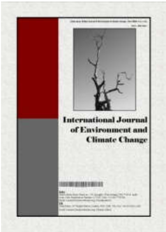

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Investigation of Climate Variability Over High Rainfall Zone of Tamil Nadu, India

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ABSTRACT

Rainfall is one of the most important climatic variables that determine the spatial and temporal patterns of climate variability of a region, which also provides useful information for the planning of water resources, agricultural production, and others. Climate change is one of the most significant worldwide issues talked among scientists and researchers, and one of the consequences of climate change is the alteration of rainfall patterns. 'India's population and the economy is linked to climate-sensitive activities, including rainfed agriculture and excess climate anomalies, deficient and flooded rainfall years have a dramatic impact on the economy as well as on the living conditions of the inhabitants of the affected region. An understanding of current and historical trends and variation is inevitable to her future development, especially in agricultural and hydrological sectors. In the present study, historical weather data for 33 years (1981-2013) was analyzed for rainfed cropping season (September - December) to understand the climatic variability in the Kanyakumari district of Tamil Nadu. The maximum daily air temperature increased on average by 0.02°C per year, whereas minimum daily air temperature remained constant during the rainfed cropping season. The high rainfall zone receives an annual and rainfed cropping average rainfall of 1307and 672 mm, respectively. Analysis of rainfall during rainfed cropping period over 33 years showed ten years had standard RF, nine years had deficit rainfall, six years had below standard RF, one year had above standard RF and seven years had excess RF.

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Analysis indicates that the deficit condition prevailed in every alternate year in recent decades. The onset of rainfed cropping season varied over the years (1981-2013), 13 years had onset in the slot from 1st to 5th September, and in others, years onset occurred between 6 and 30th September. Cessation also had a variation over 33 years and 16 years had cessation from 26 to 31st December while remaining years had cessation in the period of 1-25th December. LGP ranged from 57 to 143 days, with an average LGP of 106 days. Dry spell varied from 3 to 12 days with the mean of 6 days, and wet spell varied from 2 to 8 days with an average of 5 days.

Keywords: Climate variability; wet spell; dry spell; long period average (LPA); onset; cessation.

1. INTRODUCTION

The agricultural sector is adversely affected by climate variability, primarily through droughts, floods, and other extreme weather events [1]. Overall, the success or failure of crop production under rainfed systems is strongly coupled with rainfall patterns that prevail during the cropping season [2]. Trend analysis is a method to determine the spatial variation and temporal changes for different parameters associated with climate [3]. For a nation like India, this is a crucial issue as our country is having an agro-based economy, which largely depends on rainfall due to monsoon [4-6]. Thus, any change in that phase of a year. It may ruin the agricultural conditions of the country and thereby the economy [3].

Moreover, it will also cause a threat to the food security of the nation. Kanyakumari District is a land of varied topography with the sea on three sides and the mountains of the Western Ghats bordering the northern side [7-9]. The district has a unique advantage of rainfall during both the southwest and northeast monsoons. The investigation of climate variability over the Kanyakumari district helps the farmers to make farming decisions according to the changing climate patterns.

2. MATERIALS AND METHODS

2.1 Description of the Study Area

The high rainfall zone of Tamil Nadu consists of Kanyakumari district, located in the southern tip of peninsular India, between 77.05 and 77.36 longitudes and 8.03 and 8.35oN, latitude. It is bordered by Tirunelveli district of Tamil Nadu in the North and North-East, and Kerala State in the North-West, and sea in the West and the South. The cropping pattern differs in the two identified physiographic regions. In the hills, the principal crops are rubber, clove, tapioca, and banana. Generally, there is no crop rotation since the majority of the crops are perennial. In the least, two crops of rice, the first from May - June to August - September and the second from September - October to February - March are cultivated. Occasionally a third crop of a pulse is grown. In the plains, the primary area is under rice, and two crops are raised in a year. During the summer season, black gram or green gram or gingelly is grown in some areas. Paddy - banana - paddy rotation is followed in about 10 percent of the area. In addition to these crops, tapioca, cashew, mango, vegetables, flower crops, palmyrah, tamarind, etc., also exist [10].

2.2 Temperature Analysis

The maximum and minimum average temperature was calculated for the cropping period (September to December) with the span of 33 years from 1981 through 2013 at high rainfall zone and temperature variation over 33 years was studied by computing the anomaly in temperature from the normal temperature averaged for the cropping period.

