Climatic Trends in Western Maharashtra, India

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Preface

Agricultural production systems of India are extremely sensitive to climatic vagaries. Each crop has its own requirement of optimum climatic conditions for achieving potential yield. It is, therefore, very important to understand the climatic parameters of a region to improve the agricultural practices for increasing the productivity and profitability of farmers. The vulnerability of agricultural production systems to various climatic aberrations is increasing with increasing incidences of extreme weather events such as droughts, floods, heat or cold waves, cyclones and hailstorms due to climate change.

Science of weather forecasts and agro-advisories at the district level has advanced considerably. However, the deviations are high in block and village level forecasts especially in the areas with low rainfall with high variability. Characterizing the agro-climate at the micro-scale is important for the selection of cropping systems and resource management options for higher profitability. This micro-level analysis of climate may be integrated into a bottom-up approach to develop a climate database at national level.

Considering the importance of weather and climate in agriculture under the changing climatic conditions, the long-term weather data should be is analyzed and trends identified so that the variability can be captured, assessed and utilized by different stakeholders for their respective objectives.

We sincerely hope that the long-term climate (1986-2019) analysis presented in this bulletin will be useful for researchers, farmers, students and other stakeholders. It will be of immense help for improving agro-advisories, contingency planning, agro-climatic classification, weather-based crop insurance and decision making at district, block and village levels.

Authors

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Summary

Rainfall and temperature are two of the most important variables in the field of climate sciences and hydrology frequently used to trace the extent and magnitude of climate change and variability. Since there are complex patterns of rainfall trends in India, micro-scale studies into variability and trend of extreme rainfall events are essential to understanding local-scale manifestations of climate change and to design context specific adaptation interventions. In places where rainfall is highly variable and geophysical characteristics vary within a short distance, studies of rainfall and temperature variation focusing on large areas would be of no use for local agriculture. Baramati is situated in the eastern part of the Pune district which is a part of the Western Maharashtra region. It falls under the agro-ecological region Deccan Plateau, hot and semi-arid climate (AER-6) and agro-climatic zone AZ-95 which is the scarcity zone of Maharashtra. The long-term average annual rainfall is 576 mm, and this is restricted to the south-west and retreating monsoon. Because of low rainfall, the soils in the area are shallow and poorly developed. As the major agricultural area is rainfed with limited sources of irrigation from the canal it is highly important to characterize the weather and climate for proper management of resources. Hence using the daily temperature and rainfall data for the period of 1986-2019 analysis was carried out, to find out the changes in frequency and intensity of temperature and rainfall. From these datasets, daily statistics were computed and are presented in tabular formats for the period January 1986 to December 2019.

The key observations on the weather variables recorded during the last thirty-four years are summarized below:

- Weekly maximum temperature has two peaks. It gradually increases from 1st week and a steep increase is observed after February 9th SMW to 18th SMW. After that, it is reduced in 30th SMW due to monsoon rainfall. A secondary peak is observed in 42nd SMW after the monsoon gets over while the weekly mean minimum temperature has one peak. It increases from 2nd SWM to 20th SMW, after that it decreases continuously.
- Long term monthly mean temperature reached its peak in May at 31.2 °C and dipped to its minimum at 21.9 °C in December.

- Long Period Average (LPA) annual mean temperature at Baramati is recorded as 26.3 °C.
- The annual mean maximum temperature varied between 27.8 ˚C (1987) and 34.4 ˚C (2002) with a long period average value of 33.0 ˚C, while annual mean minimum temperature fluctuated between 17.3 ˚C (2005) and 22.3 ˚C (1998) with across the years around a mean 19.5 ˚C.
- The highest number of hot days in a year (55) was recorded in 2010 while the highest cold days (16) were observed in the year 2018.
- It was found to that May, 1993 (34.1 ˚C) was the warmest month and January, 1988 (18.5 ˚C) was the coldest month.
- Based on the annual mean temperature the year 1998 (27.6 ˚C) was the warmest year while the year 2011 (17.5 ˚C) was the coldest.
- During the monsoon period starting from 20th to 43rd SMW, about 80-90% of the total rainfall occurs.
- Monthly rainfall had a unimodal peak. September receives maximum rainfall of 158.8 mm and January receives the minimum amount (0.6 mm).
- Long Period Average (LPA) for the last 34 years at Baramati is only 576.0 mm which is distributed in monsoon (69%), pre-monsoon (10%), and post-monsoon (21%) seasons.
- The distribution of rainfall monthly expected at 75% probability is less than 20 mm in almost all the months except September during the southwest monsoon period which adds uncertainty factor in rainfed crop production.
- Annual rainfall showed that it was alternatively increasing and decreasing in nature, consisting of a period of five or six years.
- The total number of rainy days per year during the study period was 34 in which the frequency of light rainy days (2.5-10 mm) was highest (17 days) followed by moderate light rainy days (10-25 mm) and moderate rainy days (25-50 mm) 10 and 5 days respectively.
- During these last 34 years, SW and post-monsoon rainfall were in the normal range in 14 and 7 years, respectively. In the case of annual total rainfall, 17 years received normal rainfall while in 8 years it was excess.

The above findings of the analysis can be used directly by different stakeholders including researchers for their respective objective sand it can further be used for characterizing the agro climate at micro-level and developing region-based agro advisories for better resource management and doubling farmer's income. Such analysis should also be performed for other small regions (village/block level) of the country to develop location-specific climate databases to improve the spatial scale of climate data which will improve the specificity and accuracy of the advisory services in India.

