



# International Journal of Research in Agronomy

E-ISSN: 2618-0618  
P-ISSN: 2618-060X  
© Agronomy  
NAAS Rating (2026): 5.20  
[www.agronomyjournals.com](http://www.agronomyjournals.com)  
2026; SP-9(8): 06-11  
Received: 11-05-2026  
Accepted: 15-06-2026

**Indianraj N**  
Department of Agronomy,  
PAJANCOA & RI, Karaikal,  
Puducherry, India

**AL Narayanan**  
Department of Agronomy,  
PAJANCOA & RI, Karaikal,  
Puducherry, India

**Santosh Kumar Meena**  
Department of Agronomy,  
PAJANCOA & RI, Karaikal,  
Puducherry, India

**L Aruna**  
Department of Soil Science and  
Agrl. Chemistry, PAJANCOA &  
RI, Karaikal, Puducherry, India

**S Nadaradjan**  
Department of Crop Physiology,  
PAJANCOA & RI, Karaikal,  
Puducherry, India

**S Mala**  
Department of Agronomy,  
PAJANCOA & RI, Karaikal,  
Puducherry, India

**J Gokila**  
Department of Agronomy,  
PAJANCOA & RI, Karaikal,  
Puducherry, India

**Corresponding Author:**  
**Indianraj N**  
Department of Agronomy,  
PAJANCOA & RI, Karaikal,  
Puducherry, India

## Assessing impact of climate change on rainfall patterns of Karaikal region, Puducherry, India

**Indianraj N, AL Narayanan, Santosh Kumar Meena, L Aruna, S Nadaradjan, S Mala and J Gokila**

**DOI:** <https://www.doi.org/10.33545/2618060X.2026.v9.i8Sa.6177>

### Abstract

Global climate change may have a significant effect on several environmental components in many different nations worldwide. Variations in the pattern of precipitation have an immediate impact on the management of water resources. To improve water resource management techniques, it is critical to investigate differences in the temporal and geographical rainfall patterns. The current study looks at rainfall patterns in the Karaikal region, Union Territory of Puducherry. Utilizing the mean monthly data from rain gauge location and analysed rainfall statistics over an extensive timespan of 29 years (1996–2024). For precision in temporal categorization, this data was meticulously divided into four seasonal classifications: summer, winter, southwest monsoon (SWM), and northeast monsoon (NEM). The region receives an average of 1347.96 mm of precipitation each year, with the summer, winter, SW monsoon, and NE monsoon providing 103.94 mm, 79.25 mm, 250.46 mm, and 914.30 mm, respectively. The data were used to calculate weekly, monthly, yearly and seasonal average rainfall.

**Keywords:** Climate change, rainfall pattern, SWM, NEM and probability of rainfall

### Introduction

Climate change is a global phenomenon that significantly influences atmospheric processes, particularly precipitation patterns. Changes in rainfall distribution, intensity, and frequency can have profound effects on water resource management, agriculture, and overall ecosystem sustainability (IPCC, 2021) [2]. The Indian subcontinent, particularly coastal regions, is highly vulnerable to climate-induced variations in precipitation, making it essential to study long-term trends in regional rainfall patterns (Guhathakurta *et al.*, 2015) [3].

Karaikal is situated on the east coast of India, near latitude 11°N in the deltaic region of the Cauvery, experiences tropical maritime type of climate with small daily range of temperature and moderate rainfall (Pai *et al.*, 2014 and Dash *et al.*, 2009) [8, 1]. Karaikal has an annual average rainfall of about 126 cm. 68 percent of which occurs during October to December. The amount of rainfall during the south-west monsoon period is small, being less than 20 per cent of the annual. November is the rainiest month, accounting for about a third of the annual total. The range of variation of annual rainfall is wide (IMD, 2023) [4]. As monsoonal rainfall plays a critical role in agriculture, groundwater recharge, and water resource planning, any alterations in its distribution or intensity can pose challenges to local communities and policymakers (Kripalani & Kulkarni, 1997; Roxy *et al.*, 2017) [6, 10]. Several studies have highlighted shifting monsoon patterns across India, with evidence of decreasing rainfall in some regions and increasing extreme rainfall events in others (Rajeevan *et al.*, 2008; Kothawale *et al.*, 2010) [9, 5]. However, there is limited region-specific analysis focusing on the long-term rainfall variability in Karaikal. Understanding precipitation trends in this region is crucial, as it can aid in climate adaptation strategies, water conservation planning, and disaster preparedness (Nair *et al.*, 2018) [7].