Anomaly = (Observed – long term average)

2.3 Rainfall Analysis

Daily rainfall accumulated for rainfed cropping period (September –December) over 33 years (1981 to 2013) and analyzed the performance of rainfed cropping season. Onset, cessation, wet and dry spell period, as well as Length of the growing period (LGP), was estimated during the rainfed cropping season.

2.4 Analysis of Performance of Rainfed Cropping Season

Based on the India Meteorological Department (IMD) classification, if the rainfall received in that particular year is within $\pm$ 19% of the LPA, that year is called as a normal rainfall year, <-19% to

-59% of the LPA is deficit rainfall year, <-59% of LPA is grouped under scanty rainfall year. On the other hand, if the rainfall is >+19% to +59% of LPA, it is excess rainfall year, and >+59% LPA is termed as a wet year. In our current analysis, the normal rainfall category has been further classified as -19 to -10.1% of LPA as below normal rainfall year, -10 to +10% of LPA as normal rainfall year and +10.1 to +19% of LPA as above normal rainfall years.

2.5 Length of the Growing Period (LGP)

LGP was arrived by estimating the number of days between onset and cessation, in addition, to support from soil moisture for crop growth from the last spell of rainfall for the rainfed cropping season.

2.6 Onset of Monsoon

Onset was determined using the pentad analysis performed from 1st September to 10th October. Considering the first pentad with a quantum of 10 mm of rainfall and four consecutive pentads records 10 mm of rainfall per pentad for rainfed cropping period.

2.7 Cessation of Monsoon

In the rainfed cropping period, cessation of monsoon was seen in December month. In case of cessation 'did not occur during December, the cessation time was noted in November month. At the end of the season, the last day received the rainfall amount of $\geq$ 2.5 mm considered to be an indicator of cessation of monsoon.

2.8 Wet Period

The wet spell was calculated during the rainfed cropping period (September – December). A week (7 days) with the cumulative rainfall amount of 50 mm was considered as one wet spell. The number of weeks with this condition was counted during the entire rainfed cropping period in each year.

2.9 Dry Spell

The dry spell was calculated during the rainfed cropping period (September–December). Suppose non-rainy days observed continuously for a decade (10 days), that period was considered to be one dry spell. The number of dry weeks was counted during the entire rainfed cropping period in each year.

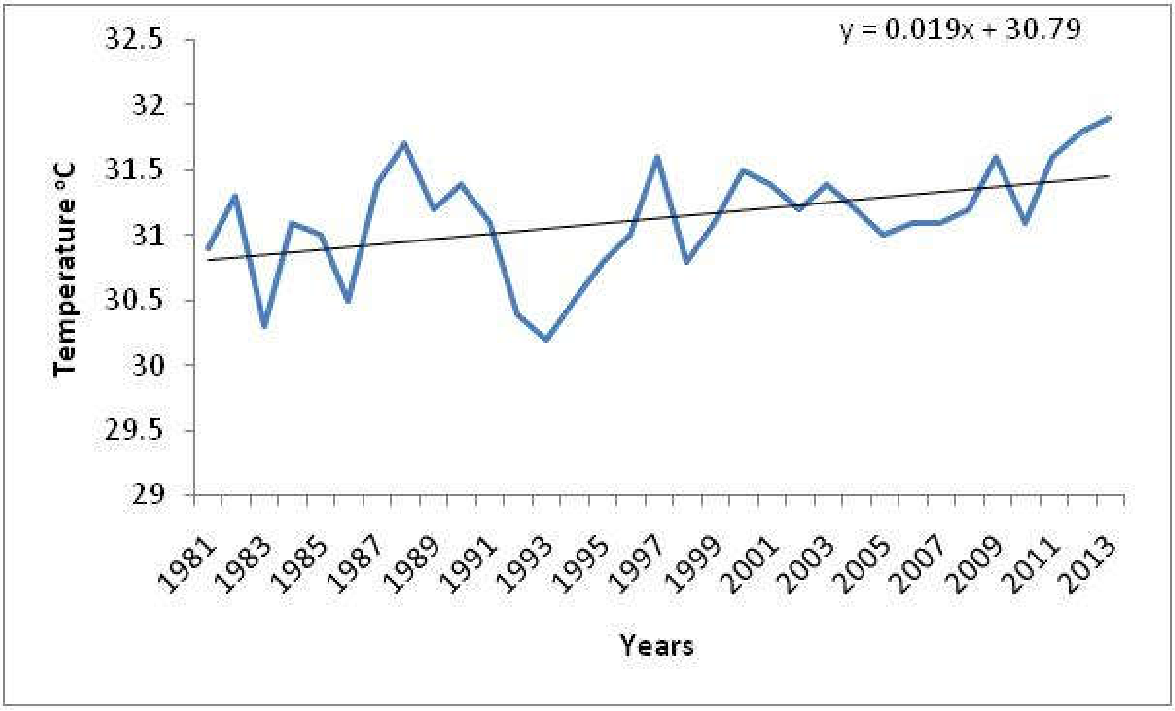

Fig. 1. The average maximum temperature during rainfed cropping period (1981-2013)