2. Introduction

Climate is the primary determinant of agricultural productivity. Over the past few decades, the man-induced changes in the climate have intensified the risk of climate-dependent crop production. The most imminent of the climatic change is the increase in the atmospheric temperature due to the increased levels of greenhouse gases in the atmosphere. Indian agriculture is highly prone to the risks due to climate change because two-third of the agricultural land in India is rainfed. Drought and flood are major problems in many parts of the country. In addition, frost, heat waves and cyclones also cause severe damages to agriculture. In recent years, the frequency of climatic extremes has increased resulting in increased risks to agricultural production and food security. Climate change can affect agriculture through direct and indirect effects on crop, soil, water and pest. Yields of major crops are likely to be reduced due to climate change. It will also have considerable effects on agricultural land use due to reduced availability of water and deteriorating soil quality.

Accurate weather monitoring and forecast is essential to achieve healthy plants and increased productivity and profitability. The past climatic data is often used for future weather forecasts of a region. Weather monitoring offers a set of measurement options to provide useful information about soil and crop conditions as well. Despite impressive advances in agricultural technology over the last century, a large part of the agricultural production system is still dependent on weather and climate. They have direct as well as indirect influences on all farm activities related to crop production, horticulture, animal husbandry and fishery. Farm income is sensitive and highly dependent upon weather and climatic conditions. A farmer can either harvest rich crops by exploiting the weather or incur a great loss by getting exposed to extreme weather conditions. It is necessary to learn about weather and climatic issues and use that knowledge judiciously and sustainably. Farmers can plan different farm activities like ploughing, sowing, applying irrigation and fertilizers and managing insect pest disease according to favorable weather conditions to maximize the farming output. Also, the land management, cropping system and cropping pattern, selection of cultivars and other farm management practices should be supported by the knowledge of climatic conditions of the region.

Extreme weather events (e.g. heat & cold waves, droughts, heavy rainfall) have always posed risks to human society. Efforts to identify the cause of individual

extreme events need to be understood. Extreme events has a significant role in defining the risk level of the agricultural production system and help in deciding management practices for reducing risk. The informational aspect of climate is an essential pre-requisite for proper agricultural planning and development, where past and present data can potentially be used to make optimal decisions for social and economic alternatives.

3. Methodology

As per the agro-climatic zonation, Baramati falls under the scarcity zone (NARP zone: AZ-95) and physio-graphically and is a part of *Deccan* plateau with average elevation of about 550 m AMSL. It is under the Madhya Maharashtra sub-division that is one of the 36 meteorological sub-divisions of the country that India Meteorological Department (IMD) has classified for rainfall forecasts during the monsoon season.

The daily long-term meteorological data of 34 years (1986-2019) of Baramati was processed and analyzed for three variables, viz. the maximum and minimum temperature and rainfall. The data have been collected from ICAR-NIASM Malegaon, Baramati (2012-2019) (Fig. 1) and Maharashtra State Irrigation Department office, Malegaon colony, Baramati (1986-2011) situated about three kilometers from the NIASM campus. Because of low rainfall, the soils in the area are shallow and poorly developed. Major agricultural area is rainfed except for about one-third of Baramati area along the Nira canal that is irrigated and mainly supports sugarcane. Agricultural drought is a common phenomenon in the area.

The mean, standard deviation and variability along with its highest and the lowest values of the surface weather elements temperature and rainfall has been studies on weekly, monthly and annual basis for Baramati. The extreme weather conditions were also identified and reported.

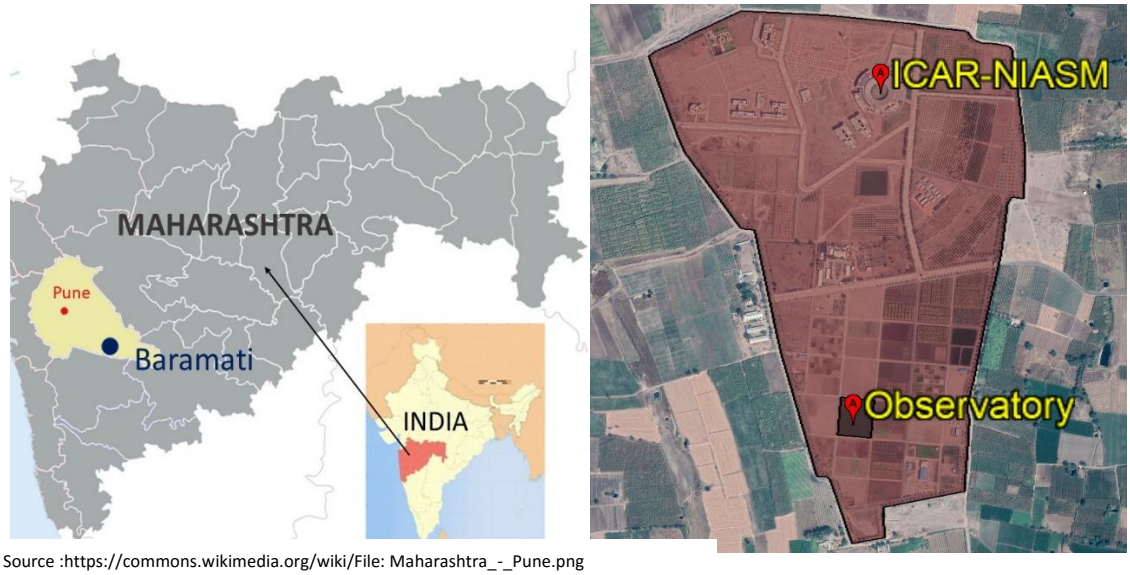

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Fig.1. Location of the observatory.