### Study Area

The Union Territory of Puducherry consists of two districts, viz., Puducherry and Karaikal, situated at different geographical locations isolated from one another. Puducherry District

comprises Puducherry, Mahe and Yanam regions. Karaikal region forms the Karaikal District. Karaikal region is about 130 Km. south of Puducherry and is sandwiched by Nagapattinam District of Tamil Nadu. It is located between 10° 49' and 11° 01' N, and 79° 43' and 79° 52' E. Forming part of fertile delta, the Karaikal region is completely covered by the distributaries of

Cauvery River. Covered completely by a thick mantle of alluvium of variable thickness, the region is flat having gentle slope towards Bay of Bengal in the east. It is limited on the north by the Nandalar and on the south east by the Vettar. The group of rocks known as Cuddalore formations is contiguous to along with those in the Tanjore District.

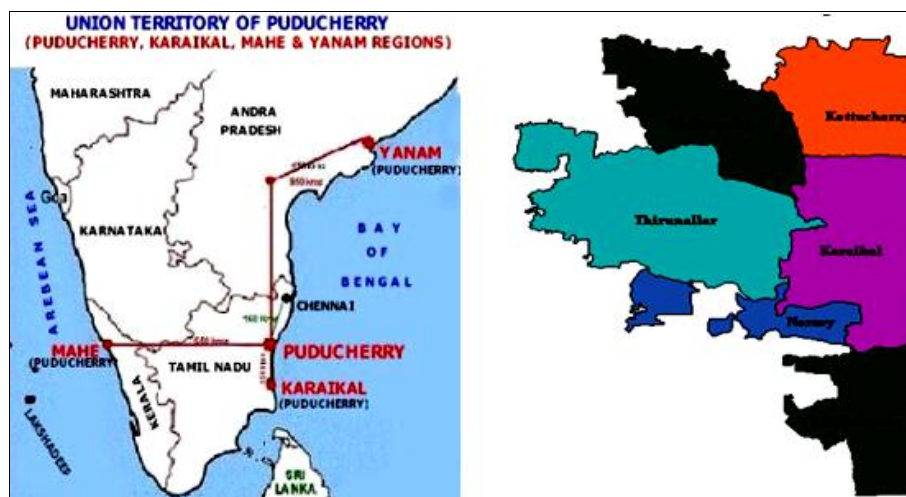


Fig 1: Location of Karaikal district in U.T of Puducherry

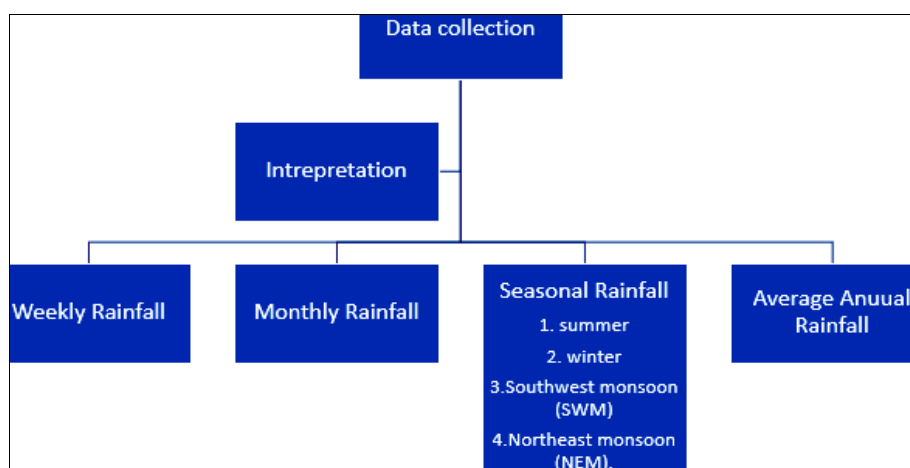


Fig 2: Assessment of Rainfall Data Methodology.

