 mm). Both during SW monsoon and NE monsoon seasons, the rainfall quantity has increased over the past 10 years, which extends the growing period for *rabi* crops (Fig. 7 & 8). In total, Gadag hobli recieved the highest amount of rainfall across the seasons which suggests more reliability on the monsoon and assurance of better crop in the Gadag Hobli.

The variability during pre monsoon (March - May) season, was found to be the highest in Shirahatti hobli (77.27%) followed by Naragund hobli (65.22%) and the lowest in Betageri hobli (46.29%). Similarly, during SW monsoon (June - September) season the highest variability was observed with Shirahatti hobli (39.43%) followed by Naragund hobli (39.30%) but the lowest in Naregal hobli (29.15%). Whereas, during NE monsoon (October - December) season the highest variability was observed again with Shirahatti hobli (70.65%), but followed by Gadag hobli (70.57%) and the lowest in Ron hobli (58.37%). The variability of rainfall across the seasons was the highest in Shirahatti hobli, which indicates higher risk of rainfed agriculture and increasing role of supplemental or assured irrigation for reliable crop production.

Annual and seasonal distribution of rainy days at hobli level

Not only the amount of rainfall, but number of rainy days greatly influence rainfall effectiveness and water use efficiency. The mean annual rainy days for 11 hoblis of Gadag is furnished in Fig 4. On the basis of available data (2013-2023), the highest annual rainy days were recorded for Gadag hobli (58 days) followed by Naregal and Shirahatti hoblis (53 days) and the lowest for Naragund hobli (46 days). The difference between the maximum and the minimum rainy days at hobli level is 12 days. This is quite considerable in the context of rainfed crop production. The rainy days, like the annual and SW monsoon season, also increased over the past 10 years for the hoblis of Gadag district, and it increased by 17 days (Fig. 6). The seasonal rainy days during winter, pre monsoon, SW monsoon and NE monsoon for all the hoblis of Gadag are shown in the Table 3. The mean number of rainy days during pre monsoon (March - May) season, was found to the highest in Gadag hobli (12 days) followed by Betageri and Laxmeshwara hoblis (11 days) and the lowest in Mundaragi hobli (8 days). During SW monsoon (June - September) season the highest rainy days found to be again in Gadag hobli (36 days) followed by Naregal hobli (35 days) and the lowest in Naragund and Konnur hoblis (26 days). The highest rainydays in NE monsoon (October - December) season was observed again in Gadag hobli (10 days) followed by Dambal, Mundaragi, Laxmeshwar and Shirahatti hoblis (9 days) and lowest in Betageri, Konnur, Naragund, Holealur, Naregal and Ron hoblis (8 days). The difference between the maximum and the minimum rainy days at hobli level for SW monsoon season was 10 days, whereas it is very less for pre monsoon (4 days) and NE monsoon (2 days)

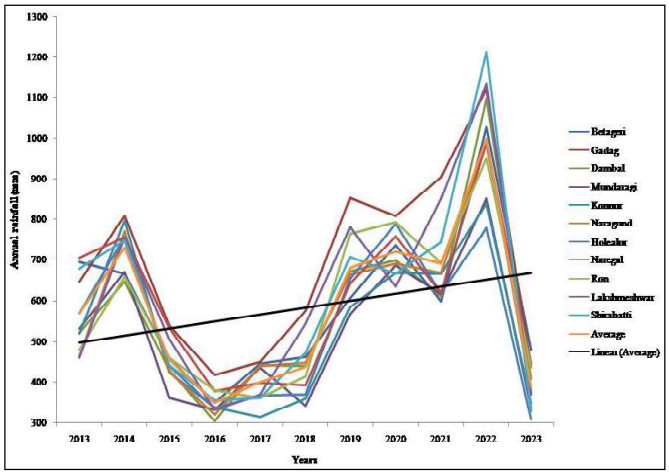

Fig 5. Annual rainfall (mm) at Hoblis across Gadag district (2013-2023)