4. Climatic Parameters

4.1 Temperature

Temperature is one of the most influencing factors of the climate, which influences the growth and development of the crop and livestock. Different crops have different (optimum, maximum and minimum) and specific temperature requirements for their growth and development. Low temperature affects several aspects of crop growth viz. photosynthesis, cell division, water and nutrient transport, growth, etc. High temperature adversely affects photosynthesis, mineral nutrition, shoot growth and pollen development resulting in yield losses. Seed germination is highly sensitive to the temperature, even small changes in temperature at the time of seed germination have a significant impact on seed emergence. Some crops are highly sensitive to temperature throughout their life cycle. For example, potato is very sensitive to temperature for tuber development. An increase in temperature above 21 ^{o}C causes a reduction in tuber yield and temperature above 30 ^{o}C leads to complete inhibition of tuber formation. The changes in temperature variability, as well as extremes due to the impact of climate change, are manifested in the form of early or late flowering, reduced fertility, yield reduction etc. The variation in daily, weekly, monthly and annual temperature study helps farmers plan their cropping patterns during the season. Daily and weekly temperature variation help in planning intercultural activities like spraying, irrigation schedule, etc. Monthly temperature range helps to decide the seasonal cropping pattern i.e. *kharif*, *rabi* and summer. The annual mean temperature and its trend are useful to farmers for designing an efficient cropping system to achieve maximum profits.

Temperature is also important for the development of insect and pests and favorable temperatures may lead to severe losses in crops as well as livestock. Generally, insects are the cold blooded animals that have temperature approximately same as the environment therefore their life cycles strongly depend upon temperature. Variations in temperature cause an outbreak of disease and pest on crops. Vectors like aphids cause maximum damage to crop after certain threshold temperature by transmitting the pathogen e.g. at 25 ^{o}C the banana bunchy top virus which is transmitted by aphids causes maximum damage to the crop, similarly, the temperature range of 26-31 ^{o}C is suitable for the attack of papaya ringspot virus. Every plant pathogen has an optimal temperature range for their development e.g. 15 ^{o}C for

Globodera pallida nematodes on potato, 35 °C (day temp) *Xanthomonas oryzae* bacteria on rice. The rust pathogen *Puccinia striiformis* was unable to cause infections, if inoculated in wheat seedlings at constant temperatures over 21 °C, while in the field, infections occurred even in the temperature range of 18-30 °C. Temperature also plays a crucial role in livestock rearing and production. With maximum temperature shooting above normal causes heat stress in livestock which results in irregular activities like low milk yield, drinking more water, loss of appetite, heatstroke, heat exhaustion, heat syncope, heat cramps, and ultimately organ dysfunction. When the body temperature of livestock rises 3 to 4 °C above normal these heat-induced complications occur. Temperature is an important weather parameter because the information generated from it can help in the planning of agricultural activities such as the date of sowing, application of agrochemicals and harvesting of the crop. The monthly mean temperature also helps to decide on the suitability of crops for a given region. The knowledge of annual mean temperature and its trend can also help in mitigating the harmful effect of climate change by adopting appropriate action plans. An increase in temperature extends the length of the potential growing season, allows earlier planting, early harvesting and opens the possibility of completing two crop cycles in the same season.

4.1.1 Weekly Mean Temperature (1986-2019)

4.1.1.1 Weekly Mean Maximum Temperature

The weekly mean maximum temperature during all standard meteorological weeks for Baramati is given in Fig. 2. The lowest (29.4 ˚C) was recorded in the fourth week of December. A steep increase was observed after February from 34.4 ˚C (9th SMW) to 39.6 ˚C (18th SMW). After that, it is reduced to 29.9 ˚C in 30th SMW due to monsoon rainfall. A secondary peak (32.6 ˚C) was observed in 42nd SMW after the monsoon was over. After 44th SMW, it decreased sharply to its lowest (29.4 ˚C) in 51st SMW.

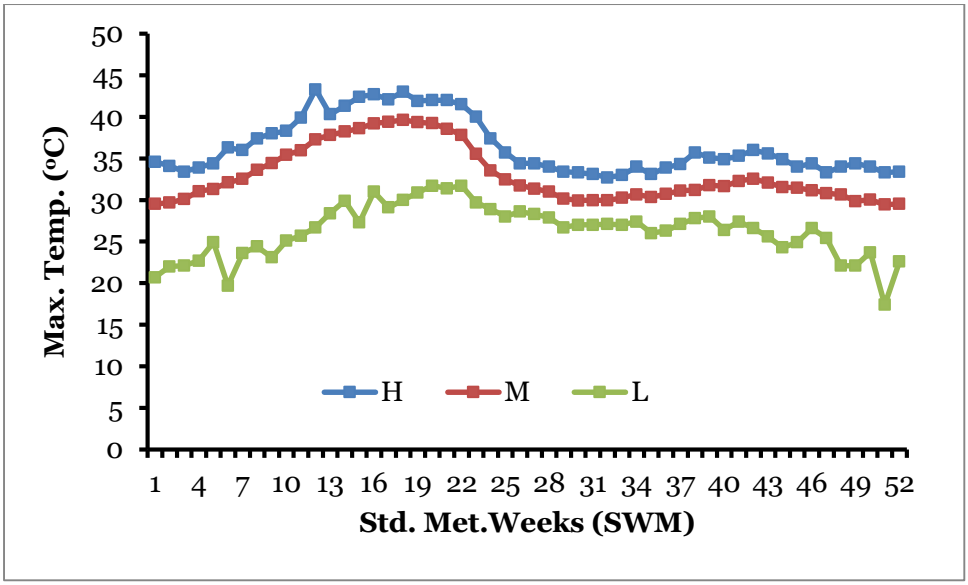

Fig. 2. Weekly mean (M), highest (H) and lowest (L) maximum temperature (1986 -2019).

