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Insights into Rainfall Extremities Across the Agroclimatic Zones of Tamil Nadu, India

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Authors' contributions

This work was carried out in collaboration among all authors. Author ED, VG, KB and SM carried out verification of output, and wrote the protocol and the first draft of the manuscript. Author KB and SMK generated the outputs. Authors SP, GaD, RK and SMK defined the methodology of the research and verification part. All authors read and approved the final manuscript.

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ABSTRACT

Rainfall is a crucial agrometeorological parameter that impacts hydrology and agricultural planning in a region. The spatiotemporal changes in the occurrences of precipitation extremes must be monitored to reduce the hazards caused by the fluctuating rainfall pattern. The extreme rainfall indices for each year categorized under excess, normal and deficit rainfall categories were calculated over the agroclimatic zones of Tamil Nadu using the high-resolution CHIRPS datasets from 1991 to 2022. The results highlighted that High Rainfall Zone has more consecutive wet days (22 days), minimum consecutive dry days (25 days) and Daily Intensity Index with threshold of 2.5 mm (28.6 mm) compared to other zones. The maximum consecutive dry days of 99 days, a high

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rainy day of 142 days, and minimum daily intensity of 8.9 mm are experienced by the Cauvery Delta Zone, High Altitude and Hilly Zone, and Western Zone, respectively. Overall, the High Rainfall Zone faces a higher number of extreme rainfall events in terms of wet days and intensity, whereas the average maximum consecutive dry days and minimum rainfall intensity is observed over the north eastern zone and north western zone, respectively indicating high dry periods.

Keywords: Rainfall, extreme precipitation indices, CHIRPS, rainfall years, agroclimatic zones.

1. INTRODUCTION

Rainfall is one of the most significant variables influencing the hydrologic cycle and agricultural planning in a region [1]. The induced variation in rainfall due to climate change has serious impacts on agriculture, water sectors and eventually on food security [2], leading to an increase in the frequency of extreme precipitation events. The climate extremes highly vary over time and geographical features [3], thus making it hazardous, particularly affecting the crop production. Monitoring the spatiotemporal changes in the occurrences of precipitation extremes with credible weather information [4] is essential for preventing hydrological disasters [5-7] and reducing the hazards caused by extreme fluctuations in rainfall patterns [8,9] for both current and future climates [10], that inflict the loss on crop production and socio-economy of the country [11,12]. Soltani et al. [13] has reported that the extreme events like drought (more dry periods), flood and cyclone (extreme rainfall) generally occur due to alteration in rainfall frequency.

Tamil Nadu comes under tropical semiarid region, receives the average annual rainfall of 1232 mm from different seasons such as summer season, winter season, southwest monsoon (SWM) and northeast monsoon (NEM). The majority contribution is from monsoon seasons with 42 % (512 mm) from NEM and 35 % (441 mm) from SWM and understanding their rainfall pattern is essential in assessing extreme rainfall events over the region [14]. Nowadays, the rising uncertainties in rainfall due to climate change and variability further complicate the weather and crop-related sectors [15], which can be studied with numerous historical datasets through a complex interaction between meteorological and climatological data [16].

Gridded satellite datasets are essential for assessing extreme events and provide alternative sources for ungauged areas without ground-based observations [17]. Satellite-based precipitation products are more reliable in estimating extreme events with greater accuracy and spatial coverage [18]. Climate Hazard Infrared Precipitation with Station (CHIRPS) data was used because the detection capability was good, particularly in complex topographical regions, and can be used to identify rainfall patterns, water resource management [19]. Previous researchers have analysed the extreme rainfall events focusing CHIRPS dataset using ETCCDI indices in comparison with rain gauge observations over Cyprus island [20] and Qinghai-Tibet Plateau [21] which showed better performance in terms of daily precipitation threshold indices with greater correlation and spatial resolution. Some studies have highlighted that the CHIRPS performed well in capturing the intensity over India [22], particularly over the eastern coast region [23]. Hence, the present study was carried out to identify the extreme precipitation indices the agroclimatic zones of Tamil Nadu using a high-resolution precipitation dataset.