## Materials and Methods

The daily precipitation records were kindly furnished by the Department of Agronomy, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal, U.T of Puducherry. Subsequently, these data points were methodically categorised according to average seasonal rainfall patterns during the post-monsoon period encompassing January and February. It should be noted that March through May are identified as pre-monsoon months whereas June through September fall within the realm of Southwest monsoon months. Lastly, October to December is acknowledged as Northeast monsoon timeframe. This allowed for the computation of the average annual rainfall for the previous 29 years. The rainfall station in the investigation region of Karaikal, are utilised to calculate twenty nine years of rainfall data (1996–2024). The data were used to calculate weekly, monthly, annual and seasonal average rainfall. The yearly average rainfall was finally calculated and interpreted using the data specified above. The mean, standard deviation (SD), and coefficient of variation (CV) of rainfall were calculated using Microsoft Excel to analyze the variability and distribution of precipitation patterns in the Karaikal region. These statistical

measures provide insights into the consistency and fluctuation of rainfall over the study period, aiding in the assessment of long-term climatic trends.

## Mean weekly, monthly and annual analysis

### Co-efficient of variation

Co-efficient, of variation is used to understand the behavior of rainfall in terms of its variability over time. Higher the CV, lower the dependability and vice versa. There is a strong relationship exists between CV and rainfall dependability.

### Procedure

The variability of rainfall is determined by working out the CV. It is a unit free measure and always expressed in percentage. The formula based in this method is

$$CV = \frac{SD}{\bar{X}} * 100$$

Where,  
CV = Co-efficient of variation.

SD = Standard deviation

$\bar{X}$  = Mean

For doing such analysis, rainfall data from long term records are required atleast for a block of 30 years for more precision on results. The following are the threshold levels of CV for any interpretation.

#### Period CV Permissible

- Yearly rainfall: It must be < 25 per cent.
- Seasonal rainfall: < 50 per cent.
- Monthly rainfall: < 100 per cent.
- Weekly rainfall: < 150 per cent.
- Daily rainfall: < 250 per cent.

(Veeraputhiran *et al.*, 2003) <sup>[11]</sup>.

The rainfall data of Karaikal from 1996-2024 were analysed for CV and the results are presented here under.

### Results and Discussion

#### 1. Weekly rainfall and CV (%) (Table 1)

The analysed data reveals a higher value for the 13<sup>th</sup> std week i.e. 32500% which shows that the dependability of getting 0.10mm is very low. A lowest CV value is found in the 45<sup>th</sup> std week (25.7%) which shows that there is a higher dependability of rainfall in this week.

#### 2. Monthly rainfall (Table 2)

The data indicates that the highest mean monthly rainfall is recorded during November (427.45 mm) followed by October (282.57 mm) and this was 31 and 20 per cent to the total mean

annual rainfall respectively.

By considering the CV, the month November registered the lowest CV (60%) followed by October (61%) indicating more dependability during these months. For monthly rainfall the threshold level of CV range of 50-100 per cent was associated with July to October and December this indicated the great dependability of rainfall in these months as compared to other months.

During January to June highest CV value (more than or equal 100 per cent) indicates the less dependability of getting rainfall during these months.

#### 3. Annual

The mean annual rainfall of Karaikal was 1347.96 mm and the annual CV is 29.22 percent.

