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Decadal Analysis of Rainy Days and Extreme Rainfall Events in Different Agroclimatic Zones of Punjab

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ABSTRACT

In India, agriculture is dependent and influenced by Indian summer monsoon rainfall. The variation in rainfall during the pre-monsoon, monsoon, post monsoon and annual period plays the crucial role in crop choice, crop planning and crop productivity. The rainfall data of 68 years has been observed from 1951-2018 for different agroclimatic zones of Punjab, India. The data used to observe the increase or decrease of rainy days during the 7 decades (1951-60 to 2011-18). It has been concluded that the least number of rainy days were recorded at Bathinda during the decade 1951-60 and 1961-70 which later shifted to Sri Muktsar sahib where the least number of rainy days were recorded during the next 5 decades (1971-80, 1981-90, 1991-2000, 2001-10 and 2010-18). Maximum number of rainy days were recorded every year and also during monsoon season at Hoshiarpur during all decades, whereas, maximum number of rainy days during pre monsoon season were recorded at Gurdaspur. During post monsson season, maximum number of rainy days were recorded at Hoshiarpur during first 4 decades which later shifter to Gurdaspur (1191-2000, 2001-10 and 2011-18).Comparing the other decades by taking 1951-60 as a base, results showed that during annual and monsoon season, rainy day events increased up to the decade 1991-2000 and decreased afterwards while during pre monsoon season, rainy day events decreased up to 1971-80 and increased afterwards. Rainy day events decreased with time and least number of rainy days were during 2011-18.

Keywords: *agroclimatic zones, rainy days, pre-monsoon, monsoon, post-monsoon*

Introduction

The agriculture-based economy like India mainly dependent upon timely and adequate availability of water. The amount of rainfall received over a region plays the key role to meet the demand of water for agriculture, power generation, domestic water supply and other industries. Climate change globally impacts the pattern, intensity, duration and frequency of rainfall events. The southwest monsoon contributes for the 80 per cent of total rainfall over the whole country which received during June to September [1]. Climate change in the Indian region, mainly have a significant impact on the southwest monsoon and eventually affects the agriculture production of the country. In India, 60 % area under agriculture is rainfed so it is necessary to consider rainfall as a primary factor for crop planning. The changing rainfall behaviour in terms of distribution, intensity and frequency of rainfall results in the reduction in the productivity of crops [2]. The shortage of water accessibility is due to the delay in rainy season, dry spells during the wet season and reduction in the length of the growing season leads towards the crop failure.

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The information about rainy days can help plan adaption and mitigation to reduce vulnerability [3]. The analysis of rainfall trends is crucial to study the effect of change in climate on water resources [4]. The different studies showed a very diverse Pattern of rainfall at regional and national scales because of the disproportion in natural resources [5]. The rainfall at BallowalSaunkhri has been changed during the Annual, *kharif* and *rabi* season by -14.7, -12.9, and -1.9 mm/year, respectively [6]. The information about the rainfall of any particular area is based on the seasonal, monthly and annual rainfall data and the two main parameters that help to design abetter picture of rainfall conditions are a number of rainy days and rainfall intensity [7].

Recent studies have further explored the changing rainfall patterns in India, shedding light on the complex dynamics influencing precipitation trends. For instance, [8] conducted a comprehensive analysis of monsoon rainfall data, revealing spatial and temporal variations in extreme precipitation events across different regions of the country. Their findings suggest an intensification of extreme rainfall events in certain areas, particularly in coastal regions, while other parts of India experience variability in the frequency and intensity of heavy rainfall events.

Additionally, [9] investigated the role of climate change in shaping monsoon dynamics, emphasizing the influence of warming temperatures on atmospheric moisture content and convective processes. Their study highlights the intricate interplay between atmospheric circulation patterns, sea surface temperatures, and land surface characteristics in modulating rainfall variability during the monsoon season.

Furthermore, recent advancements in climate modeling techniques have enabled researchers to project future changes in monsoon precipitation patterns with greater accuracy. Studies by [10] utilized state-of-the-art climate models to assess the potential impacts of greenhouse gas emissions on monsoon

rainfall distribution and intensity. Their simulations indicate a heightened risk of extreme precipitation events and associated flooding in vulnerable regions, underscoring the urgent need for adaptive strategies and climate-resilient infrastructure.

Overall, these recent investigations contribute valuable insights into the evolving monsoon dynamics in India and the underlying factors driving changes in rainfall patterns. By integrating observations, modeling, and interdisciplinary approaches, researchers continue to enhance our understanding of the complex interactions between climate variability, land-atmosphere processes, and human influences on the monsoon system.

Recent research has provided valuable insights into the changing rainfall patterns across India, highlighting the need for further investigation into regional variations and their implications for local ecosystems and socio-economic activities. For instance, [11] conducted a comprehensive analysis of rainfall trends in different agroclimatic zones of Punjab, focusing on the pre-monsoon, monsoon, and post-monsoon periods. Their study revealed significant variability in annual rainy days and extreme rainfall events across the state, with certain districts experiencing a decrease in rainy days during the monsoon season and an increase in extreme precipitation events. Furthermore, [12] investigated the impact of climate change on agricultural productivity in Punjab, emphasizing the importance of understanding changing rainfall patterns for crop planning and water management strategies. Their findings underscored the need for adaptive measures to mitigate the potential risks posed by erratic rainfall and extreme weather events, particularly in regions dependent on rain-fed agriculture.