2. MATERIALS AND METHODOLOGY

2.1 Materials

2.1.1 Study area

The study regions cover the seven agroclimatic zones of Tamil Nadu *viz.,* North Eastern Zone (NEZ), North Western Zone (NWZ), Western Zone (WZ), Southern Zone (SW), Cauvery Delta Zone (CDZ), High Rainfall Zone (HRZ), High Altitude and Hilly Zone (HAHZ) which were classified based on irrigation pattern, rainfall distribution, and soil characteristics. Different agroclimatic zones and the districts covering each zone are depicted in Fig. 1.

2.1.2 Data collection

The gridded high resolution Climate Hazard Infrared Precipitation with Station (CHIRPS) data [24] produced through merging satellite and in-situ observation used in the study was downloaded between 1991 and 2022 at 0.05° x 0.05° spatial and daily temporal resolution from the website of Climate Hazard Centre to assess the performance of satellite based extreme precipitation indices.

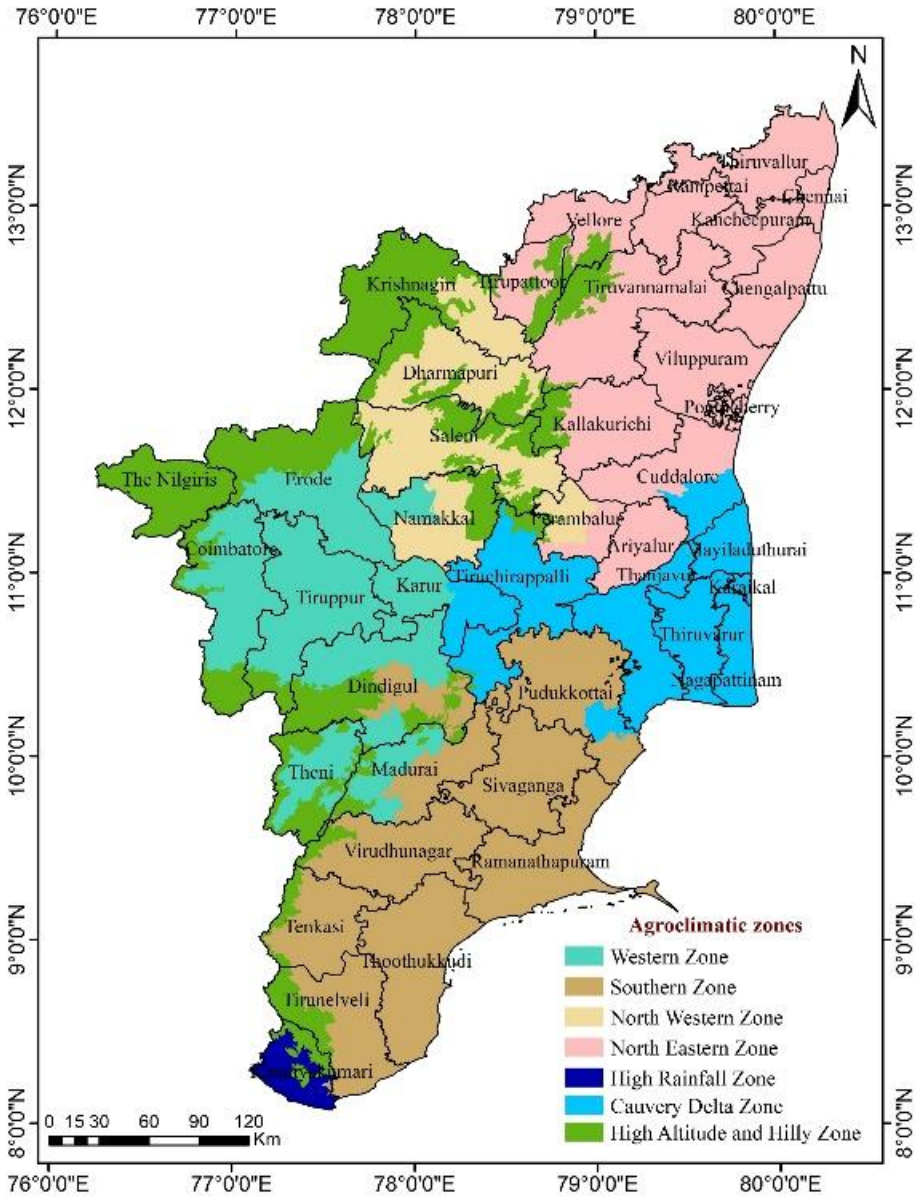

Fig. 1. Map showing seven agroclimatic zones of Tamil Nadu

2.1.3 Extreme rainfall indices

The extreme rainfall indices with their description as per Expert Team on Climate Change Detection and Indices (ETCCDI) worked out in the study was given in the Table1.

2.2 Methodology of the Study

Extreme rainfall indices such as consecutive dry days (CDD), consecutive wet days (CWD), number of days with precipitation more than 2.5 mm (Rainy days) and simple daily intensity index (SDII) were calculated using Climate Data Operators (CDO).

The processed indices are then used to obtain the annual zone-wise average values using zonal statistics as table tool in ArcGIS software. The zonal annual rainfall is used to calculate the rainfall departure in percentage to categorize the years as per the classification mentioned in Table 2 by using the following formula:

$$\text{Rainfall Departure (\%)} = (\text{Actual Rainfall} - \text{Normal Rainfall}) / \text{Normal Rainfall} \times 100$$

where actual rainfall indicates the annual mean rainfall of the particular year and normal rainfall indicates the long period average of the annual rainfall.

Table 1. List of extreme rainfall indices used in the present study

Index	Definition	Units
CWD	Number of consecutive dry days with threshold of 2.5 mm	Days
CDD	Number of consecutive wet days with threshold of 2.5 mm	Days
Rainy days	Annual count of days when daily precipitation > 2.5 mm	Days
SDII	Simple Daily Intensity Index with threshold of 2.5 mm	mm

Table 2. List of rainfall category with respect to their percentage deviation

Category	Rainfall Departure (%)
Large Excess (LE)	≥ 60%
Excess (E)	≥ 20% and ≤ 59%
Normal (N)	≥ -19% and ≤ +19%
Deficient (D)	≥ -59% and ≤ -20%
Large Deficit (LD)	≥ -99% and ≤ -60%
No Rain (NR)	= -100%

3. RESULTS AND DISCUSSION

In Tamil Nadu, none of the location had large deficit and large excess rainfall year category. The rainfall departure categories in terms of excess, normal and deficient years in agroclimatic zones are represented in the Fig. 2. The result indicated that the maximum number of excess rainfall years (5 years) were experienced by North Western Zone, normal rainfall years (27 years) by High Rainfall Zone and deficient rainfall years (5 years) by both Cauvery Delta Zone and North Western Zone. In contrast, minimum number of excess (3 years), normal (22 years) and deficient (1year) rainfall years were observed in Western Zone, North Western Zone and High Rainfall Zone, respectively. Overall, all the zones received more normal rainfall years followed by excess and deficient rainfall years.