The highest weekly mean maximum temperature was recorded 43.3 ˚C in 12th SMW of the year 2004 and the lowest one (17.4 ˚C) was recorded in the 51st SMW of 1987. The standard deviation (SD) of the weekly mean maximum temperature of each week across the years varied from 1.4 to 2.9 and the coefficient of variation (CV) varies from 4.6 to 9.0% (Table 1).

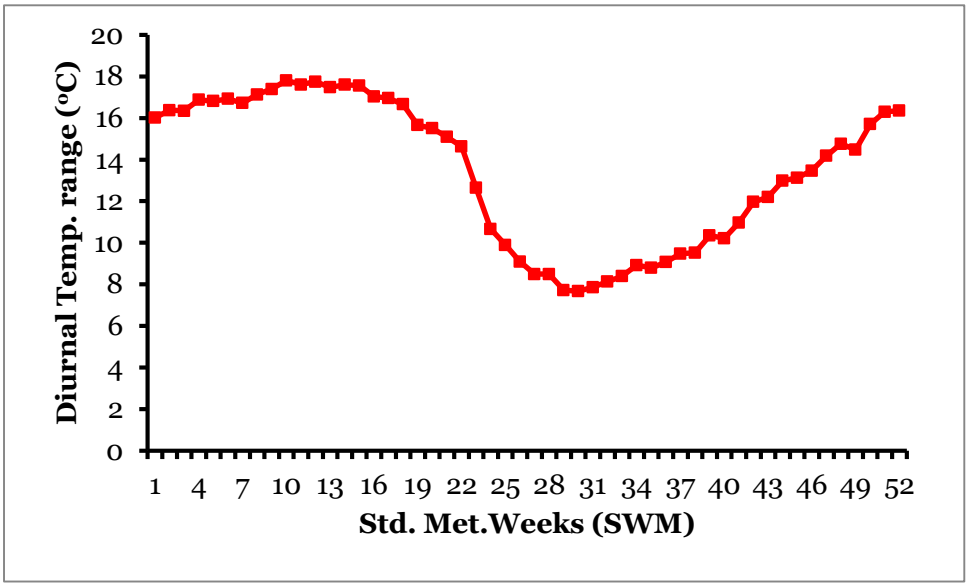

Fig. 3. Weekly mean diurnal temperature range (1986-2019).

The diurnal temperature range (DTR) is an important indicator of climate change because of its sensitivity to variations in the radiated energy balance. The mean diurnal temperature range for different weeks at Baramati is given in Fig. 3. The observed data the peak of the diurnal range was attained in the months of Dec-Feb. It

was found to be increasing from 16.0 ˚C (1st SWM) to 17.8 ˚C (10th SMW) during the start of the year. After that, it starts decreasing and reached 7.7 ˚C in 29th SMW. Again it starts to attain the peak in 52nd SMW (16.4 ˚C) and continues to rise in the next year. The diurnal temperature range remains above 10 ˚C between 1st to 24th SMW and 39th to 52nd SMW. While during the monsoon season from 25th to 38th SMW diurnal temperature is less due to the presence of moisture in the atmosphere.

Table 1. Weekly means maximum and minimum temperature (˚C) along with standard deviation (SD) and coefficient of variation (CV) (%) (1986-2019).

SMW	Maximum Temperature			Minimum Temperature		
	Normal	SD	CV	Normal	SD	CV
1	29.5	2.3	7.8	13.5	3.3	24.1
2	29.7	2.3	7.8	13.3	3.6	26.9
3	30.1	2.4	7.9	13.8	3.0	21.8
4	31.0	2.2	7.1	14.2	3.4	23.9
5	31.3	2.4	7.6	14.5	3.2	22.1
6	32.1	2.8	8.8	15.2	3.5	23.2
7	32.5	2.4	7.4	15.8	3.5	22.4
8	33.6	2.5	7.5	16.5	3.4	20.6
9	34.4	2.8	8.3	17.0	3.1	18.4
10	35.4	2.6	7.3	17.6	2.7	15.3
11	36.0	2.6	7.1	18.4	2.4	13.0
12	37.3	2.6	7.0	19.5	2.3	11.9
13	37.8	2.7	7.1	20.3	2.4	11.8
14	38.2	2.5	6.7	20.6	3.0	14.5
15	38.6	2.9	7.6	21.1	2.9	13.7
16	39.2	2.4	6.2	22.2	2.8	12.5
17	39.4	2.6	6.5	22.4	2.8	12.6
18	39.6	2.3	5.9	23.0	2.6	11.4
19	39.3	2.1	5.3	23.7	2.6	11.1

20	39.2	2.1	5.4	23.7	2.2	9.5
21	38.6	2.0	5.3	23.5	2.2	9.3
22	37.8	2.4	6.3	23.2	2.1	9.1
23	35.5	2.9	8.2	22.9	2.0	8.9
24	33.6	2.3	6.8	22.9	2.2	9.5
25	32.5	1.9	5.8	22.6	2.0	9.1
26	31.7	1.6	5.0	22.6	1.6	7.0
27	31.4	1.5	4.6	22.9	1.5	6.6
28	31.0	1.4	4.6	22.5	1.5	6.5
29	30.2	1.6	5.4	22.5	1.3	5.7
30	29.9	1.7	5.5	22.3	1.4	6.1
31	30.0	1.5	5.2	22.1	1.3	6.1
32	30.0	1.5	4.9	21.8	1.2	5.5
33	30.3	1.5	5.1	21.9	1.2	5.3
34	30.7	1.7	5.4	21.7	1.4	6.5
35	30.3	1.7	5.5	21.5	1.5	7.0
36	30.7	1.6	5.1	21.7	1.4	6.3
37	31.1	1.7	5.6	21.7	1.3	5.9
38	31.2	1.9	6.0	21.7	1.3	6.0
39	31.8	1.8	5.6	21.4	1.5	7.2
40	31.7	2.1	6.7	21.4	1.5	7.1
41	32.3	1.9	6.0	21.3	1.4	6.6
42	32.6	2.0	6.0	20.6	2.0	9.5
43	32.1	2.4	7.4	19.9	2.4	12.2
44	31.6	2.2	6.9	18.6	2.7	14.6
45	31.5	1.8	5.9	18.3	2.7	14.7
46	31.2	1.8	5.7	17.7	3.2	18.1
47	30.8	1.5	4.9	16.6	3.4	20.1