Moreover, recent studies have explored the linkages between rainfall variability and groundwater recharge in Punjab, given the region's heavy reliance on groundwater for irrigation and domestic purposes. [13] conducted hydrogeological assessments to examine the recharge potential of different aquifers in response to variations in precipitation patterns. Their findings highlight the importance of sustainable groundwater management practices to ensure water security in the face of changing climatic conditions. In light of these developments, the present study aims to build upon existing research by analyzing long-term rainfall data for Punjab's districts and exploring the spatial and temporal dynamics of precipitation trends. By identifying patterns of variability and extreme events, the study seeks to provide valuable insights for policymakers, farmers, and other stakeholders involved in water resource management and agricultural planning in the region.

Materials and Methods

Punjab is divided into 5 agroclimatic zones i.e., the Sub-mountain zone, Undulating plain zone, Western plain zone, Western zone, and Central plain zone which lie between 30° 09' to 31°06' N latitude and 74°55' to 76°23' E longitude respectively and 211-355 m above the mean sea level. As the study involved 20 districts of the state according to different agroclimatic zones, they are mentioned as follows:

1. Sub- Mountain undulating zone - Gurdaspur and Hoshiarpur

2. Undulating plain zone- Rupnagar, SBS Nagar and SAS Nagar

3. Central plain zone- Amritsar, Fatehgarh sahib, Jalandhar, Kapurthala, Patiala, Tarn Taran and Ludhiana

4. Western Plain zone- Ferozepur and Faridkot

5. Western zone- Muktsar, Mansa, Barnala, Moga, Bathinda and Sangrur

Data collection and analysis

The rainfall data from 1951-2018 of different districts were collected from India's meteorological department. If the rainfall in a day is more than 2.5mm it is considered as rainy day. So, rainy days has been analyzed decade-wise during pre-monsoon (March, April, May), monsoon (June, July, August, September), post-monsoon (October, November, December, January, February)and for annual period.

The contribution of rainfall events to annual and monsoon rain specifies the temporal variation in the distribution of rainfall over the whole year, so extreme events of rainfall are calculated by adding the rainfall of rainy days in continuous for the whole year.

Results and Discussion

Decade-wise analysis of rainy days was conducted and the results are explained as under:

1951-60

During the decade 1951-60 (fig 1), the annual rainy day events ranges from 223 (Bathinda) to 657 (Hoshiarpur), indicating significant variations in rainy day events among the districts. Thenumber of rainy day events during the pre-monsoon season ranged between 21 (Bathinda) to 72 (Gurdaspur). This suggests that Gurdaspur district experienced higher pre-monsoon rainy day events compared to other districts. During monsoon season, rainy day events varied from 158 (Bathinda) to 464 (Hoshiarpur) indicating that Hoshiarpur district has the highest number of rainy days during monsoon, indicating a relatively wetter monsoon season compared to other districts. The number of rainy day events during the post-monsoon season ranged between 41 (Sri Muktsar Sahib) to 134 (Hoshiarpur) Hoshiarpur district again shows the highest post-monsoon rainfall, indicating a relatively wetter post-monsoon season compared to other districts.

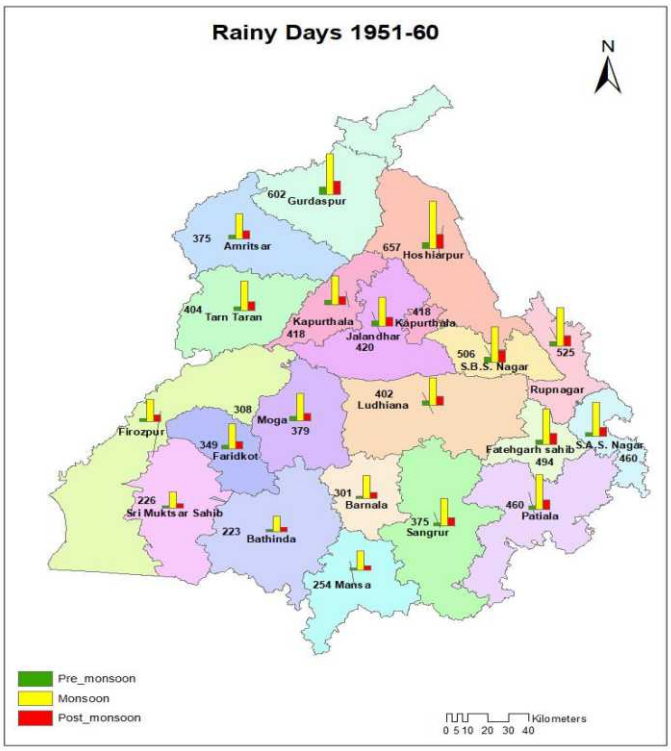

Fig. 1: Variation in the number of rainy days in different districts of Punjab during the decade 1951-60

1961-70

Analysis of rainy days during the decade 1961-70 (fig 2) indicatedthe annual rainy day events ranged from 223 (Bathinda) to 668 (Hoshiarpur), indicating significant variations in rainy day events among the districts (Table 1). The number of rainy-day events during the pre-monsoon season ranged between 17 (Bathinda) to 12 (Gurdaspur). This suggests that Gurdaspur district experienced higher pre-monsoon rainy day events compared to other districts. During monsoon season, rainy day events varied from 168 (Bathinda) to 482 (Hoshiarpur) indicating that Hoshiarpur district has the highest rainy days during monsoon, indicating a relatively wetter monsoon season compared to other districts. The number of rainy day events during the post-monsoon season ranged between 43 (Sri Muktsar Sahib) to 130 (Hoshiarpur). Hoshiarpur district again shows the highest post-monsoon rainfall, indicating a relatively wetter post-monsoon season compared to other districts.