3.1 High Altitude and Hilly Zone

The extreme rainfall indices depicted in Table 3 over the High Altitude and Hilly Zone indicates that the consecutive dry days (CDD) ranged from 37 to 46 days in excess years, 34 to 59 days in normal years, and 45 to 47 days in deficient rainfall years, whereas the consecutive wet days (CWD) ranged from 11 to 14 days, 6 to 13 days, and 6 to 8 days in excess years, normal years and deficient years, respectively. The annual count of rainy days ranged from 115 to 118 days, 75 to 129 days, and 76 to 84 days with a simple daily precipitation intensity index (SDII) of 12.5 to 14.1 mm, 10.5 to 16.4 mm, and 10.1 to 14 mm in excess, normal, and deficient rainfall years, respectively. Furthermore, greater CDD of 59 days was recorded in 1992 (normal), CWD of 14 days in 2021 (excess), SDII of 16.4 mm in 1993 (normal), and Rainy days of 142 days in 2010 (excess), and less CDD of 34 days in 1999, 2000, 2008 (normal), CWD of 6 days in 1993 (normal), SDII of 10.1 mm in 2016 (deficient), and Rainy days of 75 days in 1997 (normal), respectively. The Hilly Zone attains a higher number of rainy days (142 days) at annual timescales, as the rainfall in this zone varies from 1000 mm at the foothills to 5000 mm at the peaks [25].

3.2 Southern Zone

Table 4 indicates that maximum consecutive dry days (CDD) of 84 days is obtained in 1998 indicating the maximum occurrence of drought as the zone typically experiences higher rainfall variability [26], particularly in Virudhunagar district and lower CDD of 42 days in 2000 in normal rainfall years ranging from 42 to 84 days, 51 to 66 days in excess, and 53 to 68 days in deficient rainfall years. A higher consecutive wet day (CWD) of 17 days is obtained in 2021, ranging between 11 and 17 days in excess; a lesser CWD of 5 days in 1992 and 1997, ranging between 5 and 15 days in normal years; and a range of 53 to 68 days in deficient rainfall years. The simple daily precipitation intensity index was maximum in 1993 of 16.5 mm and minimum in 2018 of 9.1 mm during normal rainfall years ranged between 9.1 and 16.5 mm, and rainy days ranged from 91 to 107 days in excess, 58 to 104 days in normal, and 54 to 66 days in deficient rainfall years, with maximum days in 2010 (excess) and minimum days in 1992 (normal).

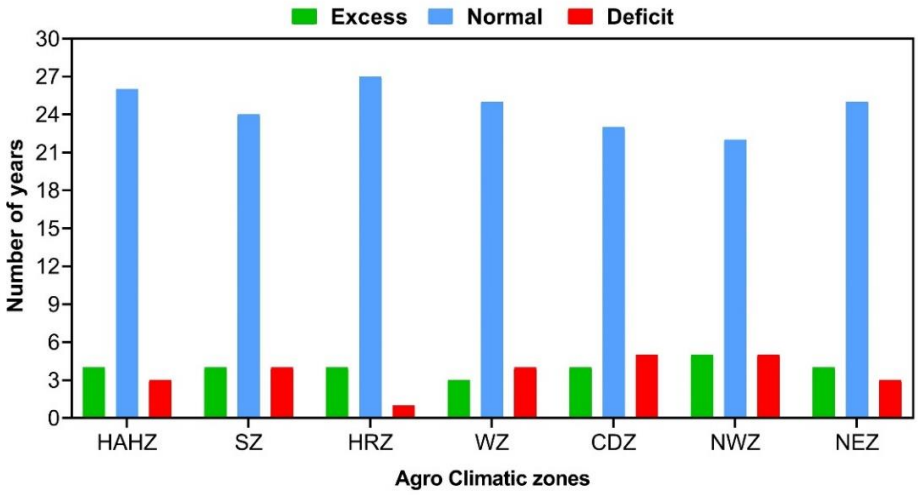

Fig. 2. The number of years under excess, normal and deficit rainfall based on rainfall departure percentage

Table 3. Extreme rainfall indices as per classified rainfall years over the High Altitude and Hilly Zone