48	30.6	2.0	6.4	15.9	3.0	19.0
49	29.9	2.3	7.6	15.4	2.9	18.5
50	30.0	2.0	6.5	14.3	2.9	20.2
51	29.4	2.6	9.0	13.1	3.1	23.4
52	29.5	2.0	6.6	13.2	3.5	26.6
Mean	**33.0**	**2.1**	**6.4**	**19.5**	**2.4**	**13.2**

4.1.1.2 Weekly Mean Minimum Temperature

The weekly mean minimum temperature during different weeks of Baramati was given in Fig. 4. Unlike, weekly mean maximum temperature, it has one peak. It was found to be increasing from 2nd SWM (13.3 ˚C) to 20th SMW (23.7 ˚C). After that, it decreases continuously to reach its minimum at13.1˚C in 51st SMW. The values of weekly mean minimum temperature were observed >20 ˚C from 13th SMW to 42nd SMW. The highest (29.6 ˚C) and the lowest (7.1 ˚C) weekly mean minimum temperatures were observed during the 19th SMW of 1988 and 3rd SMW of 2012, respectively. The standard deviation and coefficient of variation varied from 1.2 -3.6% and 5.3- 26.9% respectively (Table 1)

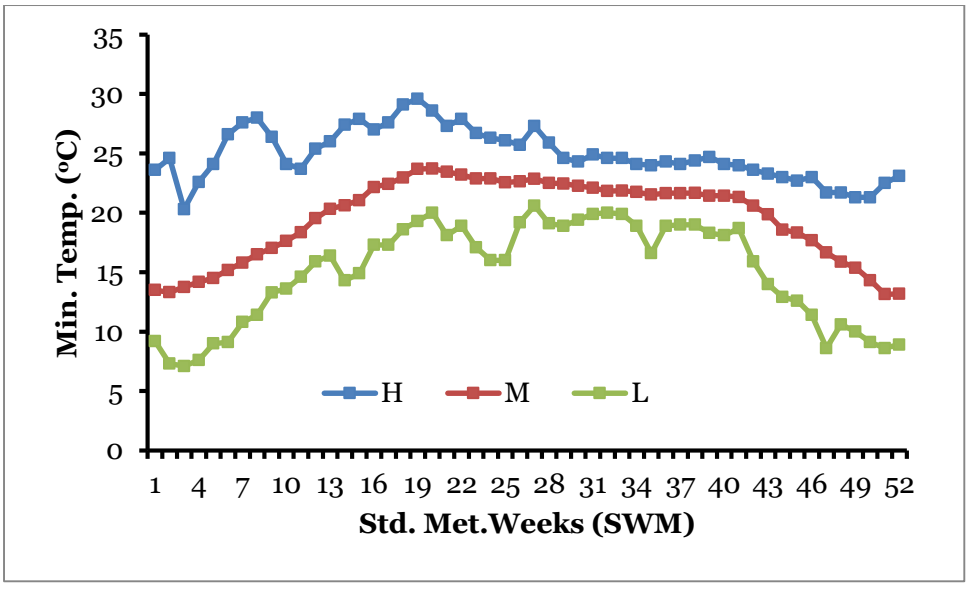

Fig. 4. Weekly mean (M), highest (H) and lowest (L) minimum temperature (1986-2019).

Importance to agriculture

Temperature is a primary factor affecting the rate of plant development. Warmer temperatures expected with climate change and the potential for more

extreme temperature events will impact plant productivity. At Baramati, the period around 14th to 21st SMW may not be suitable for growing any crop as the weekly mean maximum temperature hovers around 38-40 ˚C (Fig. 2). Evapotranspiration rate will be high and photosynthesis rate at 20 ˚C decreases because the enzyme does not work as efficiently at this temperature and as a beneficial side insect and pest controlled more efficiently by summer ploughing. Soil-borne insects, diseases and nematodes can be controlled more efficiently by summer ploughing of the fields during this time. Weekly mean minimum temperature may go below 10 ˚C from 49th to 6th SMW (Fig. 4). As a result, the enzymes that carry out photosynthesis do not work effectively leads to a decrease in photosynthesis and glucose production and stunted growth of plant occurs. For plants inside the greenhouse, the installation of a greenhouse heater and rest of the week are suitable for the crop which selected based on a particular region and on the basis of their climatic normal and threshold temperatures.

4.1.2 Monthly Mean Temperature (1986-2019)

The variability of the monthly mean temperature of Baramati from 1986-2019 is depicted in Fig. 5.