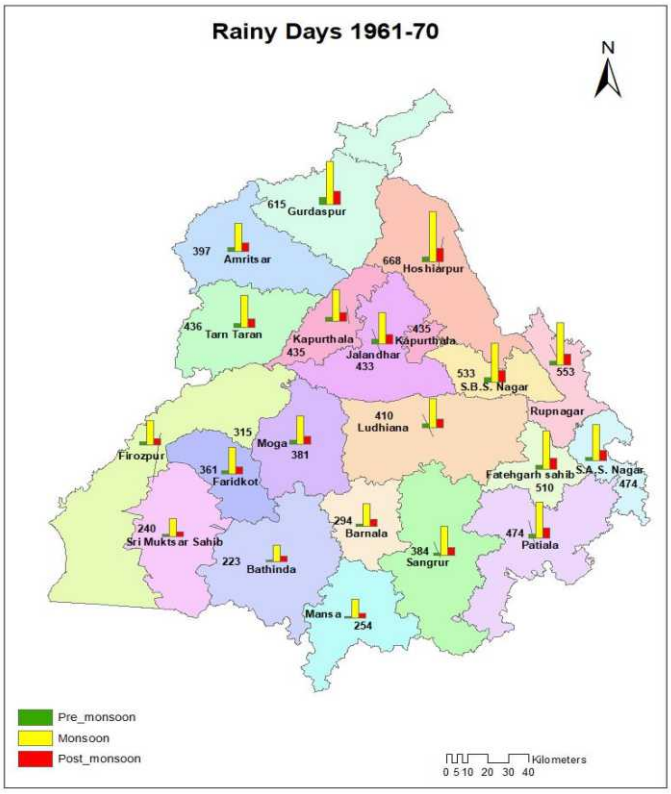

Fig.2: Variation in the number of rainy days in Punjab during the decade 1961-70

1971-80

Analysis of rainy days during different seasons was studied during the decade 1971-80 and represented in Fig 3. Results indicated a maximum number of rainy days recorded annually at Hoshiarpur District (676) followed by the least number of rainy days at Sri Muktsar sahib (232) (Table 1). During pre-monsoon season, maximum number of rainy days was recorded at Gurdaspur (67) and the least at Sri Muktsar sahib (22). During monsoon season, rainy day events varied from 166 (Sri Muktsar sahib) to 496 (Hoshiarpur) indicating that Hoshiarpur district has the highest rainy days during monsoon, indicating a relatively wetter monsoon season compared to other districts. The number of rainy day events during the post-monsoon season ranged between 41 (Sri Muktsar Sahib) to 1324 (Hoshiarpur). Hoshiarpur district again shows the highest post-monsoon rainfall, indicating a relatively wetter post-monsoon season compared to other districts.

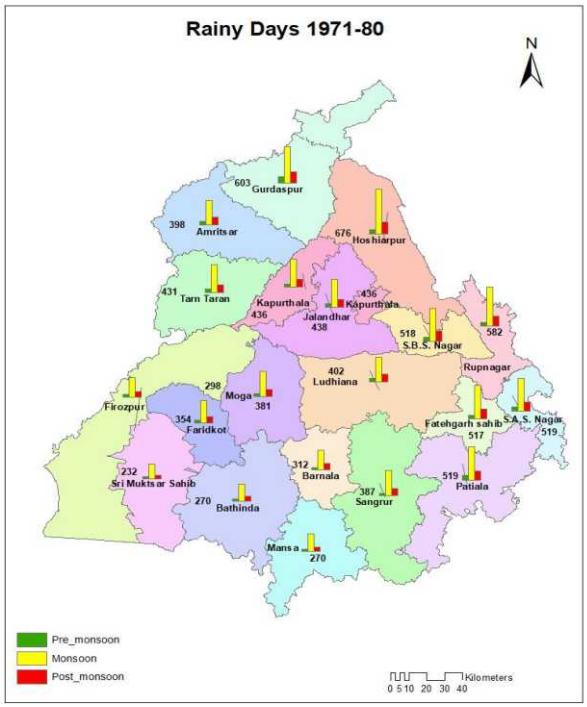

Fig.3: Variation in the number of rainy days in Punjab during the decade1971-80

1981-90

Analysis of rainy days during the decade 1981-90 (fig 4) indicated annual rainy day events ranged from 230 (Sri Muktsar Sahib) to 674 (Hoshiarpur), indicating significant variations in rainy day events among the districts (Table 1). The number of rainy day events during the pre-monsoon season ranged between 23 (Sri Muktsar Sahib) to 76 (Gurdaspur). This suggested that Gurdaspur district experienced higher pre-monsoon rainy day events compared to other districts. During monsoon season, rainy day events varied from 166 (Sri Muktsar Sahib) to 491 (Hoshiarpur) indicating that Hoshiarpur district has the highest rainy days during monsoon, indicating a relatively wetter monsoon season compared to other districts. The number of rainy day events during the post-monsoon season ranged between 35(Sri Muktsar Sahib) to 120 (Hoshiarpur). Hoshiarpur district again showed the highest post-monsoon rainfall, indicating a relatively wetter post-monsoon season compared to other districts.