Category	Years	CDD	CWD	SDII	Rainy days
Excess	2005	37	11	14.0	118
	2007	44	12	14.1	115
	2010	46	12	12.6	142
	2021	41	14	12.8	140
Normal	1991	40	7	14.0	82
	1992	59	7	14.7	78
	1993	38	6	16.4	80
	1995	41	8	13.6	87
	1996	44	10	13.7	95
	1997	44	7	15.1	75
	1998	50	13	14.9	109
	1999	34	13	12.3	112
	2000	34	10	13.2	112
	2001	52	13	12.6	106
	2002	46	9	11.8	92
	2003	42	8	10.6	107
	2004	51	12	13.2	115
	2006	44	10	13.2	108
	2008	34	11	12.5	116
	2009	43	9	13.2	96
	2011	45	12	13.4	118
	2012	39	12	12.5	109
	2013	39	10	11.0	105
	2014	41	9	11.0	110
	2015	39	11	12.5	117
	2017	35	18	11.5	124
	2018	39	13	10.6	121
	2019	43	11	12.1	112
	2020	39	11	10.5	129
	2022	40	12	12.7	118
Deficient	1994	47	6	14.0	76
	2016	45	8	10.1	84

Table 4. Extreme rainfall indices as per classified rainfall years over Southern Zone

Category	Years	CDD	CWD	SDII	Rainy days
Excess	2006	54	11	13.1	91
	2010	66	15	12.9	107
	2015	66	12	12.4	104
	2021	51	17	13.0	108
Normal	1992	82	5	14.6	58
	1993	59	6	16.5	65
	1996	63	9	12.9	72
	1997	63	5	15.2	62
	1998	84	10	14.5	77
	1999	53	10	11.3	77
	2000	42	8	11.8	82
	2001	61	8	10.9	83
	2002	58	10	11.4	80
	2003	57	8	11.5	81
	2004	60	10	12.0	89
	2005	54	10	13.3	88
	2007	62	12	11.8	92
	2008	50	11	12.6	89
	2009	56	7	14.1	70
	2011	53	12	12.1	92
	2012	59	15	12.2	86
	2013	46	8	10.8	80
	2014	66	9	10.4	89
	2017	47	9	9.9	91
	2018	50	12	9.1	104
	2019	61	9	12.5	89
	2020	63	8	10.4	99
	2022	50	8	11.1	88
Deficient	1991	68	7	13.2	54
	1994	53	5	13.5	55
	1995	57	7	11.8	66
	2016	61	7	9.9	63

3.3 High Rainfall Zone

The consecutive dry days is higher with 49 days in excess years (2015) and lower with 25 days in normal years (2009). The normal rainfall year of 2018 had more consecutive wet days of 22 days, while the year 1992 had fewer consecutive wet days of 4 days, high daily precipitation intensity of 28.6 mm, and lesser number of rainy days (43 days). The consecutive dry days, consecutive wet days, daily precipitation intensity, and rainy days generally ranged from 38 to 49 days, 7 to 19 days, 15 to 18.5 mm, and 107 to 120 days in excess, 25 to 55 days, 4 to 22 days, 11.8 to 28.6 mm, and 43 to 125 days in normal years, and 31 days, 8 days, 15.4 mm, and 67 days in deficient years, respectively (Table 5). The minimum CDD of 25 days and maximum of 22 wet days are obtained in this zone over the normal rainfall years. Furthermore, in terms of the simple daily precipitation intensity index (SDII), the High Rainfall Zone faces a higher intensity of 28.6 mm, as the average rainfall received throughout the year is quite high [27].

3.4 Western Zone

Table 6 depicts the extreme rainfall indices over the Western Zone indicates that the consecutive dry days (CDD) ranged from 58 to 85 days in excess, 45 to 83 days in normal, and 46 to 68 days in deficient rainfall years, whereas the consecutive wet days (CWD) ranged from 12 to 13 days, 5 to 14 days, and 5 to 8 days in excess, normal and deficient years, respectively. The annual count of rainy days ranged from 93 to 128 days, 68 to 112 days, and 64 to 87 days with a simple daily precipitation intensity index (SDII) of 11.3 to 13.6 mm, 9 to 15.1 mm and 8.9 to 11.5 mm in excess, normal, and deficient rainfall years, respectively. Furthermore, greater CDD of 85 days is recorded in 1998 (excess), CWD of 14