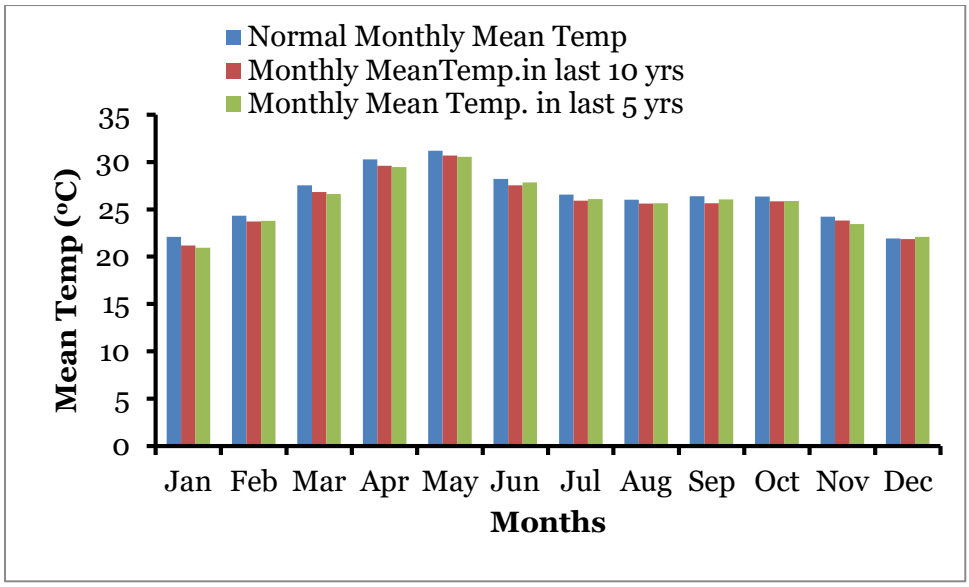

Fig. 5. Monthly mean temperature variations during 1986-2019.

The long term average of the monthly mean temperature varied between 21.9 °C (December) and 31.2 °C (May). However, during last ten years monthly maximum temperature reached its peak in May at 30.7 °C and dipped to its minimum at 21.2 °C

in January whereas during last five years the highest monthly maximum temperature recorded in May was 30.6 °C and December has the lowest value of 21.0 °C.

4.1.2.1 Monthly Mean Maximum Temperature

The monthly mean maximum temperature during different months at Baramati has presented in Fig.6. It increases from 30.2 ˚C to 39.0 ˚C from January to May. After this it reduces to 30.3˚C in August due to the cooling effect of the monsoon winds. A slight increase was observed in September (31.2 ˚C) and October (32.2 ˚C). Then it started decreasing and attains a value of 29.8 ˚C in December. The highest (41.3 ˚C) and lowest (21.5 ˚C) monthly mean maximum temperature were found in the months of April 2010 and December 1987, respectively. The standard deviation varied from 1.1 to 2.5 and the coefficient of variation varied from 3.5% to 7.6 % (Table 2).

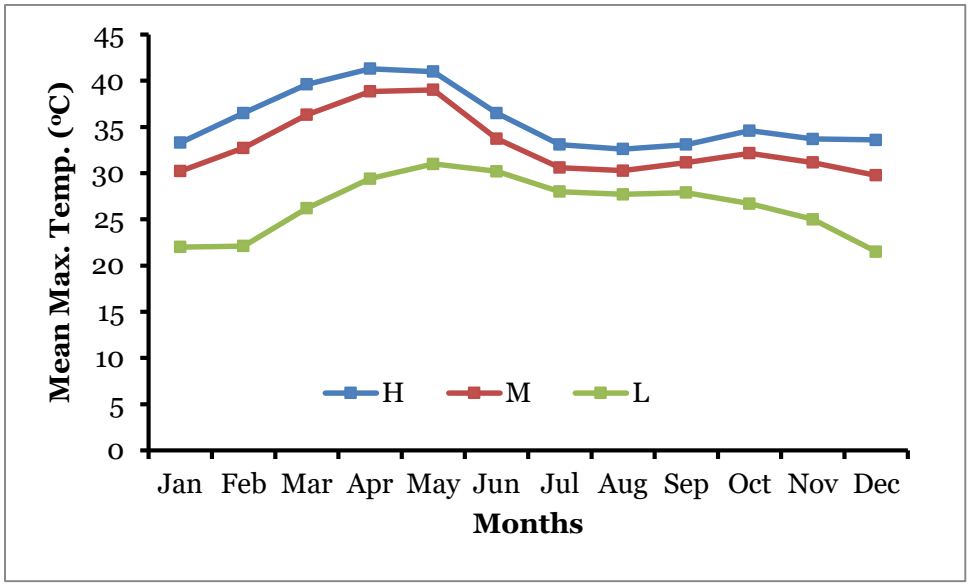

Fig. 6. Monthly mean (M), highest (H) and lowest (L) maximum temperature (1986-2019).

4.1.2.2 Monthly Mean Minimum Temperature

Monthly mean minimum temperature during different months at Baramati is depicted in Fig. 7. The lowest value of monthly mean minimum temperature (13.8 ˚C) was observed in January. After that it gradually increases to its highest value of 23.5 ˚C in May. Thereafter, it declines to 14.0 ˚C in December. A sharp decrease was noticed from October (20.6 ˚C) to December (14.0 ˚C). The monthly mean minimum temperature during April to October remained above 20.0 ˚C. The monthly standard

deviation varied from 1.2 to 3.1 and coefficient of variation varied from 5.3 to 21.2% (Table 2).

