



INSTITUTE FOR CLIMATE CHANGE STUDIES (ICCS)

A Research Organization under Kerala State Council for Science
Technology and Environment (KSCSTE), Govt. of Kerala

STATEMENT ON CLIMATE FOR THE STATE OF KERALA: 2022

HIGHLIGHTS

The Kerala State averaged annual mean land surface air temperature during 2022 was $+0.45^{\circ}\text{C}$ warmer than the average (1971-2020). Thus 2022 was 6th warmest year for Kerala along with 1987 on record since 1901. The warmest year for Kerala on record is 2016 ($+0.97^{\circ}\text{C}$) followed by 2019 ($+0.88^{\circ}\text{C}$). The warmer than normal annual mean temperature over the state during 2022 was mainly contributed by the above average mean temperature during the winter season (1.02°C). The 9 of the 10 warmest years in record were pertaining to the recent decade (2013-2022) and therefore the annual mean temperature of Kerala during the past decade (2011-2020/ 2013-2022) was also the warmest decade on record with the decadal averaged annual mean temperature anomaly of $0.51^{\circ}\text{C} / 0.58^{\circ}\text{C}$.

The state averaged annual maximum as well as minimum temperatures during the 2022 were warmer than average (1971-2020) with anomalies of 0.41°C (9th warmest) and 0.49°C (7th warmest) respectively.

The observed warming trend in the Kerala averaged temperatures is in line with the observed warming trends in the Global mean surface temperature and in the all India averaged annual mean temperature.

The annual mean land surface air temperature averaged over India during 2022 (https://imdpune.gov.in/Latest_news/Statement_climate_of_india_2022.pdf) was $+0.51^{\circ}\text{C}$ above the long-term average (1981-2010 period) and 2022 was 5th warmest year on record since 1901.

Kerala experienced seasonal rainfall of 8.7% below its Long Period Average (LPA, 1971-2020) during the southwest monsoon season and 1.0% below its LPA during the northeast monsoon season, which are the main rainy seasons of the state.

Introduction

The Institute for Climate Change Studies (ICCS) is an autonomous Research and Development institution under Kerala State Council for Science Technology and Environment (KSCSTE), Government of Kerala. The Centre is envisioned for integrated research, technical support and capacity building in all aspects of Climate change issues and integrate development policies, plans and programs at State level. Last year, as part of its state level climate monitoring activities, ICCS had issued statement of annual climate for the State of Kerala for the year 2021 in line with national level annual statement being issued regularly by India Meteorological Department (IMD) for the country. Now, ICCS has prepared annual climate statement for the year 2022 and presented here. The present

statement contains, important information about the monthly, seasonal and annual state averaged temperature and rainfall for the year 2022 vis a vis the same during the last 121 years. This statement also includes state specific information related to various extreme weather and climate events experienced during 2022. The rainfall and temperature data and extreme weather events information used for the preparation of this report was provided by IMD.

Temperatures

The monthly and seasonal maximum, minimum and mean temperature anomalies averaged over the State of Kerala is given in the **Fig.1**. The anomalies were computed based on the Long Period Average (LPA) for the period 1971-2020. The State averaged monthly maximum temperature was warmer than average during all the months of 2022 except during the pre-monsoon months of April & May. June recorded highest monthly maximum temperature (anomaly of 1.08°C; 4th warmest since 1901) and May recorded the lowest anomaly (-1.52°C). The State averaged monthly minimum and mean temperatures were warmer than the average during all months except in May. Among the months, January experienced both the highest monthly minimum (1.55°C; warmest since 1901) and monthly mean temperatures (anomaly 1.2°C; 2nd warmest since 1901). Season wise, the winter season (January and February) recorded the highest state averaged maximum, minimum and mean temperatures. The 2022 state averaged winter season temperature anomalies were; maximum temperature (anomaly of 0.73°C, fifth warmest since 1901), minimum temperature (anomaly of 1.32°C; warmest since 1901), and mean temperature (anomaly of 1.02°C, third warmest since 1901).

During the year 2022, the annual mean land surface air temperature during 2022 was +0.45°C warmer than average (1971-2020) and equal to 1987. Thus 2022 along with 1987 was the 6th warmest year for Kerala on record since 1901. The nine warmest years on record prior to 2022 on ascending order are: 2018 (0.38°C), 2014 (0.42°C), 2021 (0.44°C), 1987(0.45°C), 2015 (0.66°C), 2017 (0.71°C), 2020 (+0.81°C), 2019 (+0.88°C), 2016 (+0.97°C). It is also important to note that 9 of the 10 warmest years in record were pertaining to the recent decade (2013-2022). As a result, the annual mean temperature of Kerala during the past decade (2011-2020/ 2013-2022) was also the warmest decade on record with the decadal averaged annual mean temperature anomaly of 0.51°C /0.58°C. A significant increasing trend of 1.05°C/100 years is observed in the state averaged annual mean temperature during 1901-2022 (**Fig.2**).