days in 2018 (normal), SDII of 15.1 mm in 1993 (normal), and Rainy days of 128 days in 2021 (excess), and less CDD of 45 days in 2000, 2008 (normal), CWD of 5 days in 1993 (normal) and 1994 (excess), SDII of 8.9 mm and Rainy days of 64 days in 2016 of deficient rainfall years. The Western Zone obtains a low rainfall intensity of 8.9 mm, as the mean annual rainfall received during the northeast monsoon is lower than the remaining zones and also [28] identified that the frequency of very light rainfall (0.1-2.4 mm) is higher than moderate rain (7.6-35.5 mm) over Coimbatore district of this zone.

3.5 Cauvery Delta Zone

The consecutive dry days is higher with 99 days (1998) and lower with 33 days (2000) in normal rainfall years. The excess rainfall year of 2021 has more consecutive wet days of 15 days and also rainy days of 119 days, while the normal rainfall year of 1993 has more daily precipitation intensity of 20.4 mm. The consecutive dry days, consecutive wet days, daily precipitation intensity, and number of rainy days generally ranged from 46 to 75 days, 11 to 15 days, 14.7 to 16.2 mm and 96 to 119 days in excess years, 33 to 99 days, 6 to 12 days, 10,9 to 20.4 mm and 66 to 101 days in normal years and 51 to 89 days, 5 to 9 days, 11.2 to 16.3 mm and 55 to 68 days in deficient years, respectively (Table 7). The highest CDD of 99 days is found over the Cauvery Delta Zone, particularly in the Thanjavur Delta region [29], leading to the occurrence of drought with no specific pattern to mitigation planning [30].

Table 5. Extreme rainfall indices as per classified rainfall years over High Rainfall Zone

Category	Years	CDD	CWD	SDII	Rainy days
Excess	2006	38	14	17.3	107
	2015	49	7	17.3	114
	2019	42	11	15.0	118
	2021	45	19	18.5	120
Normal	1991	47	7	20.7	59
	1992	45	4	28.6	43
	1993	40	5	23.2	52
	1994	35	4	27.2	49
	1995	29	5	20.5	61
	1996	31	8	20.5	55
	1997	39	6	22.5	64
	1998	43	8	17.4	77
	1999	32	6	15.4	77
	2000	23	8	13.3	95
	2001	55	12	16.1	81
	2002	37	9	15.3	84
	2003	37	11	16.2	80
	2004	42	11	16.5	97
	2005	26	6	16.7	88
	2007	33	8	16.4	91
	2008	37	16	15.5	93
	2009	25	6	22.0	70
	2010	36	16	15.5	108
	2011	31	12	16.9	79
	2012	31	21	15.6	79
	2013	33	7	15.2	87
	2014	32	10	14.7	89
	2017	27	9	14.8	95
	2018	26	22	12.2	125
	2020	42	17	13.7	114
	2022	39	13	11.8	82
Deficient	2016	31	8	15.4	67

Table 6. Extreme rainfall indices as per classified rainfall years over Western Zone

Category	Years	CDD	CWD	SDII	Rainy days
Excess	1998	85	12	13.6	93
	2010	65	12	11.3	124
	2021	58	13	11.5	128
Normal	1991	70	6	12.3	68
	1992	83	6	13.0	68
	1993	57	5	15.1	73
	1996	63	8	10.8	79
	1997	66	7	13.6	70
	1999	50	13	11.2	96
	2000	45	9	11.4	96
	2001	63	10	10.6	93
	2002	51	7	10.3	81
	2003	52	7	9.6	88
	2004	72	9	11.6	94
	2005	55	11	11.4	104
	2006	51	10	11.4	98
	2007	72	13	11.4	99
	2008	45	12	10.5	96
	2009	60	8	10.8	84
	2011	53	12	10.8	112
	2012	69	10	10.6	91
	2014	70	11	9.4	98
	2015	61	12	11.2	102
	2017	47	12	9.1	108
	2018	60	14	9.6	105
	2019	69	9	10.4	95
	2020	66	8	9.0	102
	2022	49	11	11.5	108
Deficient	1994	59	5	11.5	67
	1995	68	6	11.1	72
	2013	46	8	9.0	87
	2016	65	**7**	8.9	64