#### 4. Seasonal rainfall (Table 3)

The data reveals that the highest mean seasonal rainfall of 914.30 mm is recorded during North East Monsoon (NEM) season was followed by Southwest Monsoon (SWM) season (250.46 mm). The mean summer rainfall received is 103.94 mm and that of winter season is 79.25 mm. The contribution to mean annual rainfall by NEM, SWM, summer and winter seasons is 68.94, 18.88, 7.8 and 5.9 per cent respectively

Considering the CV it is observed that NEM received the lowest CV (68.85 percent) followed by the SWM (82.15 percent) for summer season (147.19 percent). The highest CV of 157.35 percent is found for winter season indicating higher rainfall variability during this season. Thus from CV study it can be inferred that the possibility of getting higher% rainfall lies with NEM followed by SWM, SUMMER and WINTER.

**Table 1:** Mean standard weeks and CV (%) from 1996-2024

| Std weak |                | Std week mean | CV%    | Descending order Rainfall (cv%) | Order number |
|----------|----------------|---------------|--------|---------------------------------|--------------|
| 1        | JAN 1-7        | 12.70         | 217.33 | 32500.0                         | 1            |
| 2        | JAN 8-14       | 14.76         | 253.22 | 2031.3                          | 2            |
| 3        | JAN 15-21      | 7.80          | 259.80 | 955.9                           | 3            |
| 4        | JAN 22-28      | 1.55          | 276.35 | 902.8                           | 4            |
| 5        | JAN 29- FEB 4  | 8.19          | 475.62 | 855.3                           | 5            |
| 6        | FEB 5-11       | 10.76         | 329.51 | 792.7                           | 6            |
| 7        | FEB 12-18      | 5.41          | 411.21 | 792.7                           | 7            |
| 8        | FEB 19-25      | 4.41          | 319.49 | 773.8                           | 8            |
| 9        | FEB 26- MAR 4  | 3.26          | 350.91 | 722.2                           | 9            |
| 10       | MAR 5-11       | 10.54         | 285.09 | 722.2                           | 10           |
| 11       | MAR 11-18      | 7.69          | 360.02 | 677.1                           | 11           |
| 12       | MAR 19-25      | 3.13          | 518.05 | 637.3                           | 12           |
| 13       | MAR 26- APR 1  | 2.82          | 447.59 | 560.3                           | 13           |
| 14       | APRIL 2-8      | 6.89          | 491.06 | 464.3                           | 14           |
| 15       | APRIL 9-15     | 8.43          | 281.91 | 433.3                           | 15           |
| 16       | APRIL 16-22    | 3.99          | 208.16 | 416.7                           | 16           |
| 17       | APRIL 23-29    | 4.14          | 283.26 | 406.3                           | 17           |
| 18       | APR 30- MAY 6  | 10.56         | 286.89 | 386.9                           | 18           |
| 19       | MAY 7-13       | 7.73          | 211.53 | 386.9                           | 19           |
| 20       | MAY 14-20      | 12.06         | 174.45 | 373.6                           | 20           |
| 21       | MAY 21-27      | 6.77          | 189.88 | 357.1                           | 21           |
| 22       | MAY 28- JUNE 3 | 11.21         | 298.62 | 331.6                           | 22           |
| 23       | JUNE 4-10      | 15.49         | 156.35 | 306.6                           | 23           |
| 24       | JUNE 11-17     | 7.50          | 208.73 | 303.7                           | 24           |
| 25       | JUNE 18-24     | 5.20          | 216.66 | 253.9                           | 25           |
| 26       | JUNE 25-JULY 1 | 3.55          | 294.04 | 222.6                           | 26           |
| 27       | JULY 2-8       | 8.35          | 201.30 | 219.6                           | 27           |
| 28       | JULY 9-15      | 8.66          | 202.23 | 219.6                           | 28           |
| 29       | JULY 16-22     | 9.70          | 184.73 | 218.1                           | 29           |
| 30       | JULY 23-29     | 13.65         | 148.22 | 212.4                           | 30           |
| 31       | JULY 30-AUG 5  | 14.12         | 128.54 | 209.7                           | 31           |