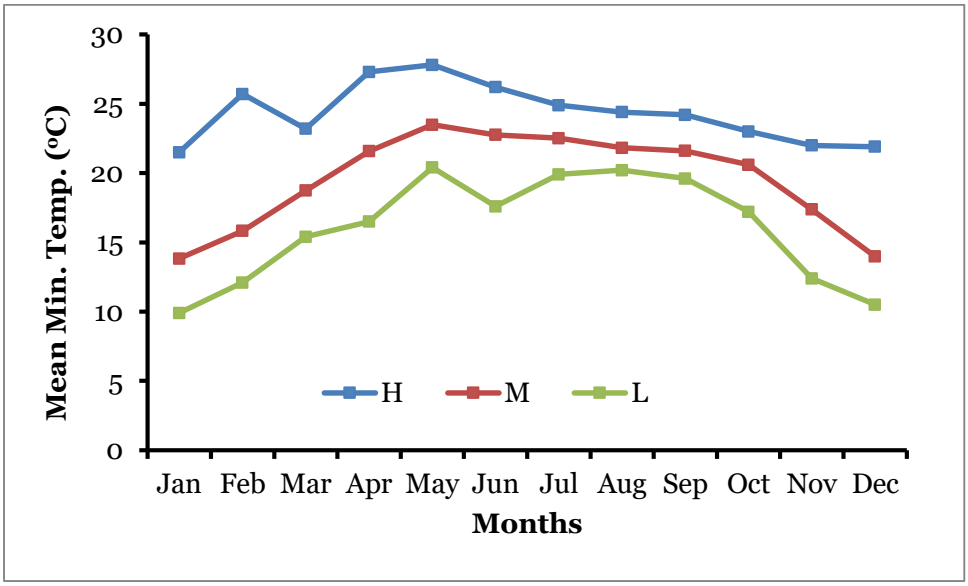

Fig. 7. Monthly mean (M), highest (H) and lowest (L) minimum temperature (1986-2019).

Importance to Agriculture

Recent research in agriculture science has pointed the importance of temperature fluctuations for the plant growth. Available data, such as monthly mean temperature will mask these daily fluctuations so it is important to keep record. Kharif (Jun-Sep) crops are also known as monsoon crop and associated with warm temperatures. The crops like *kharif* maize, soybean, sorghum, bajra, millets, and pigeon pea with a high threshold of temperature can be grown during this season. They required 25 °C average temperatures for crop growth. On the other hand, *rabi* crops like wheat, *rabi* maize, chickpea can be grown in the *rabi* or winter season (Nov-Mar). Wide variation in monthly mean temperature during season allow farmer of a particular region to grow different crop range as it helps to maintain the nutritional balance of the soil and also secure income in the particular season against crop failure.

Table 2. Monthly mean maximum and minimum temperature (˚C) along with standard deviation (SD) and coefficient of variation (CV) (1986-2019)

Months	Maximum Temperature			Minimum Temperature		
	Normal (˚C)	SD	CV	Normal (˚C)	SD	CV
Jan	30.2	2.1	6.9	13.8	2.9	21.2

Feb	32.7	2.5	7.6	15.8	3.1	19.5
Mar	36.3	2.4	6.6	18.7	2.1	11.1
Apr	38.8	2.4	6.2	21.6	2.6	11.9
May	39.0	1.8	4.7	23.5	2.1	9.0
Jun	33.7	1.6	4.7	22.8	1.9	8.1
Jul	30.6	1.1	3.5	22.5	1.2	5.5
Aug	30.3	1.1	3.5	21.8	1.2	5.3
Sep	31.2	1.2	4.0	21.6	1.2	5.7
Oct	32.2	1.8	5.6	20.6	1.7	8.3
Nov	31.1	1.5	4.9	17.4	2.5	14.6
Dec	29.8	2.0	6.8	14.0	2.6	18.7

4.1.3 Annual Mean Temperature (1986-2019)

4.1.3.1 Annual Mean Maximum and Minimum Temperature

The annual mean maximum temperature varied between 27.8 ˚C (1987) and 34.4 ˚C (2002) with a long period average value of 33.0 ˚C. The standard deviation and coefficient of variation were 1.3 and 3.9% respectively.

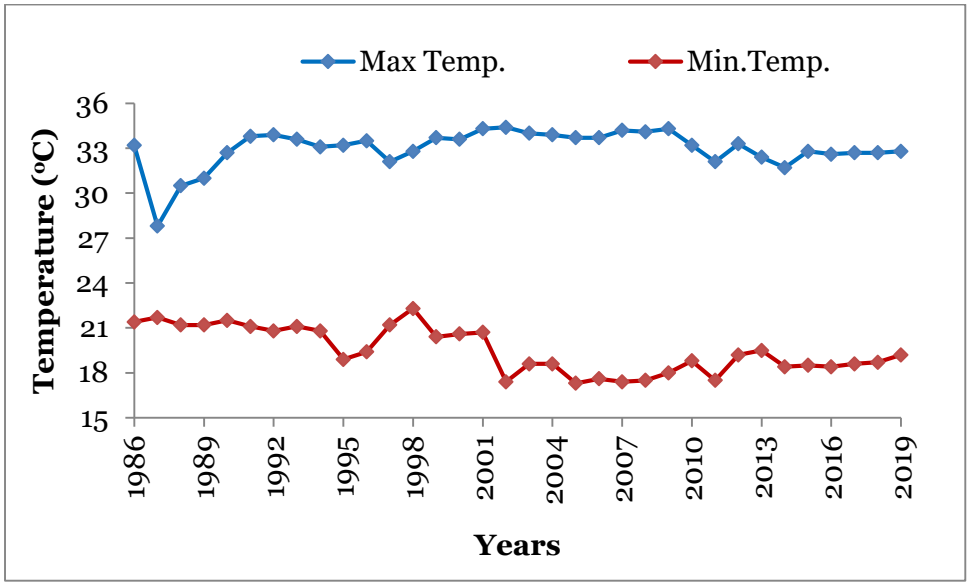

Fig. 8. Annual mean maximum and minimum temperature during 1986-2019.

Annual mean minimum temperature fluctuated between 17.3 ˚C (2005) and 22.3 ˚C (1998) with across the years around a mean 19.5 ˚C. The standard deviation 1.5 and coefficient of variation 7.8% are small indicating only minor over the period of time (Fig. 8).