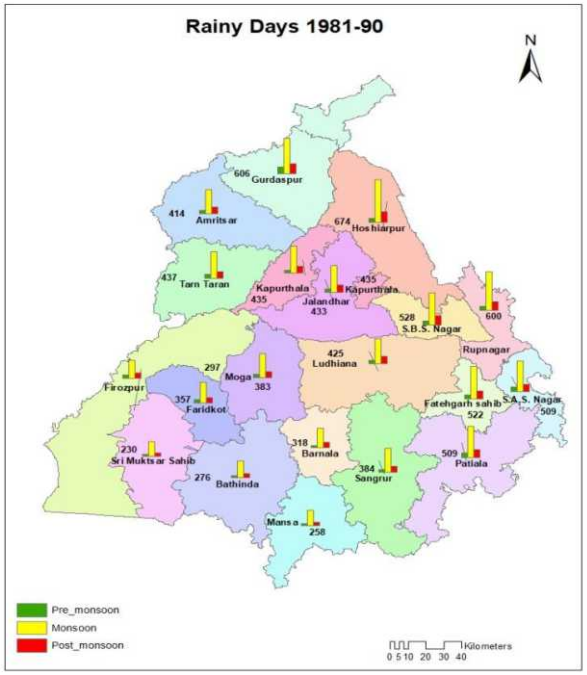

Fig.4: Variation in the number of rainy days in Punjab during the decade 1981-90

1991-2000

During the decade 1991-2000 (fig 5), a maximum number of rainy days was recorded annually at the Hoshiarpur district (659) and least at Sri Muktsar sahib (224)(Table 1). During pre-monsoon and post-monsoon seasons, maximum number of rainy days was recorded at Gurdaspur (79 during pre-monsoon and 124 during post monsoon), whereas, during monsoon season, Hoshiarpur indicated the highest number of rainy days (489). At Sri Muktsar Sahib, least number of rainy days was recorded during pre-monsoon (24) and monsoon season (166) and post monsoon season (30).

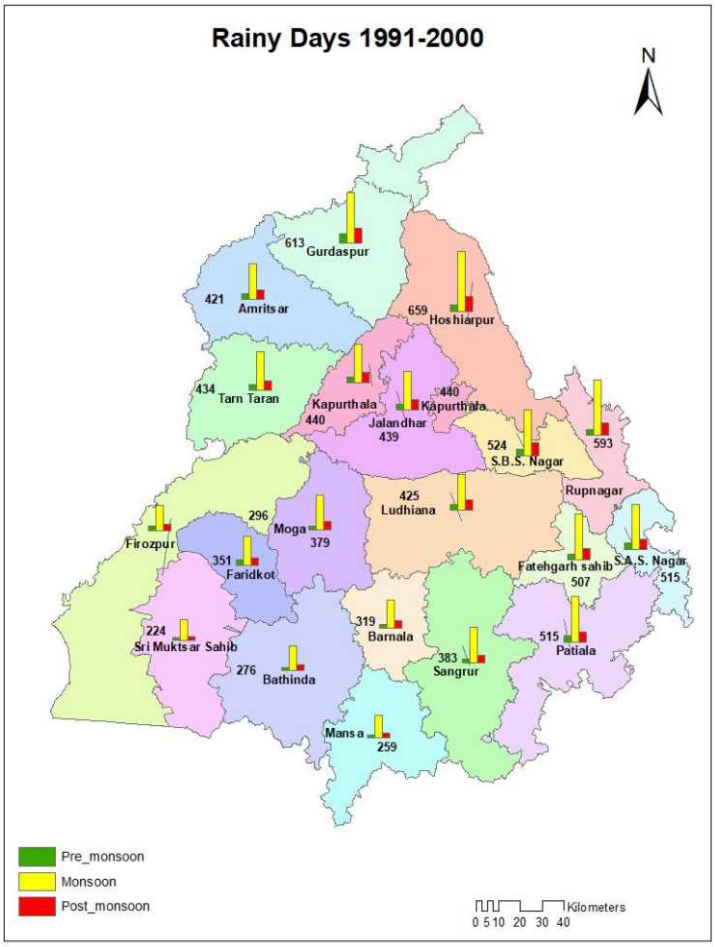

Fig.5: Variation in the number of rainy days in Punjab during the decade 1991-2000

2001-10

During the decade 2001-10 annual rainy day events which are represented inFig 6, ranges from 213 (Sri Muktsar Sahib) to 639 (Hoshiarpur), indicating significant variations in rainy day events among the districts (Table 1). The number of rainy day events during the pre-monsoon season ranged between 21 (Sri Muktsar Sahib) to 86 (Gurdaspur). This suggested that Gurdaspur district experienced higher pre-monsoon rainy day events compared to other districts. During monsoon season, rainy day events varied from 165 (Sri Muktsar Sahib) to 468 (Hoshiarpur) indicating that Hoshiarpur district has the highest rainy days during monsoon, indicating a relatively wetter monsoon season compared to other districts. The number of rainy day events during the post-monsoon season ranged between 27 (Sri Muktsar Sahib) to 120 (Gurdaspur). Gurdaspur district showed the highest post-monsoon rainfall, indicating a relatively wetter post-monsoon season compared to other districts.