During 2022, both the state averaged annual maximum and minimum temperatures were warmer than average (1971-2020) with anomalies of 0.41°C (9th warmest) and 0.49°C (7th warmest) respectively (**Fig.2**). During the period 1901-2022, the state averaged maximum temperature showed a significant increasing trend (1.66°C/100 years) and the state averaged minimum temperature showed a relatively lower increasing trend (0.44°C/100 years). As seen in the **Fig.2**, the anomalies of annual maximum temperature were more negative than that of annual minimum temperatures till late 1980's. Thereafter, the role was reversed. This is mainly because of the observed faster increasing trend in the maximum temperatures compared to that in the minimum temperatures. This has also resulted in the increased annual state averaged diurnal variation (not shown here) in recent decades.

The trends in the district averaged maximum, minimum and mean temperatures for the period 1901-2022 is shown in the **Figures 3a, 3b** and **3c** respectively. There are significant increasing trends in the district averaged maximum and mean temperatures for all the 14 districts of the State. However, in the case of minimum temperature, significant increasing trends were observed in 9 out of the 14 districts. Among the remaining five districts, Kannur and Pathanamthitta showed increasing but non-significant trends, Kasaragod, the northern most district showed significant decreasing trend and Kollam and Thiruvananthapuram, the two southern most districts showed decreasing but insignificant trends.

Rainfall

The monthly and seasonal rainfall averaged over the State of Kerala and expressed as the percentage of departure from the Long Period Average (LPA) for the period 1971-2020 is given in the **Fig.1** along with temperature anomalies. It can be seen that there is a general inverse relationship between the monthly rainfall and temperature anomalies. Kerala receives most of its annual rainfall during the two monsoon seasons; Southwest monsoon season (June to September) and Northeast monsoon season (October to December). The state averaged season rainfalls during both the southwest and northeast monsoon seasons of 2022 were below the long-period average (LPA) (8.7% and 1.0% below respective LPAs) but within the normal range. It is observed that the State averaged season rainfall for the southwest monsoon as well as northeast monsoon seasons during the past 122 years (**Figures 4 & 5**) show decreasing trends (-11% and -7% of LPA/100 years respectively). Kerala has received southwest season rainfall less than that received during 2022 in 31 years of the period 1901-2021 including last year with lowest in 1918 (43.4% below LPA) followed by 1987 (42.6% below LPA). In case of the northeast monsoon, the lowest ever state averaged season rainfall since 1901 was recorded in 1988 with rainfall of 63.9% below LPA followed by 2016 (62.2% below LPA) and 1974 (57.6% below LPA)

During 2022 southwest monsoon season, 12 of the 14 districts received less than LPA rainfall with Alappuzha and Kasaragod recorded lowest (27.9% below LPA) and highest (18.6% below LPA) season rainfall respectively among these 12 districts. The other district which received above LPA rainfall was Palakkad (0.02% above LPA). On the other hand, during northeast monsoon season, 8 out of 14 districts received less than LPA rainfall with Kannur (36.4% below LPA) recording the lowest and Pathanamthitta (39.8% above LPA) recording the highest rainfall among all the districts.

The trend map in the district averaged southwest monsoon season rainfall during the period 1901-2022 (**Fig.6a**), shows decreasing trends in the rainfall in all the districts except in Idukki, where increasing but in significant trend is seen. The decreasing trends in rainfall over 3 districts from south (Alappuzha, Kollam and Pathanamthitta) and 4 districts from north (Kannur, Wayanad, Malappuram and Palakkad) were significant. In case of Northeast monsoon season (**Fig.6b**) also decreasing trends in seasonal rainfall was seen in all the districts except in Kasaragod, with significant decreasing trends in Palakkad and Kottayam. Kasaragod showed increasing but non-significant trend.