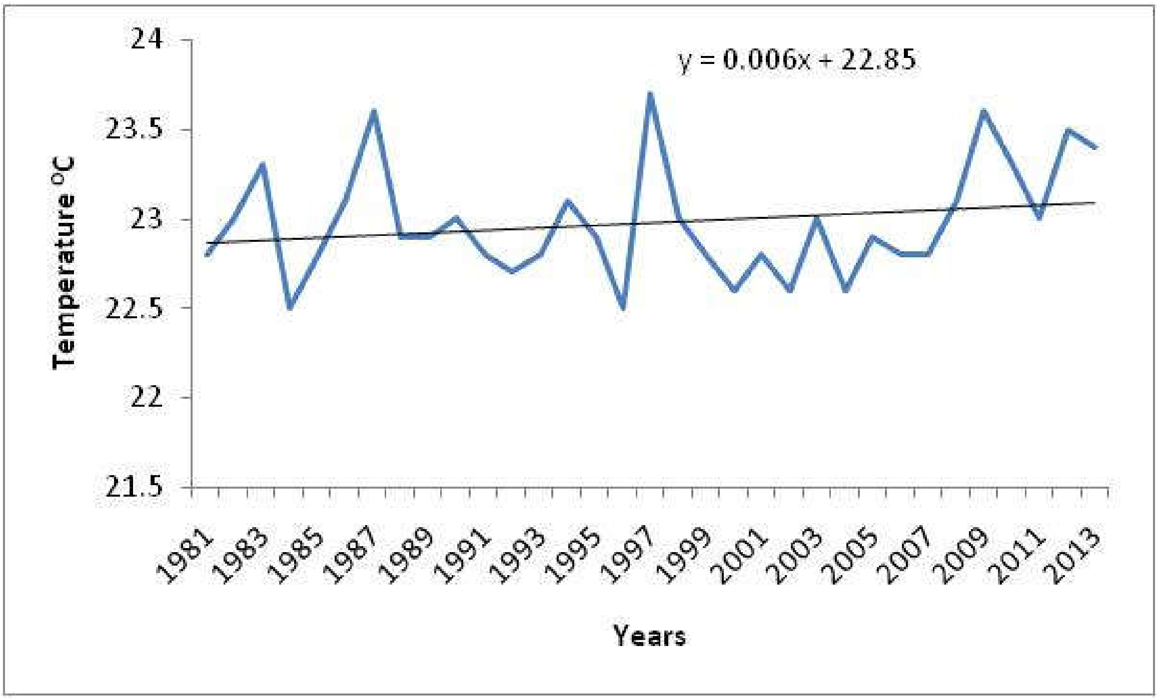

Fig. 2. Average minimum temperature during rainfed cropping period (1981-2013)

3. RESULTS AND DISCUSSION

3.1 The Temperature in High Rainfall Zone

Analysis of temperature data over 33 years indicates that maximum air temperature had an increasing trend and increased on average by 0.02°C per year, whereas minimum air temperature did not change much during rainfed cropping season (Figs. 1 and 2).

3.2 Rainfall Profile of High Rainfall Zone

Annual rainfall received from 1981 to 2013 period is presented in Fig. 3.

The Fig. 3 shows high interannual variability in annual rainfall over 33 years. The annual rainfall ranged from 807.6 mm to 2222.1 mm. Normal Annual rainfall received in 111 days was 1307.0 mm with SD of 318 and CV o 24.3%.

Rainfall received from 1981 to 2013 is presented in Table 1.

Out of 33 years of rainfall considered for the analysis, ten years had normal rainfall, six years had excess rainfall, and eight years had deficit rainfall (Fig. 4). In recent 'year's drought occurred frequently.

Analysis of rainfall during rainfed cropping period over 33 years (Fig. 5) showed ten years had normal RF, nine years had deficit rainfall, six years had below normal RF, one year had above normal RF and seven years had excess RF. Analysis indicates that the deficit condition prevailed in every alternate year in recent decades.