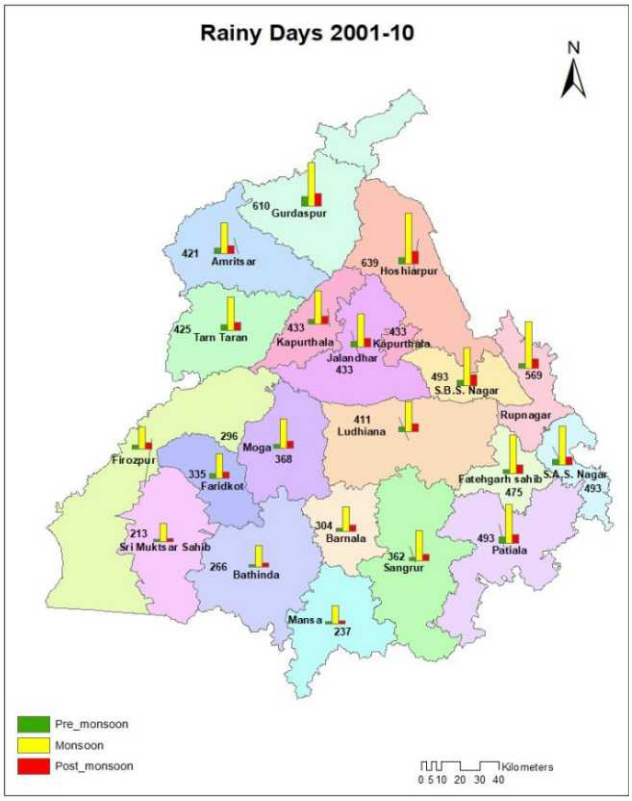

Fig.6: Variation in the number of rainy days in Punjab during the decade 2001-10

2011-18

During the period 2011-18 (fig 7), maximum number of rainy days was recorded annually at the Hoshiarpur district (639)(Table 1). During pre-monsoon and post monsoon season, maximum number of rainy days was recorded at Gurdaspur (88 during pre-monsoon and 111 during post-monsoon), whereas, during monsoon season, Hoshiarpur indicated the highest number of rainy days (456). At Sri Muktsar Sahib, least number of rainy days was recorded during annual (203), pre monsoon (19) and monsoon season (158), and post monsoon season (23).

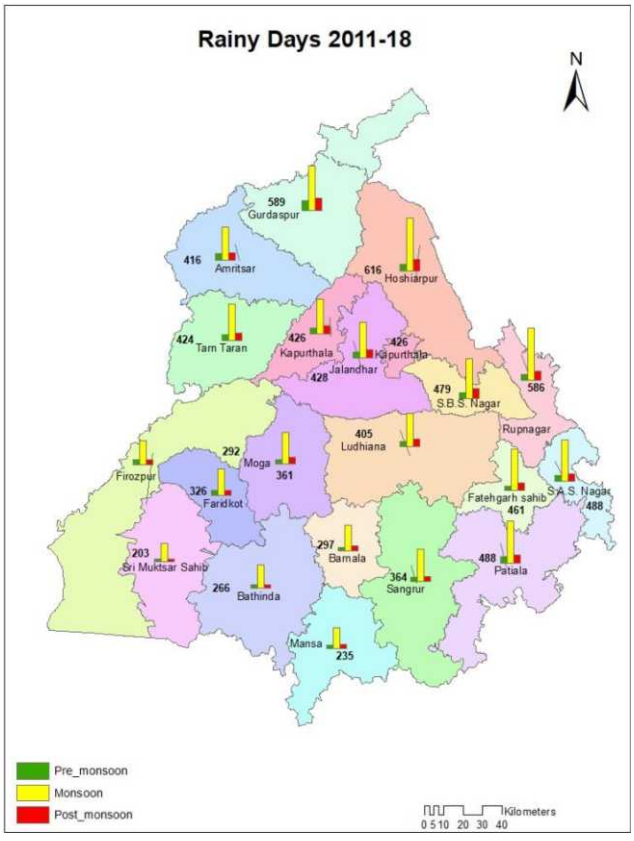

Fig.7: Variation in the number of rainy days in Punjab during the decade 2011-18

Table 1: decadal rainy days range during different seasons

		Rainy days			
		Annual	**Pre-monsoon**	**Monsoon**	**Post- monsoon**
1951-60	Minimum	223	21	158	41
	Maximum	657	72	464	134
1961-70	Minimum	223	17	161	43
	Maximum	668	71	482	130
1971-80	Minimum	232	22	166	41
	Maximum	676	67	496	132
1981-90	Minimum	230	23	166	35
	Maximum	674	76	491	120
1991-2000	Minimum	224	24	166	30
	Maximum	659	79	489	124
2001-10	Minimum	213	21	165	27
	Maximum	639	86	468	120
2011-18	Minimum	203	19	158	23
	Maximum	616	88	456	111