Extreme Weather Events:

Table 1 shows the highest maximum and minimum temperatures and highest rainfall recorded in the 12 IMD met observatories across Kerala along with the dates during 2022. It is seen that, among these stations, Punalur in Kollam district reported the highest maximum temperature of 39.2°C (on 15th March) followed by Vellanikara (38.6°C on 12th March and 14th March). The lowest minimum temperature was recorded by Punalur in Kollam district (15.5°C on 3rd March) followed by Vellanikkara (18.6°C on 23rd December). The highest one-day rainfall was recorded by Kochi airport (Nedumbassery) (211.2mm) on 2nd August followed by Palakkad (171.3mm) recorded on 1st September. Among these observatories, the highest number of daily heavy rainfall events (>64.5mm) were recorded by Kannur (14 days) followed by Kozhikode city (11 days) & Kochi NAS (10 days). Fig.7 shows the locations of extreme rainfall of various intensities that occurred during 2022 based on rainfall data available from all the stations including the 12 IMD stations given in Table 1.

The year 2022 witnessed many extreme weather events like heavy rainfall, floods, landslide, lightning, thunderstorms, etc over many parts of Kerala. Districts that experienced major Extreme Weather Events during 2022 are shown in the **Fig.8**. A few of such events and its impact that caused loss of life are listed in table 2. The causalities mentioned here are based on the media and government reports of disaster Management Authorities.

In 2022, though three cyclonic storms (two Severe Cyclonic Storms “ASANI” and “MANDOUS”, and one Cyclonic Storm “SITRANG”) formed over the Bay of Bengal, not much impacts were observed over Kerala.

Table 1: Highest/lowest maximum and minimum temperatures and highest rainfall recorded in the 12 IMD meteorological observatories across Kerala along with the dates during 2022.

IMD Stations	Highest Max. Temperature °C (Date)	Lowest Max. Temperature °C (Date)	Highest Min. Temperature °C (Date)	Lowest Min Temperature °C (Date)	Highest Rainfall mm (Date)	Frequency of Heavy Rainfall Events (>64.5 mm)
Kannur	38.0 (04-03-2022)	24.2 (06-08-2022)	28.7 (28-04-2022)	19.9 (05-02-2022)	120.3 (18-05-2022)	14
Kozhikode city	37.2 (29-04-2022)	25.0 (05-08-2022)	29.4 (28-04-2022, 29-04-2022)	21.0 (23-12-2022)	134.4 (01-06-2022)	11
Karipur A. P	35.0 (12-02-2022, 24-02-2022, 05-04-2022)	24.2 (05-08-2022)	27.3 (28-04-2022)	19.5 (24-01-2022)	115.2 (02-09-2022)	6
Palakkad	38.5 (23-03-2022)	24.4 (10-07-2022, 03-08-2022)	28.4 (28-04-2022)	19.2 (23-12-2022)	171.3 (01-09-2022)	8
Vellanikkara	38.6 (12-03-2022, 14-03-2022)	24.3 (05-08-2022)	27.5 (28-04-2022)	18.6 (23-12-2022)	131.2 (04-08-2022)	4
Kochi A.P (Nedumbassery)	37.4 (14-03-2022)	25.1 (05-08-2022)	27.1 (28-04-2022)	19.0 (03-03-2022)	211.2 (02-08-2022)	8
Kochi (NAS)	34 (28-04-2022)	24.4 (05-08-2022)	28 (28-04-2022)	21 (07-04-2022)	150.4 (15-05-2022)	10
Alappuzha	36.4 (04-01-2022)	25.7 (05-08-2022)	28.6 (01-05-2022)	21.8 (15-12-2022)	158.2 (15-05-2022)	4
Kottayam	38 (04-03-2022)	25 (05-08-2022)	26.8 (04-05-2022)	20.4 (31-12-2022)	128.0 (5-11-2022)	9
Punalur	39.2 (15-03-2022)	25.7 (6-07-2022)	24.0 (21-04-2022)	15.5 (03-03-2022)	122.2 (15-05-2022)	6
Trivandrum AP	34.9 (05-03-2022)	25.6 (04-07-2022)	27.2 (24-03-2022, 03-05-2022)	20.8 (,03-03-2022 31-12-2022)	108.0 (18-10-2022)	3
Trivandrum city	36.1 (15-3-2022, 23-3-2022)	25.5 (01-09-2022)	27.6 (04-05-2022)	21.2 (31-12-2022)	124.6 (15-05-2022)	2

Table 2: Extreme Weather Events occurred during 2022 that caused loss of human Lives.