|    |               |        |        |       |    |
|----|---------------|--------|--------|-------|----|
| 32 | AUG 6-12      | 12.59  | 145.00 | 194.6 | 32 |
| 33 | AUG 13-19     | 19.00  | 117.94 | 184.7 | 33 |
| 34 | AUG 20-26     | 25.24  | 129.99 | 160.9 | 34 |
| 35 | AUG 27- SEP 2 | 20.48  | 149.36 | 151.9 | 35 |
| 36 | SEP 3-9       | 12.91  | 161.94 | 136.6 | 36 |
| 37 | SEP 10-16     | 18.26  | 117.81 | 131.0 | 37 |
| 38 | SEP 17-23     | 27.52  | 147.61 | 114.8 | 38 |
| 39 | SEP 24-30     | 21.55  | 144.75 | 111.3 | 39 |
| 40 | OCT 1-7       | 29.27  | 119.01 | 107.6 | 40 |
| 41 | OCT 8-14      | 31.06  | 119.92 | 104.2 | 41 |
| 42 | OCT 15-21     | 55.39  | 103.48 | 100.9 | 42 |
| 43 | OCT 22-28     | 105.23 | 110.88 | 93.7  | 43 |
| 44 | OCT 29- NOV 5 | 108.59 | 99.94  | 59.7  | 44 |
| 45 | NOV 6-11      | 163.83 | 110.44 | 59.7  | 45 |
| 46 | NOV 12-18     | 90.71  | 147.10 | 56.8  | 46 |
| 47 | NOV 19-25     | 104.83 | 91.77  | 40.9  | 47 |
| 48 | NOV 26- DEC 2 | 87.10  | 100.78 | 35.9  | 48 |
| 49 | DEC 3-9       | 71.39  | 134.96 | 30.1  | 49 |
| 50 | DEC 10-16     | 49.11  | 122.73 | 28.0  | 50 |
| 51 | DEC 17-23     | 47.97  | 129.42 | 27.8  | 51 |
| 52 | DEC 24-31     | 43.88  | 205.58 | 25.7  | 52 |

**Table 2:** Mean monthly and CV (%) from 1996-2024

| Month     | Mean RF (mm) | CV (%)   | Descending order (cv%) | Order number |
|-----------|--------------|----------|------------------------|--------------|
| January   | 66.6         | 154.6096 | 262.6663               | 1            |
| February  | 12.65172     | 171.7897 | 171.7897               | 2            |
| March     | 19.24483     | 262.6663 | 154.6096               | 3            |
| April     | 44.04828     | 141.9977 | 141.9977               | 4            |
| May       | 40.64828     | 98.15904 | 107.6808               | 5            |
| June      | 35.33448     | 107.6808 | 98.15904               | 6            |
| July      | 51.92759     | 97.30661 | 97.30661               | 7            |
| August    | 86.43103     | 64.71059 | 96.58964               | 8            |
| September | 76.77586     | 79.79099 | 79.79099               | 9            |
| October   | 282.5759     | 61.59874 | 64.71059               | 10           |
| November  | 427.4536     | 60.40321 | 61.59874               | 11           |
| December  | 204.2714     | 96.58964 | 60.40321               | 12           |

**Table 3:** Mean Seasonal and CV (%) from 1996-2024

| Season                                  | Mean RF (mm) | CV (%)   | Descending order (cv%) | Order number |
|-----------------------------------------|--------------|----------|------------------------|--------------|
| Winter (January- February)              | 79.25172     | 157.3523 | 157.3523               | 1            |
| Summer (March-May)                      | 103.9414     | 147.1956 | 147.1956               | 2            |
| South West monsoon (June - September)   | 250.469      | 82.15296 | 82.15296               | 3            |
| North East Monsoon (October - December) | 914.3009     | 68.85741 | 68.85741               | 4            |