Decadal comparison

For comparing decade-wise rainy day events, the 1951-60 decade was taken as a base to compare other decades. Decade-wise comparison of annual rainy days (fig 8) indicated that for Amritsar, Patialaand Rupnagar, the number of rainy days increased from 1951-60 to 2011-18. Barnala, Kapurthala, Ludhiana, SAS nagar and Tarn Taran showed that rainy days events increased till the decade 1991-2000 and decreased afterward. For the districts, Faridkot, Fatehgarh, Ferozepur, Gurdaspur, Hoshiarpur, Mansa, Moga, Sri Muktsar Sahib, SBS nagar and Sangrur rainy days events decreased with time and the least number of rainy days were recorded during 2011-18. For overall Punjab state, per cent rainy day increased annually by 3.1 % during 1961-70,5.0 % during 1971-80, 5.6 % during 1981-90, 5.3 % during 1991-2000 which then decreased by 1.7 % during 2001-10 and only 0.1 % rainy day increased during 2011-18.

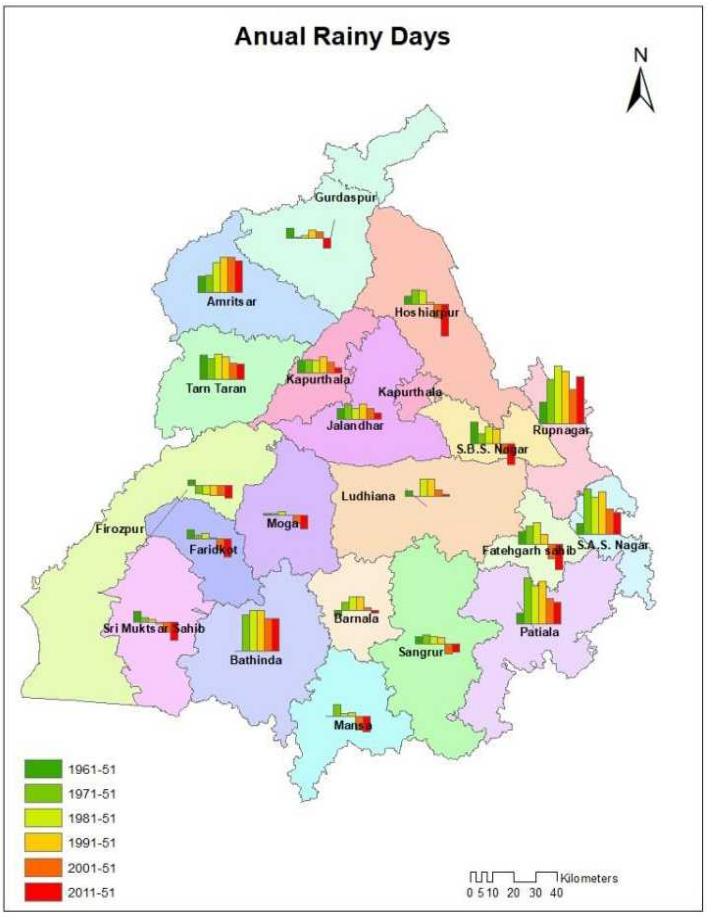

Fig.8: Comparison of annual rainy days in different districts of Punjab during different decades

A decadal comparison of rainy days during pre-monsoon season represented as fig 9, indicated that rainy day events decreased with time for the districts Fatehgarh, Hoshiarpur, Moga, and Sri Muktsar sahib. For the rest 16 districts, decade wise increase in a number of rainy-day events was observed. For overall Punjab state, per cent rainy day decreased during pre-monsoon season by 9.1 % during 1961-70 and by 6.8 % during 1971-80. It started increasing by 3.8 % during 1981-90, 8.2 % during 1991-2000,12.0 % during 2001-10 and a maximum of 13.2 % rainy days increased during 2011-18.