Impacted weather Events, 2022 Kerala			
Event	Number of casualties	Season (casualty [*])	Affected districts
Heavy Rain and Floods	30	Southwest Monsoon (30)	Various parts of the State
Landslides/mud slips	18	Southwest Monsoon (18)	Various parts of the State
Lightning and Thunderstorm	8	Pre-monsoon (5) Southwest Monsoon (2) Post monsoon (1)	Idukki, Kannur, Thiruvananthapuram, Wayanad, Kollam, Malappuram

(* Based on the media reports and the reports from disaster Management Authorities of the government)

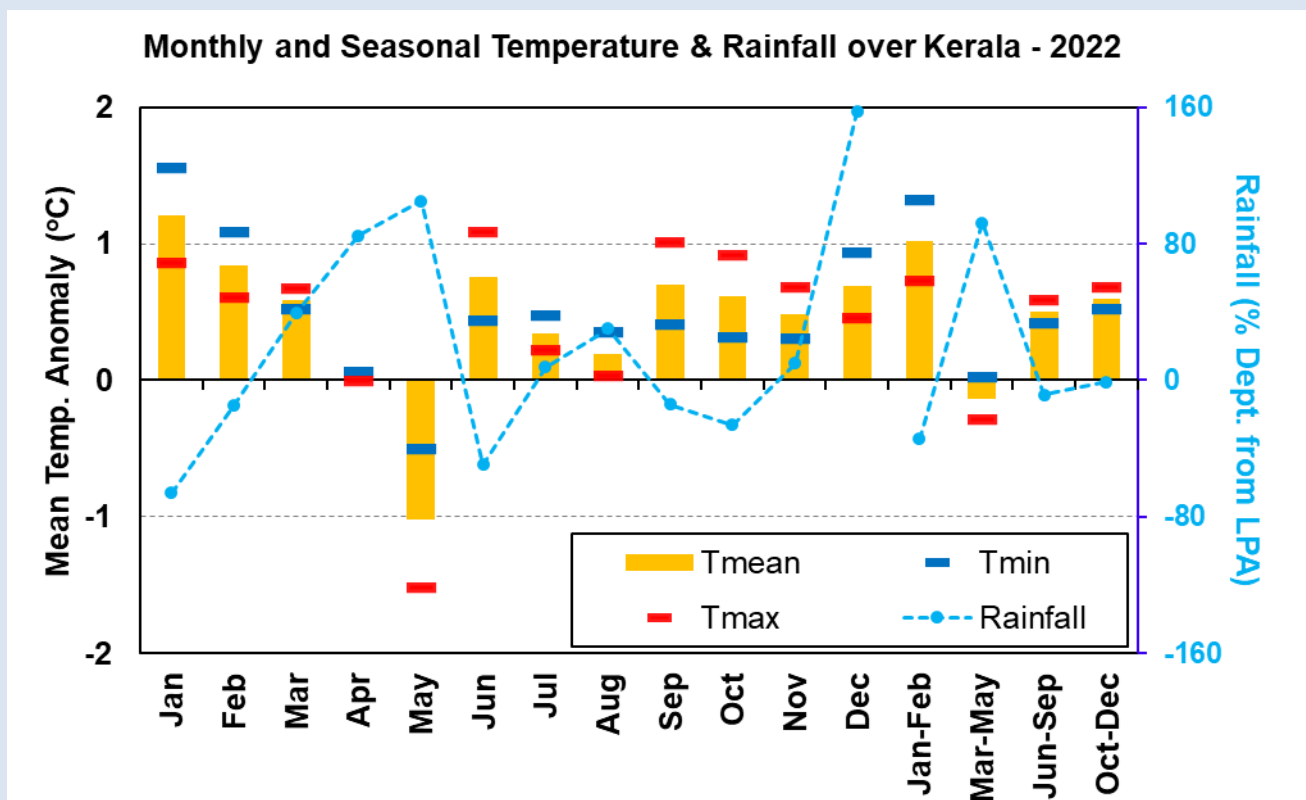


Fig.1. Monthly and Seasonal Maximum, Minimum and Mean Temperature anomalies averaged over Kerala ($^{\circ}\text{C}$) during 2022. Monthly and seasonal Rainfall anomalies averaged over Kerala (percentage departure) during 2022 is also depicted. The anomalies were computed from Long Period Average (LPA) for the base period of 1971-2020.