**Table 4:** The annual Rainfall (mm) during 1996-2024 and arranged descending order

| Year | Rainfall (mm) | Descending order | Order Number |
|------|---------------|------------------|--------------|
| 1996 | 1455.8        | 2076             | 1            |
| 1997 | 2076          | 1896.9           | 2            |
| 1998 | 1352.3        | 1784.6           | 3            |
| 1999 | 1083          | 1758.6           | 4            |
| 2000 | 1143.8        | 1670.2           | 5            |
| 2001 | 1113          | 1612.3           | 6            |
| 2002 | 1299.6        | 1581.4           | 7            |
| 2003 | 1003.7        | 1564             | 8            |
| 2004 | 1533.9        | 1544             | 9            |
| 2005 | 1758.6        | 1533.9           | 10           |
| 2006 | 1425.2        | 1482.5           | 11           |
| 2007 | 297.6         | 1461.5           | 12           |
| 2008 | 1581.4        | 1455.8           | 13           |
| 2009 | 1482.5        | 1425.2           | 14           |
| 2010 | 1394.3        | 1394.3           | 15           |
| 2011 | 1051.3        | 1382             | 16           |
| 2012 | 892.5         | 1352.3           | 17           |
| 2013 | 815           | 1299.6           | 18           |
| 2014 | 1382          | 1173.6           | 19           |
| 2015 | 1564          | 1143.8           | 20           |

|      |        |        |    |
|------|--------|--------|----|
| 2016 | 667.2  | 1113   | 21 |
| 2017 | 1784.6 | 1083   | 22 |
| 2018 | 1173.6 | 1051.3 | 23 |
| 2019 | 1612.3 | 1003.7 | 24 |
| 2020 | 1670.2 | 942.9  | 25 |
| 2021 | 1896.9 | 892.5  | 26 |
| 2022 | 1461.5 | 815    | 27 |
| 2023 | 1544   | 667.2  | 28 |
| 2024 | 942.9  | 297.6  | 29 |

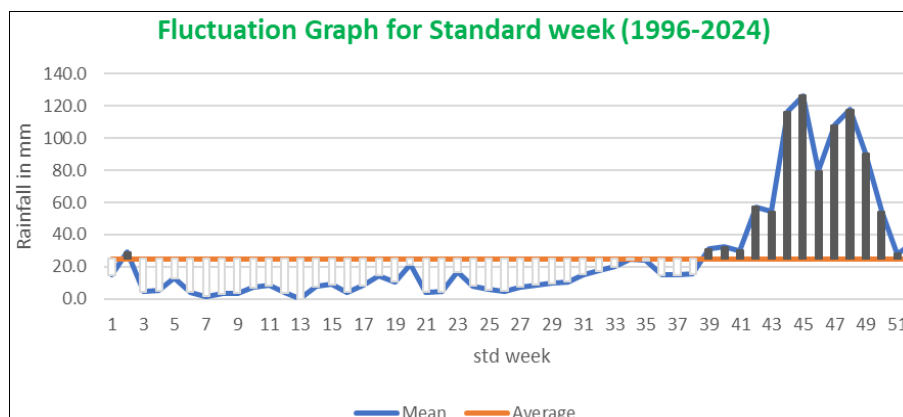


Fig 3: Mean Weekly Rainfall of Karaikal region in (mm)