3.6 North Western Zone

Table 8 indicates that maximum consecutive dry days (CDD) is recorded in 1998 and low in 2008 in normal rainfall years ranging from 35 to 77 days, 45 to 63 days in excess, and 59 to 74 days in deficient years. A higher consecutive wet day (CWD) of 14 days was obtained in 2021, ranging between 11 and 14 days in excess; a lesser CWD of 5 days in 1994, ranging between 5 and 8 days in deficient years; and a range of 6 to 13 days in normal rainfall years. The simple daily precipitation intensity index is maximum of 14.6 mm in 1993 and minimum of 9.0 mm in 2003 and 2020 in normal rainfall years ranged between 9 and 14.6 mm, and rainy days ranged from 109 to 137 days in excess, 71 to 117 days in normal, and 72 to 83 days in deficient rainfall years, with maximum days in 2021 (excess) and minimum days in 1997 (normal). The average daily rainfall intensity is lower (12%) than the other zones, which is in accordance with the study by Jagannathan et al. [31], indicating that the zone witnesses very low rainfall, particularly over the Paramathi area of Vellore district.

3.7 North Eastern Zone

The extreme rainfall indices depicted in Table 9 over the North Eastern Zone indicates that the consecutive dry days (CDD) ranged from 50 to 88 days in excess rainfall years, 38 to 91 days in normal rainfall years, and 74 to 98 days in deficient rainfall years, whereas the consecutive wet days (CWD) ranged from 7 to 12 days, 6 to 13 days, and 7 to 9 days in excess, normal and deficient years, respectively. The annual count of rainy days ranged from 86 to 125 days, 69 to 125 days, and 66 to 78 days with a simple daily precipitation intensity index (SDII) of 11.9 to 15.1 mm, 10.2 to 17.2 mm, and 10.0 to 15.9 mm in excess, normal, and deficient rainfall years,

respectively. Furthermore, greater CDD of 98 days is recorded in 2016 (deficient), CWD of 13 days in 1998, 2011, 2018 (normal), SDII of 17.2 mm in 1993 (normal), and Rainy days of 125 days in 2011 (normal) and 2021 (excess), whereas less CDD of 38 days in 2022 (normal), CWD of 6 days in 1992, 1997 (normal), SDII of 10.0 mm in 2016 (deficient), and Rainy days of 66 days in 1991 and 1994 o deficient rainfall years, respectively. The average consecutive wet days is very low when compared to the other zones as the rainfall received in this zone during southwest monsoon has shown greater variability [25].

Table 7. Extreme rainfall indices as per classified rainfall years over Cauvery Delta Zone

Category	Years	CDD	CWD	SDII	Rainy days
Excess	2005	51	11	15.6	93
	2010	75	14	15.2	112
	2015	65	12	16.2	96
	2021	46	15	14.7	119
Normal	1993	64	6	20.4	67
	1995	64	8	13.3	74
	1996	62	8	14.5	79
	1997	52	7	17.3	66
	1998	99	12	15.9	90
	1999	47	9	14.5	87
	2000	33	8	14.3	90
	2001	60	9	12.3	85
	2003	42	7	13.4	83
	2004	61	9	14.9	92
	2006	49	8	13.4	87
	2007	67	12	14.4	88
	2008	41	9	15.2	88
	2009	48	8	16.0	74
	2011	59	11	13.9	100
	2012	53	13	13.6	82
	2013	36	9	12.6	82
	2014	69	9	12.2	92
	2017	47	11	12.1	98
	2018	44	8	10.9	101
	2019	76	9	13.9	85
	2020	69	7	12.9	102
	2022	36	7	12.7	100
Deficient	1991	61	7	16.3	55
	1992	89	6	14.5	63
	1994	51	5	13.1	56
	2002	63	9	12.1	77
	2016	87	7	11.2	68