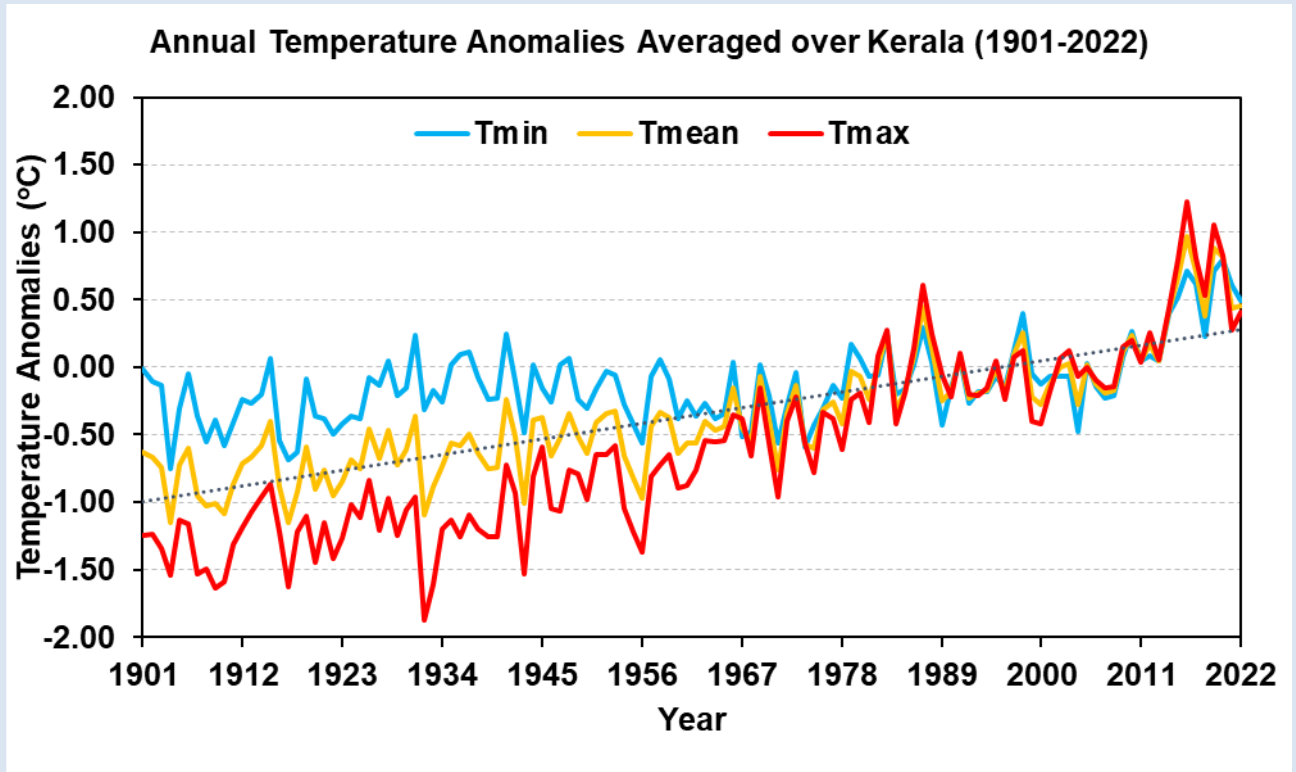


Fig.2: Annual maximum, minimum and mean land surface air temperature anomalies averaged over the State of Kerala for the period 1901-2022. The anomalies were computed with respect to the base period of 1971-2020. The dotted line indicates the linear trend in the annual mean temperature time series.