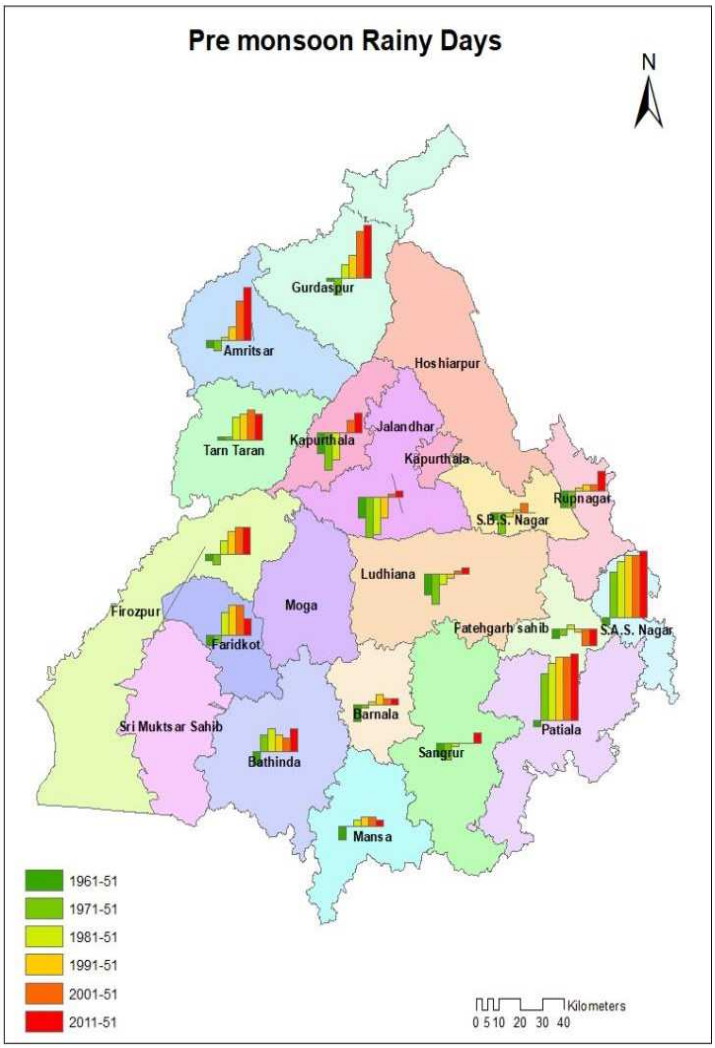

Fig.9: Comparison of pre-monsoon rainy days in different districts of Punjab during different decades

A comparison of rainy days during the monsoon season (fig 10) indicated that for the districts Amritsar, Bathinda, Rupnagar,and Tarn Taran rainy day events increased with time. For the districts Fatehgarh, Gurdaspur, Hoshiarpur, Jalandhar, Kapurthala, Ludhiana, Moga, SBS Nagar, Patiala, SAS Nagar and Sangrur, rainy day events increased up to 2000-01 and then started decreasing afterward. For overall Punjab state, percent rainy day increased during monsoon period by 4.7 % during 1961-70 and 6.1 % during 1971-80, 6.0 % recorded during 1981-90, 7.8 % during 1991-2000, 4.4 % during 2001-10 and 3.8 % was calculated during 2011-18.

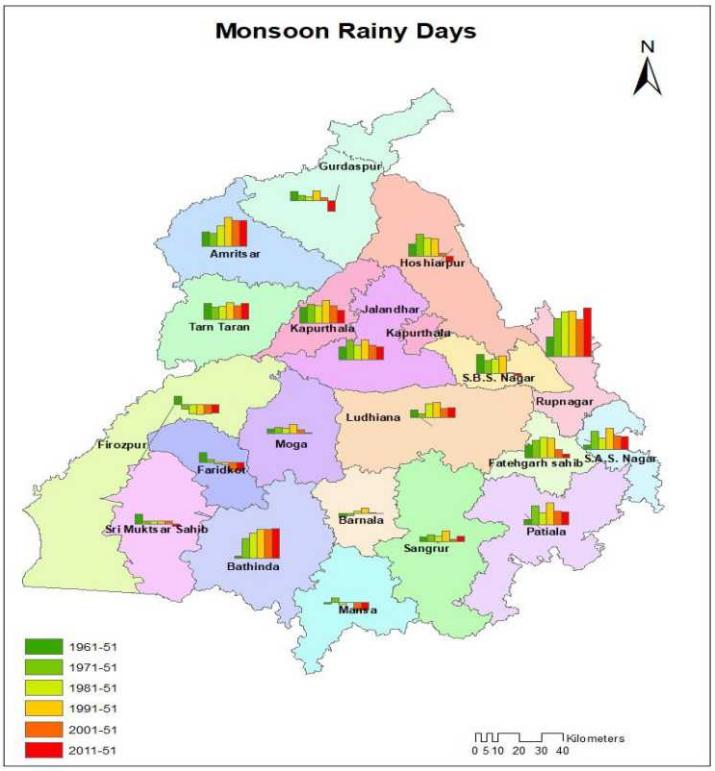

Fig.10: Comparison of monsoon rainy days in different districts of Punjab during different decades

A comparison of rainy days during the post-monsoon season (fig. 11) indicated that for all 20 districts of Punjab, rainy day events decreased with time. For Punjab state, per cent rainy days increased during post-monsoon period by 1.6 % during 1961-70 and 2.1 % during 1971-80. It started decreasing with time and loss of rainy day by 6.4 % was recorded during 1981-90, 8.7 % during 1991-2000, 14.6 % during 2001-10 and a maximum decrease of 27.0 % was calculated during 2011-18.