Table 8. Extreme rainfall indices as per classified rainfall years over North Western Zone

Category	Years	CDD	CWD	SDII	Rainy days
Excess	2005	45	11	11.9	115
	2010	63	12	10.6	136
	2015	45	10	11.0	109
	2021	49	14	11.0	137
Normal	1991	63	6	12.7	72
	1992	62	7	11.6	79
	1993	49	7	14.6	77
	1995	54	8	11.7	87
	1996	53	10	11.0	97
	1997	55	6	11.7	71

Category	Years	CDD	CWD	SDII	Rainy days
	1998	77	13	11.9	112
	1999	39	11	11.1	113
	2000	41	9	11.3	113
	2001	54	12	10.5	98
	2003	51	9	9.0	101
	2004	59	12	12.3	106
	2006	46	7	10.5	98
	2007	69	12	12.6	107
	2008	35	9	10.0	110
	2009	50	8	10.9	87
	2011	62	11	11.4	116
	2012	67	10	10.9	100
	2013	46	10	9.6	97
	2014	70	8	10.5	98
	2017	41	19	10.1	118
	2018	49	10	9.6	112
	2019	60	12	10.4	102
	2020	63	10	9.0	117
	2022	41	11	10.6	112
Deficient	1994	59	5	10.8	72
	2002	48	8	10.1	83
	2016	74	8	9.4	78

Table 9. Extreme rainfall indices as per classified rainfall years over North Eastern Zone

Category	Years	CDD	CWD	SDII	Rainy days
Excess	2006	50	7	11.9	92
	2015	70	9	15.1	101
	2019	88	10	12.6	86
	2021	53	12	14.3	125
Normal	1992	91	6	14.4	69
	1993	68	7	17.2	73
	1996	71	9	14.0	87
	1997	62	6	15.4	74
	1998	91	13	13.6	105
	1999	56	9	13.4	94
	2000	42	9	12.6	102
	2001	66	10	11.9	93
	2002	58	9	11.2	86
	2003	59	8	10.5	92
	2004	62	9	12.8	99
	2005	53	9	15.5	103
	2007	76	10	14.2	97
	2008	45	10	13.7	97
	2009	51	8	13.9	79
	2011	74	13	13.4	125
	2012	71	9	12.9	100
	2013	57	10	12.5	91
	2014	57	10	11.6	94
	2017	88	8	12.0	91
	2018	49	13	11.7	112
	2019	42	9	10.2	101
	2020	73	9	12.4	112
	2022	38	9	12.3	108
Deficient	1991	83	8	15.9	66
	1994	75	7	13.9	66

Category	Years	CDD	CWD	SDII	Rainy days
	1995	74	8	12.0	83
	2016	98	9	10.0	78

4. CONCLUSION

From the study, it was found that the High Rainfall Zone experiences minimum consecutive dry days, maximum consecutive wet days and high simple daily intensity index over normal rainfall years. The maximum number of consecutive dry days and more rainy days were noticed over the Cauvery Delta Zone and the High Altitude and Hilly Zone, respectively, whereas the minimum daily intensity index was observed over the Western Zone, as the zone receives only a smaller amount of rainfall. Overall, the High Rainfall Zone witnessed more extreme rainfall events, followed by the Western Zone, the Cauvery Delta Zone, and the High Altitude and Hilly Zone. The outcome of the study will help in futuristic climate change adaptation and mitigation strategies, particularly for the respective zones under the condition of limited data availability.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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