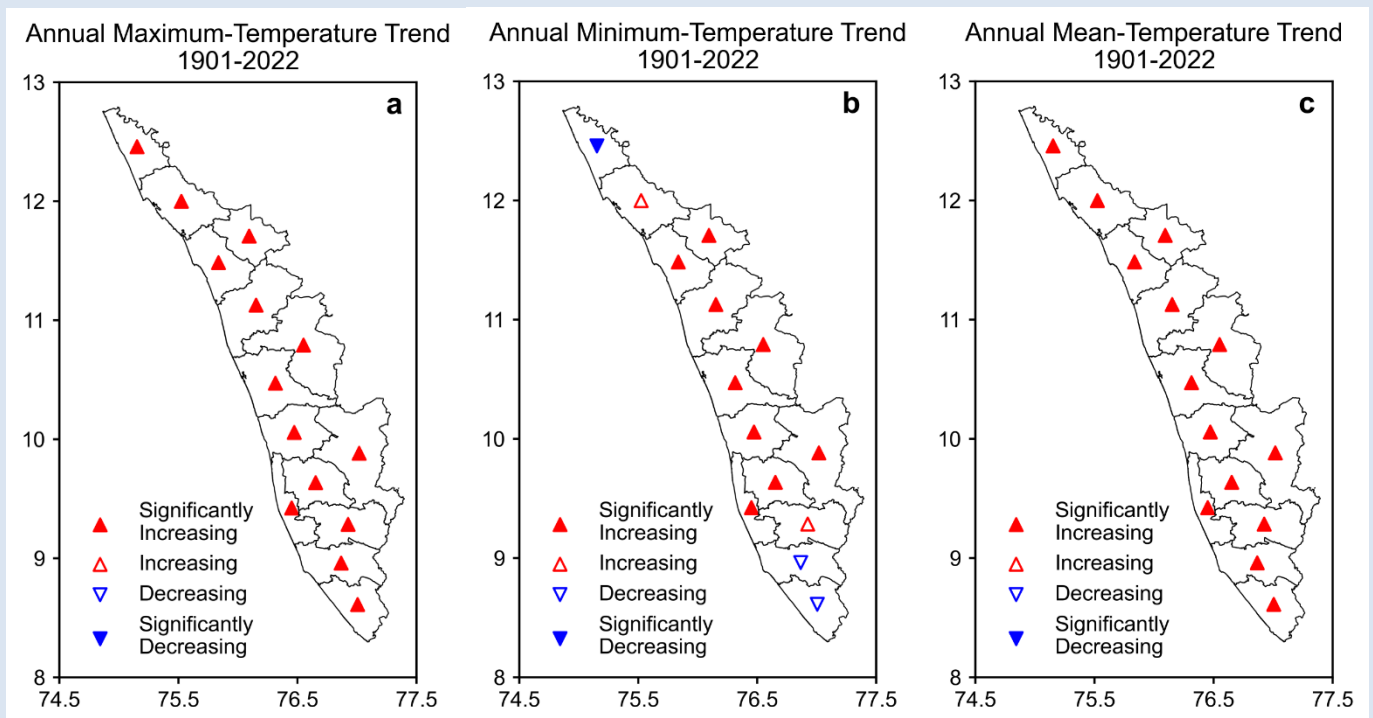


Fig.3: Trends in district averaged a) maximum, b) minimum, and c) mean land surface air temperatures for the period 1901-2022.

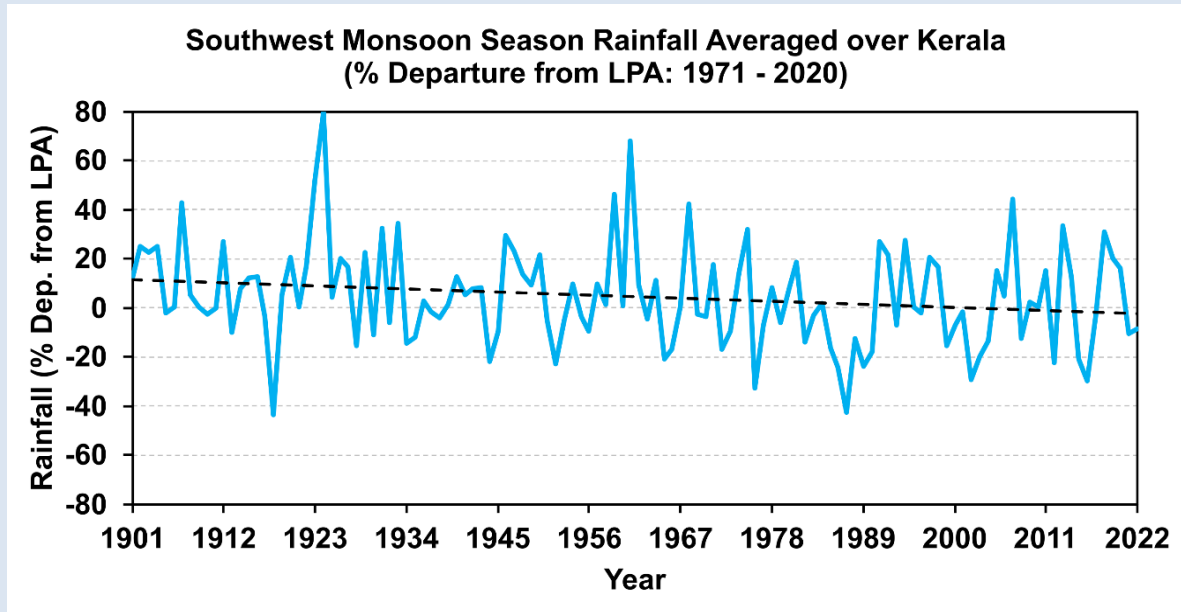


Fig.4: Seasonal departure of southwest monsoon rainfall averaged over Kerala expressed as the percentage from Long Period Average (LPA) computed for the base period of 1971-2020.