3.3 The Onset of the Rainfed Cropping Season

The rainfall onset is illustrated in (Fig. 6). The onset of rainfed cropping season varied over the years (1981-2013), and a higher number of years had onset in the slot from 1st to 5th September. Onset in the slot from 1st to 5th September was in 13 years (39%), and in others, years onset occurred between 6 and 30th September.

3.4 Cessation of the Rainfed Cropping Season

Cessation of rainfed cropping period was seen in December month. The rainfall cessation of the rainfed cropping period is portrayed (Fig. 7). Results revealed that the cessation happened during the last five days of December (26th to 31st December) was higher (48%) while remaining years had cessation in the period of 1-25th December.

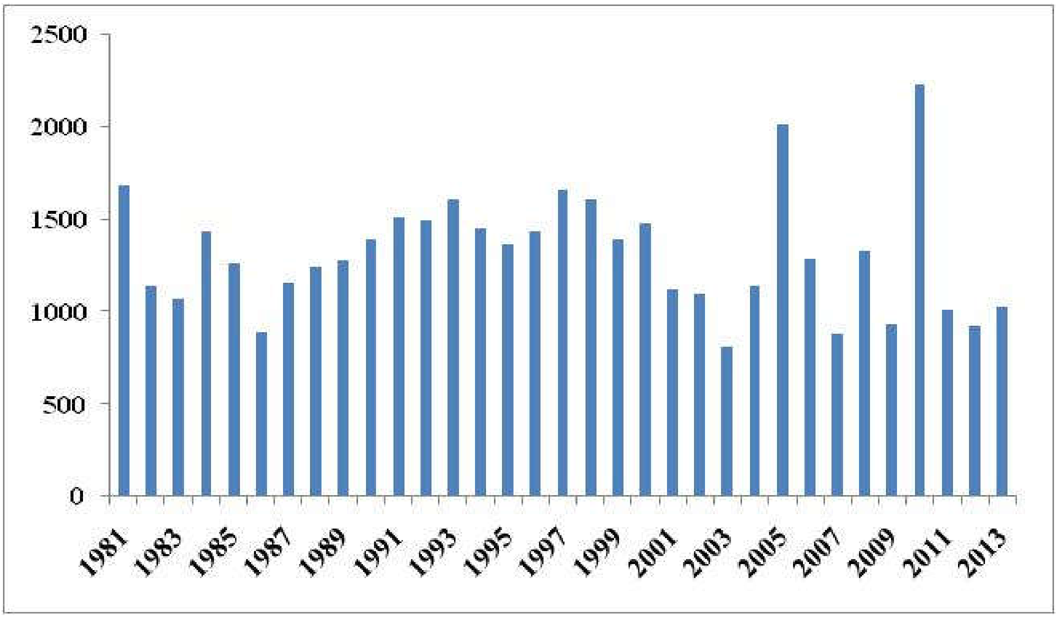

Fig. 3. Annual rainfall over 33 years (1981-2013)

Table 1. Annual rainfall (1981-2013) in High Rainfall Zone

Year	Annual rainfall (mm)	% Deviation from Normal Rainfall	Category
1981	1679.6	28.5	Excess
1982	1133.6	-13.3	Below Normal
1983	1061.6	-18.8	Below Normal
1984	1425.9	9.1	Normal
1985	1251.4	-4.3	Normal
1986	886.6	-32.2	Deficit
1987	1153.4	-11.8	Below Normal
1988	1235.8	-5.5	Normal
1989	1269.2	-2.9	Normal
1990	1384.2	5.9	Normal
1991	1506.1	15.2	Above Normal
1992	1490.4	14.0	Above Normal
1993	1602.9	22.6	Excess
1994	1441.1	10.3	Above Normal
1995	1358.8	4.0	Normal
1996	1426.2	9.1	Normal
1997	1650.6	26.3	Excess
1998	1603.3	22.7	Excess
1999	1382.9	5.8	Normal
2000	1472.1	12.6	Above Normal
2001	1115.4	-14.7	Below Normal
2002	1091.2	-16.5	Below Normal
2003	807.6	-38.2	Deficit
2004	1129	-13.6	Below Normal
2005	2006.4	53.5	Excess
2006	1277.6	-2.3	Normal
2007	869.5	-33.5	Deficit
2008	1325.3	1.4	Normal
2009	928.3	-29.0	Deficit
2010	2222.1	70.0	Excess
2011	1004.5	-23.1	Deficit
2012	918.8	-29.7	Deficit
2013	1021.2	-21.9	Deficit