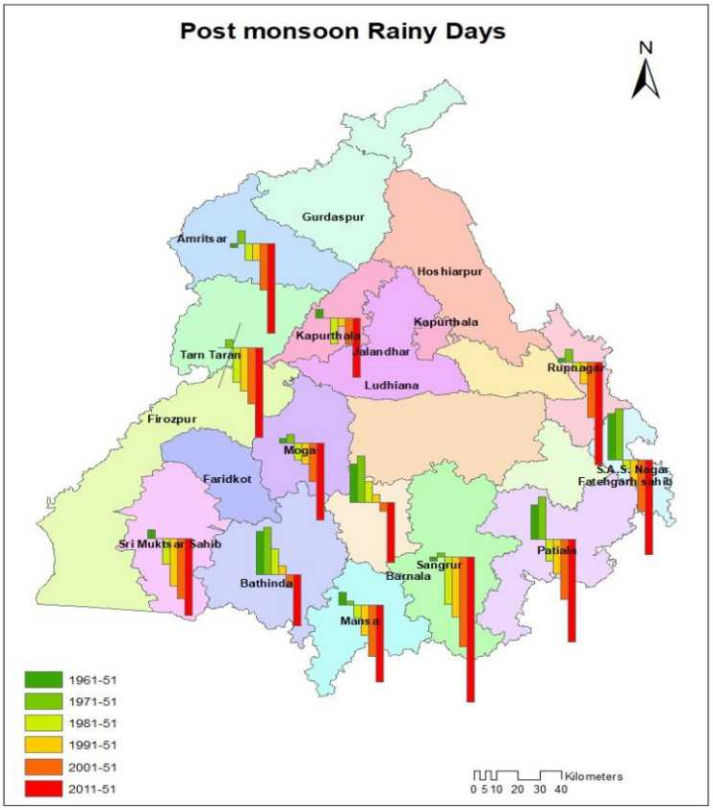

Fig.11: Comparison of post-monsoon rainy days in different districts of Punjab during different decades

Conclusion

The findings suggest an overall increasing trend in the number of rainy days in Punjab during the last seven decades. This could be attributed to climate change and global warming, leading to enhanced atmospheric moisture content and increased atmospheric instability, thereby favoring more frequent rainfall events. The study identifies decadal variations in the number of rainy days. Some decades exhibit higher numbers of rainy days compared to others, highlighting the influence of natural climate cycles, such as the El Niño Southern Oscillation (ENSO) or the Indian Ocean Dipole (IOD), on regional precipitation patterns. Understanding the long-term trends and decadal variations can assist in developing adaptive strategies for agricultural practices, such as irrigation management and crop diversification. Changes in the number of rainy days affect the recharge of groundwater aquifers and the availability of surface water resources. Adequate planning and infrastructure development, including water storage and conservation systems, can help mitigate the impacts of fluctuating rainfall patterns.

Authors' Contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

References

1. Ajayamohan, R.S., Merryfield, W.J., & Kharin,V.V. (2010). Increasing trend of synoptic activity and its relationship with extreme rain events over Central India. *J. Clim.*, 23: 1004–1013.

2. Allan, R.P. & Soden B.J. (2008). Atmospheric warming and the amplification of precipitation extremes. *Sci.,* 12:1481-84.

3. Apata, T.G. (2010). Effects of global climate change on Nigerian agriculture: an empirical analysis. *J. App. Stat.,* 2:45-60.

4. Dash, S.K., Kulkarni, M. A., Mohanty, U.C., & Prasad, K. (2009). Changes in the characteristics of rain events in India. *J. of Geophysical Research*, 114, D10109, doi:10.1029/2008JD010572.

5. Feizi, V., Mollashahi, M., Frajzadeh, M., & Azizi, G. (2015). Spatial and Temporal Trend Analysis of Temperature and Precipitation in Iran. *Ecopersia,* 2:727-42.

6. Goswami, B. N., Venugopal, V., Sengupta, D., Madhusoodanan, M. S., & Xavier, P. K. (2006). Increasing trend of extreme rain events over India in a warming environment. *Sci.*, 314(5804):1442-44.

7. Guhathakurta, P., Sreejith, O. P., & Menon, P. A. (2011). Impact of climate change on extreme rainfall eventsand flood risk in India. *J Earth Syst Sci.,* 120-359-65.

8. Nandargi, S., & Mulye, S. S. (2012). Relationships between Rainy Days, Mean Daily Intensity, and Seasonal Rainfall over the Koyna Catchment during 1961–2005. *The Scientific World J.*, Volume 2012, Article ID 894313, 10 pages

9. Pattanaik, D. R., & Rajeevan, M. (2009). Variability of extreme rainfall events over India 568 during southwest monsoon season. *J. Royal Meteorological Society*, 17: 88–104.

10. Rawat, K. S., Pal, R. K., Singh, S. K., Kumar, S., & Danu, R. (2022, November). Decadal changes in rainfall and temperature extreme in western agro-climatic zone of Punjab. In *AIP Conference Proceedings* (Vol. 2481, No. 1). AIP Publishing.

11. Prabhjyot-Kaur, Kaur, N., & Singh, H. (2016). Near- and long-term projected changes in extreme weather events in Ludhiana district of Indian Punjab. *Agric Res J.,* 53(3):360-366.

12. Sahai, A. K., Grimm, A. M., Satyan, V., & Pant, G.B. (2003). Long-lead prediction of Indian summer monsoon rainfall from global SST evolution. *Clim. Dyn.,* 20: 855–63.

13. Sahu, R. K., & Khare, D. (2015). Spatial and temporal analysis of rainfall trend for 30 districts of a coastal state (Odisha) of India. *Int. J. Geol. Earth Sci.,* 5: 40-53.