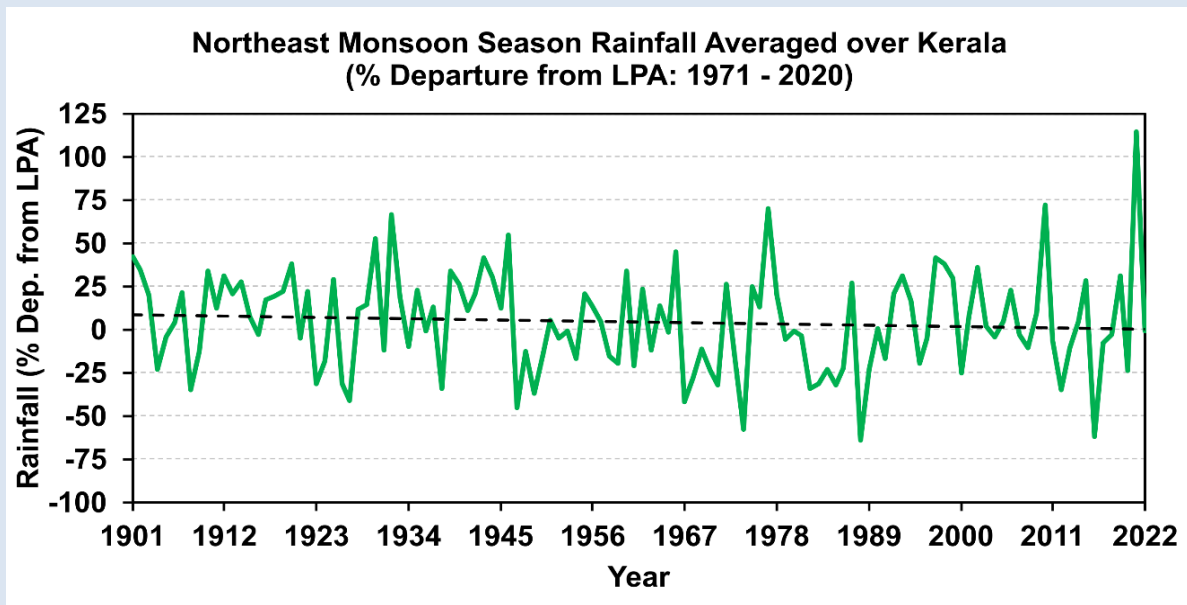


Fig.5: Seasonal departure of northeast monsoon rainfall averaged over Kerala expressed as the percentage from Long Period Average (LPA) computed for the base period of 1971-2020.

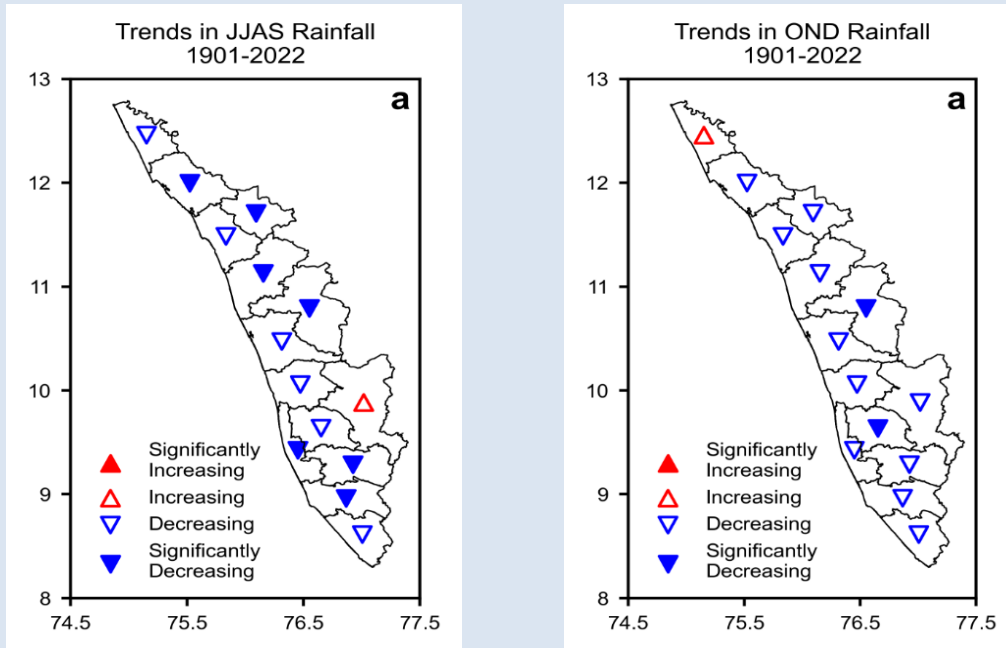


Fig.6: Trends in district averaged **a)** southwest monsoon (JJAS), and **b)** northeast monsoon (OND) season rainfalls for the period 1901-2022.