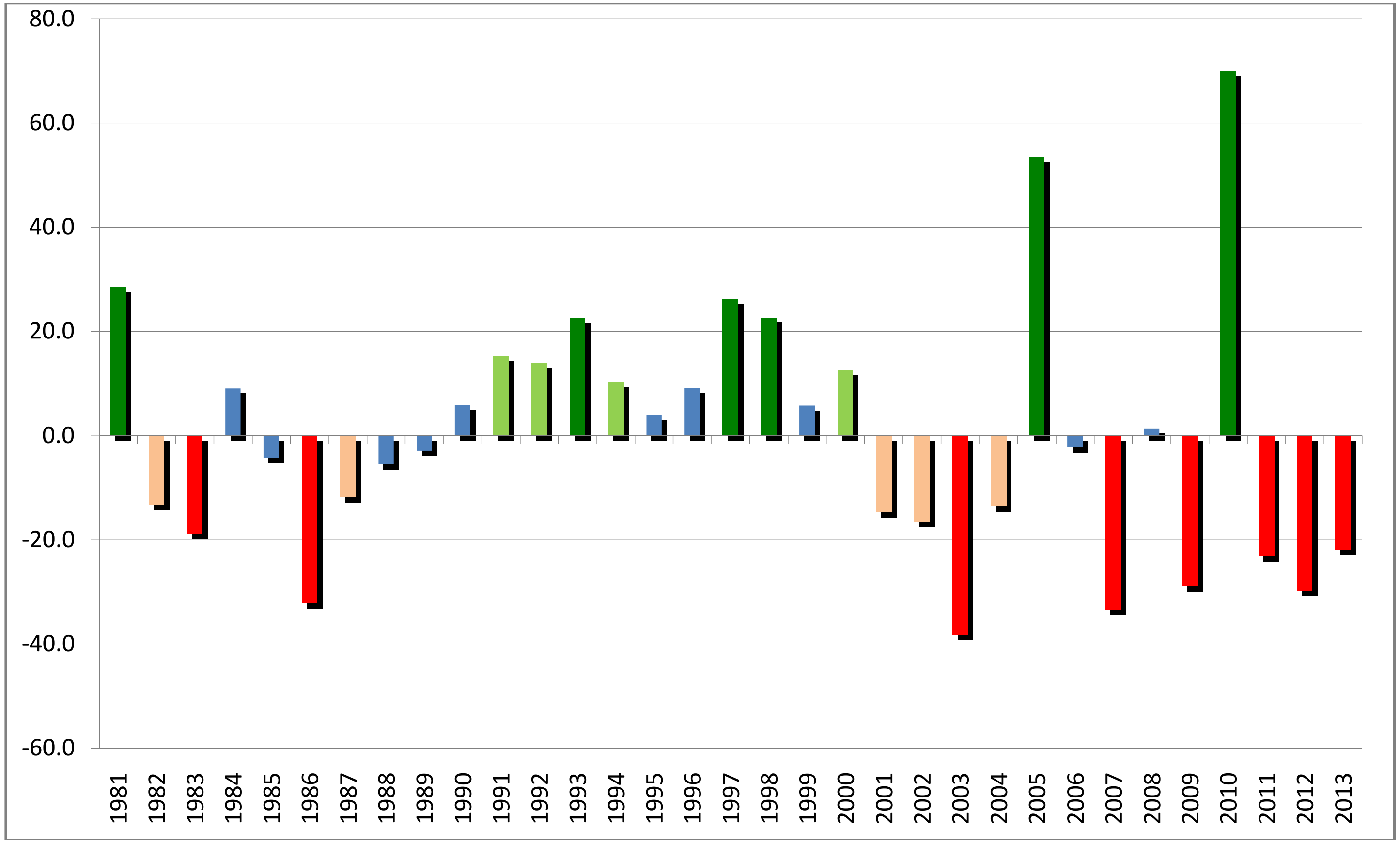

Fig. 4. Percentage deviation of annual rainfall from the normal (LPA) rainfall (%)

Deficit rainfall	Below Normal rainfall	Normal rainfall	Above normal rainfall	Excess rainfall
- 19.1 to -59% of LPA	*-19 to -10.1% of LPA*	*-10 to +10% of LPA*	*+10.1 to +19% of LPA*	*> +19.1 % of LPA*
Eight years	*Five years*	*Ten years*	*Four years*	*Six years*