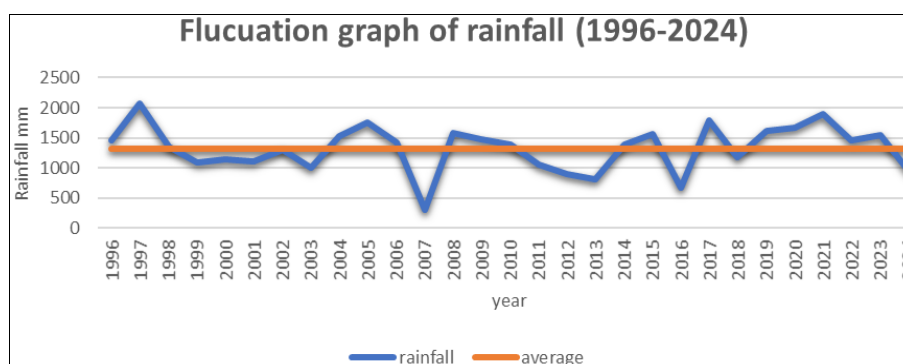


Fig 4: Average Annual Rainfall in mm (1996-2024) for Karaikal Region

## Conclusion

The present study provides a comprehensive analysis of rainfall variability over the Karaikal region of the Union Territory of Puducherry for a period of 29 years (1996–2024). The findings reveal that Karaikal receives an average annual rainfall of 1347.96 mm, predominantly contributed by the Northeast Monsoon (NEM) season (68.94%), followed by the Southwest Monsoon (SWM) (18.88%), summer (7.8%), and winter (5.9%). The coefficient of variation (CV) analysis highlights substantial inter-annual and intra-seasonal variability, especially during the winter and summer months, indicating reduced predictability and reliability of rainfall in these periods.

Notably, the NEM exhibits comparatively lower variability, making it the most dependable rainfall season for the region. However, the observed shifts in rainfall distribution and intensity, including extreme fluctuations in certain weeks and months, suggest the influence of broader climate change phenomena, aligning with trends reported across coastal India. These findings underscore the urgent need for region-specific water management strategies, adaptive agricultural planning, and early warning systems to mitigate the adverse impacts of changing rainfall regimes. Continued monitoring, incorporation of climate models, and integration of satellite and ground-based data are essential to refine predictions and support local climate

resilience planning. Ultimately, such data-driven insights can assist policymakers, farmers, and planners in formulating effective climate adaptation and mitigation strategies tailored to Karaikal and similar coastal regions.

## Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

## Competing Interests

Authors have declared that no competing interests exist

## References

1. Dash SK, Kulkarni MA, Mohanty UC, Prasad K. Changes in the characteristics of rain events in India. *Journal of Geophysical Research: Atmospheres*. 2009;114(D10):D10109. doi:10.1029/2008JD010572.
2. Intergovernmental Panel on Climate Change (IPCC). Sixth Assessment Report. 2021. <https://www.ipcc.ch>
3. Guhathakurta P, Menon PA, Sreejith OP, Rajeevan M, Thapliyal V. Trends in rainfall pattern over India. *Climate Dynamics*. 2015;44(3–4):2079–2097. doi:10.1007/s00382-

- 014-2270-8.
4. India Meteorological Department (IMD). Monsoon Reports. 2023. <https://www.imd.gov.in>
  5. Kothawale DR, Rajeevan M, Kumar KR. Monthly, seasonal and annual rainfall time series for All India, homogeneous regions and meteorological subdivisions: 1871–2005. *Current Science*. 2010;98(6):773–779.
  6. Kripalani RH, Kulkarni A. Rainfall variability over southeast India. *Theoretical and Applied Climatology*. 1997;58(1):147–156.
  7. Nair AA, Rajeevan M, Pai DS. Climate change and its impact on rainfall variability in coastal regions of India. *Journal of Earth System Science*. 2018;127(8):1–12. doi:10.1007/s12040-018-1026-x.
  8. Pai DS, Sridhar L, Rajeevan M, Sreejith OP, Satbhai NS, Mukhopadhyay B. Development of a new high-resolution ( $0.25^\circ \times 0.25^\circ$ ) daily gridded rainfall data for the Indian region. *Mausam*. 2014;65(1):1–18.
  9. Rajeevan M, Bhate J, Kale JD, Lal B. Observed trends in heavy rainfall events over India. *Journal of Climate*. 2008;21(20):5204–5219. doi:10.1175/2008JCLI2371.1.
  10. Roxy MK, Ghosh S, Pathak A, Athulya R, Mujumdar M, Murtugudde R, *et al.* A threefold rise in widespread extreme rain events over central India. *Nature Communications*. 2017;8:708. doi:10.1038/s41467-017-00744-9.
  11. Veeraputhiran R, Karthikeyan R, Geethalakshmi V, Selvaraju R, Sundersingh SD, Balasubramanian TN. Crop planning – Climate Atlas. Coimbatore: A.E. Publications; 2003. p. 1–45.