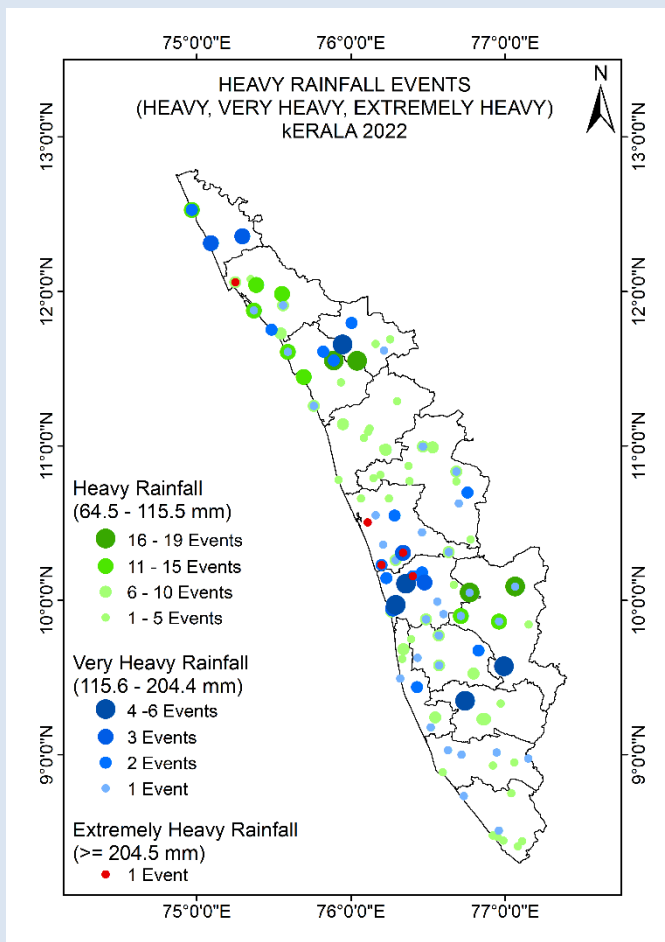


Fig.7: Location of Heavy Rainfall (64.5-115.5mm), Very Heavy Rainfall (115.6-204.4 mm) and Extremely Heavy Rainfall (more than 204.5 mm) reported stations over Kerala during 2022.

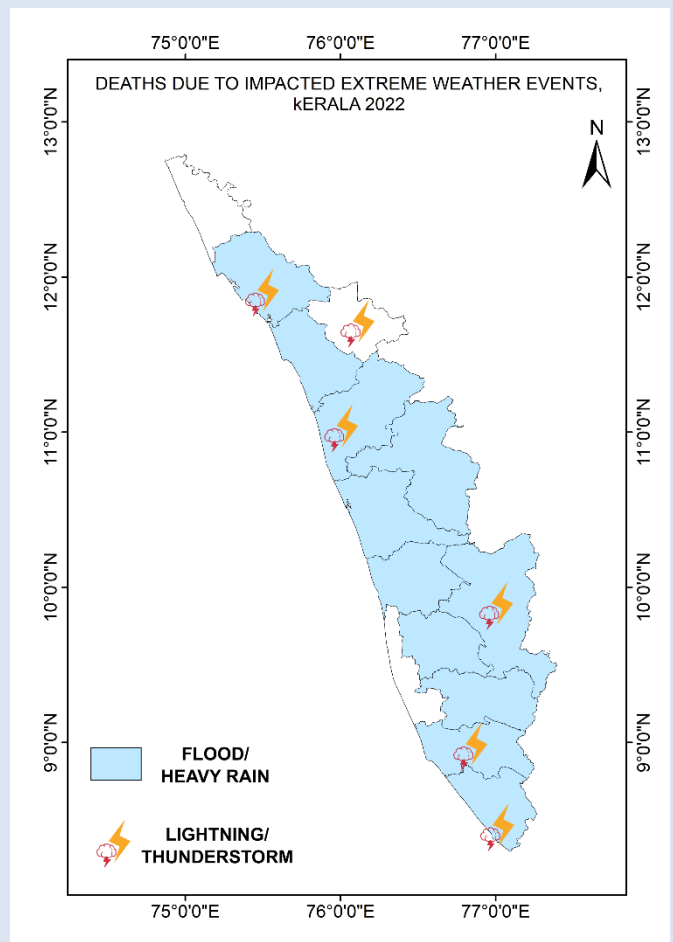


Fig.8: Locations of Major Extreme Weather Events occurred during 2022 that caused loss of life (details provided in Table 2).