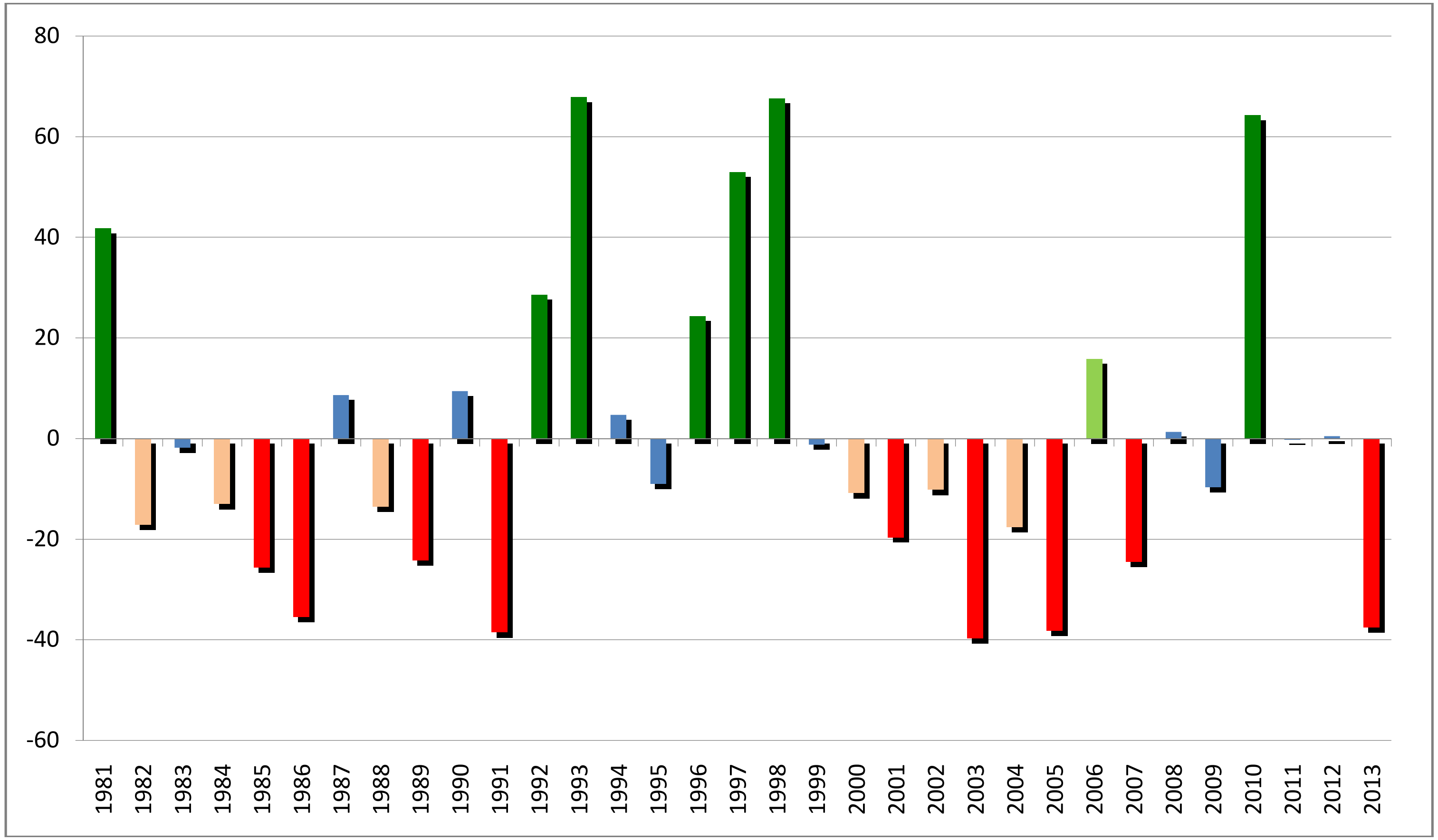

Fig. 5. Percentage deviation of rainfed cropping period rainfall from the normal rainfall (LPA) of rainfed cropping period (%)

Deficit rainfall	Below Normal rainfall	Normal rainfall	Above normal rainfall	Excess rainfall
- 19.1 to -59% of LPA	*-19 to -10.1% of LPA*	*-10 to +10% of LPA*	*+10.1 to +19% of LPA*	*> +19.1 % of LPA*
Nine years	*Six years*	*Ten years*	*One year*	*Seven years*