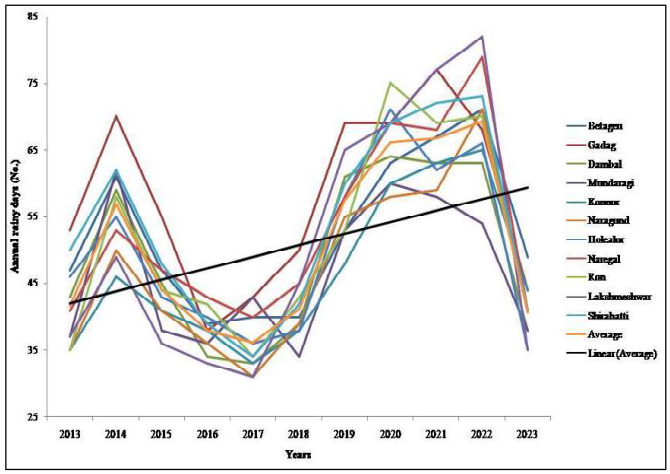

Fig 6. Annual rainy days (No.) at Hoblis across Gadag district (2013-2023)

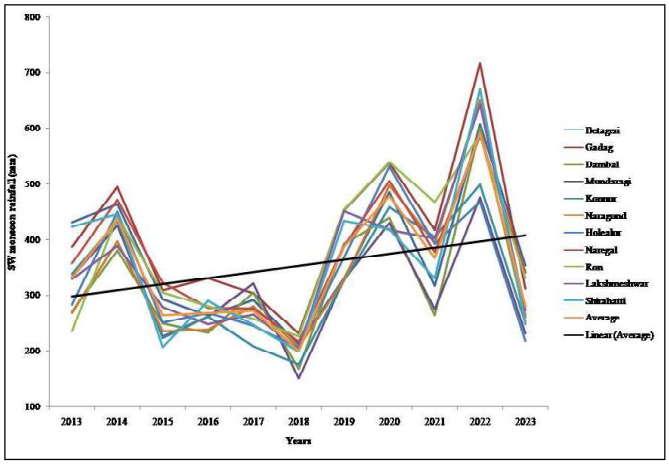

Fig 7. SW monsoon (June to September) rainfall at Hoblis across Gadag district (2013-2023)

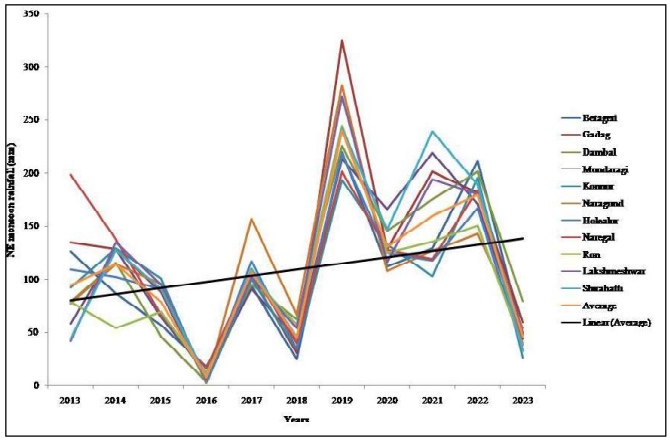

Fig 8. NE monsoon (October to December) rainfall at Hoblis across Gadag district (2013-2023)

seasons. In total, Gadag hobli recorded the highest number of rainy days across the seasons. During NE monsoon season the rainy days didn't fluctuate much compared to SW monsoon and Pre monsoon seasons. Both the increase in annual rainfall and rainy days across hoblis was greatly pushed up by four consecutive above-normal rainy seasons (2019-2022), but need to seen how much rain the coming years bring.

Conclusion

The annual rainfall and seasonal rainfall for SW monsoon and NE monsoon received over the past 10 years period (2013-23) for the hoblis of Gadag district has shown increasing trend in both the rainfall amount and rainy days. The increased annual rainfall and rainy days supplement the additional moisture to the soil profile, which in turn extends the crop growing period. The rainfall variability analysis at hobli level for Gadag district depicts low variability in the annual and SW monsoon rainfall data, while there is high variability in the pre-monsoon and NE monsoons. Among the hoblis, Gadag recieved the highest amount of annual rainfall (687.97 mm) and rainy days (58 days) across the seasons with lower variability which provides more stability for cultivation. As, Konnur and Mundaragi hoblis received the lowest amount of annual rainfall and rainy days across the seasons, they need to have more of scientific water harvesting structures and advanced water management strategies to reduce the risk of frequent crop failures. Further, such studies need to be undertaken for other districts of North Interior Karnataka at hobli level. Such studies will help farmers and agriculture department personnel to take rational decisions to build climate resilient system at hobli level.

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