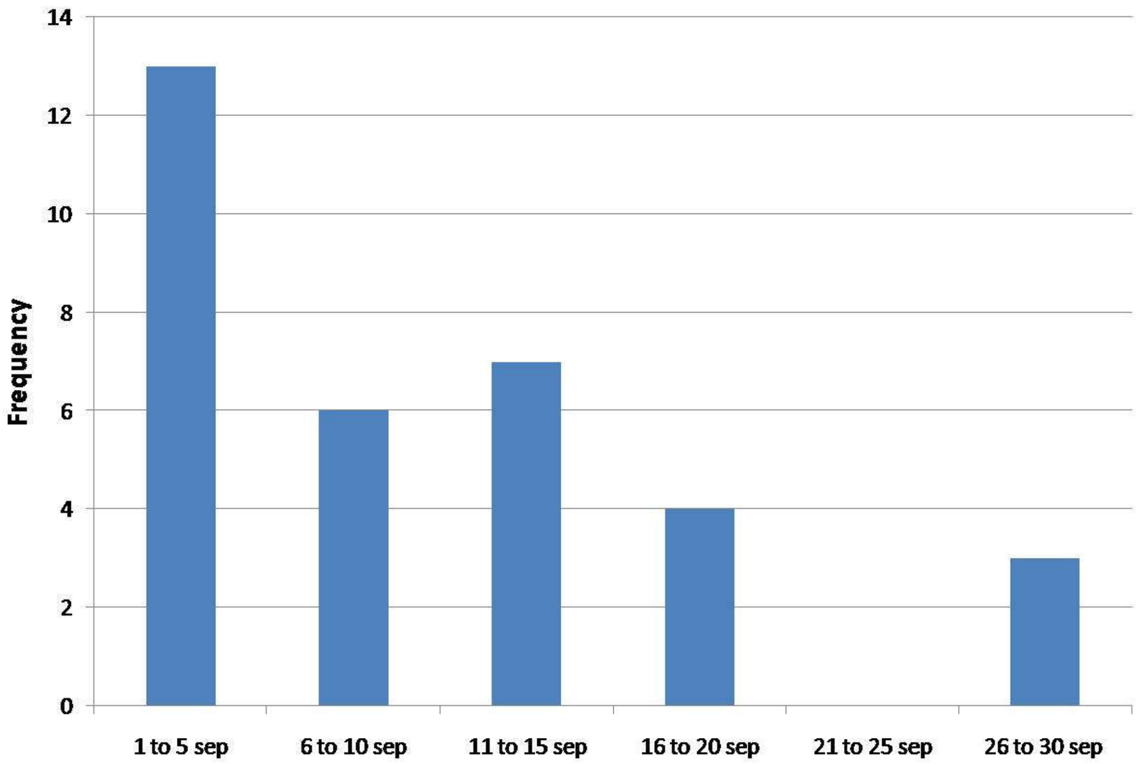

Fig. 6. The onset of the rainfed cropping season in high rainfall zone

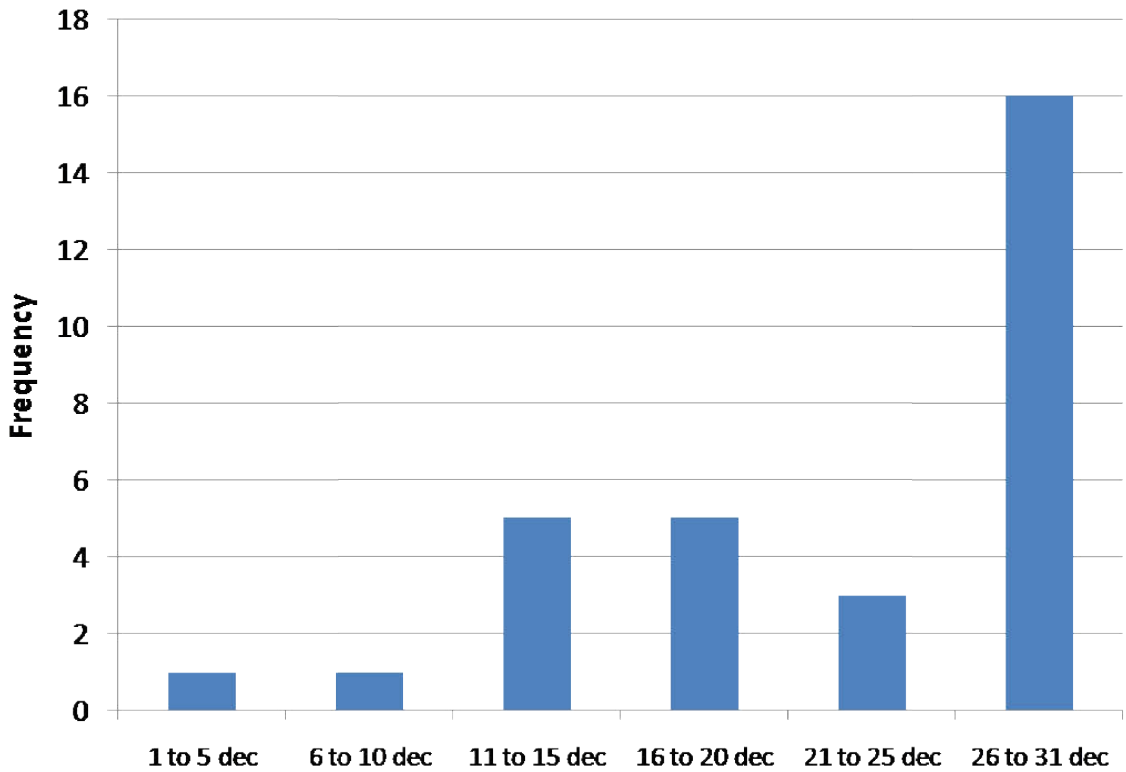

Fig. 7. Cessation of the rainfed cropping season in high rainfall zone

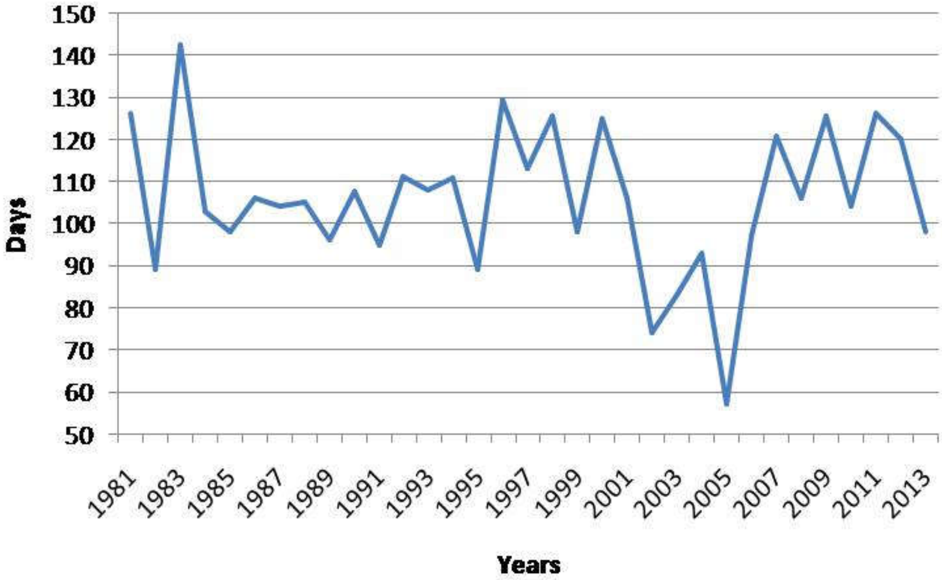

Fig. 8. Length of Growing Period (LGP) during rainfed cropping season in High Rainfall Zone

3.5 Length of Growing Period and Wet and Dry Spells

The results indicate that LGP ranged from 57 to 143 days, With an average LGP of 106 days and 36, 27, 12, and 24 percent of the years. It had LGP of less than 100, 101 to 110, 111to 120, and 121 to 140, respectively. Dry spell varied from 3 to 12 days with the mean of 6 days, and wet spell varied from 2 to 8 days with an average of 5 days.

4. CONCLUSION

Analysis indicates that the deficit condition prevailed in every alternate year in recent decades. The onset of rainfed cropping season varied over the years (1981-2013), 13 years had onset in the slot from 1st to 5th September, and in others year's onset occurred between 6 and 30th September. Cessation also had a variation over 33 years and 16 years had cessation from 26 to 31st December while remaining years had cessation in the period of 1-25th December. LGP ranged from 57 to 143 days, with an average LGP of 106 days. Dry spell varied from 3 to 12 days with the mean of 6 days, and wet spell varied from 2 to 8 days with an average of 5 days.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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