Table 3. Annual mean, maximum and minimum temperature under various classes.

Annual Temp (°C)	Normal (1986-2019)	Last ten years (2010-2019)	Last five years (2015-2019)	Last year (2019)
Mean	26.3	25.7	25.7	26.0
Maximum	33.0	32.6	32.7	32.8
Minimum	19.5	18.7	18.7	19.2

Long Period Average (LPA) annual mean temperature at Baramati is recorded as 26.3 ˚C. However during the decade and last five years mean annual temperature was recorded less than LPA. Similarly, in the case of maximum and minimum temperature, LPA is slightly higher than the annual average temperature during the decade and the last five years (Table 3). The data indicates that there is a slight decrease in maximum and minimum temperature during the last few years than LPA.

4.1.3.2 Annual frequency of hot days and cold days (1986-2019)

Between 1986 and 2019, the days with maximum temperature >40 ˚C were separated and termed as 'hot days'. Similarly, the days with minimum temperature <10 ˚C were separated and termed as 'cold days'. The year wise frequency of hot days and cold days plotted in Fig. 9. The figure revealed that the number of hot days was maximum (55) in 2010 and minimum (0) in 1987, 2011 and 2014. At Baramati lowest number of cold days (0) was observed in 17 years while the highest number of cold days (16) was observed in 2018.

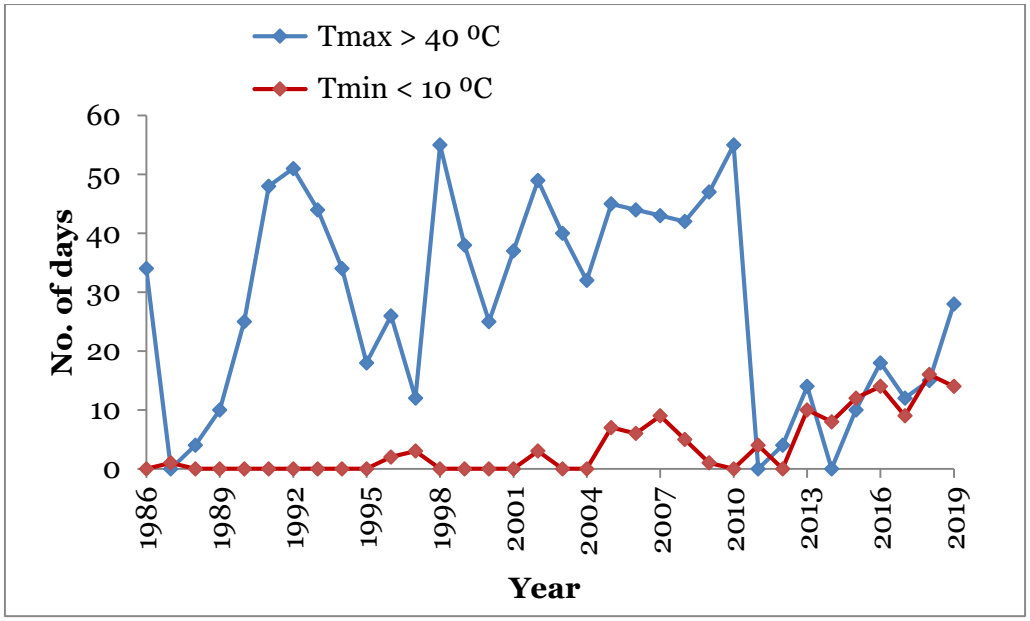

Fig. 9. Annual frequency of hot days and cold days during 1986-2019.

4.1.4 Thermal Extremes (1986-2019)

The warmest and coldest days in the entire period of 1986-2019 obtained through selection based on daily mean temperature and it was found that May 09, 1988, and May 07, 1993 (37.0 ˚C) and December 21, 1987 (14.0 ˚C), were the warmest and coldest days respectively (Table 4). The warmest months calculated based on monthly mean temperature and it was found that May, 1993 (34.1 ˚C) was the warmest month and January 1988 (18.5 ˚C) was the coldest month. Based on the annual mean temperature the year 1998 (27.6 ˚C) was the warmest year while the year 2011 (17.5 ˚C) was the coldest (Table 4).

Table 4. Temperature extremes from 1986- 2019.

S.No.	Extreme features	Mean Temperature	Value (˚C)	Occurrence
1	Warmest day	Highest daily	37.0	May 09, 88 & May 07, 93
2	Coldest day	Lowest daily	14.0	December 21,87
3	Warmest month	Highest monthly	34.1	May 93
4	Coldest month	Lowest monthly	18.5	January 88
5	Warmest year	Highest annual	27.6	1998
6	Coldest year	Lowest annual	17.5	2011

4.1.5 Hottest Days and Coldest Mornings (1986-2019)

Hottest days and the coldest mornings were obtained from daily maximum and minimum temperature, respectively, recorded in the observatory.

Table 5. Hottest daytimes and coldest morning (1986-2019).

S. No.	Hottest Daytimes		Coldest Mornings	
	Date	Max. Temp.(˚C)	Date	Min. Temp. (˚C)
1	May 28, 2003	45.0	Jan 26, 2006	5.0
2	Mar 20, 2004	45.0	Jan 27, 2006	5.0
3	May 05, 1993	44.0	Dec 29, 2018	5.7
4	May 01, 1996	44.0	Dec 30, 2018	5.8
5	May 01, 2001	44.0	Dec 31, 2018	5.8
6	May 02, 2001	44.0	Jan 11, 2015	6.0
7	May 03, 2001	44.0	Feb 9, 2019	6.2
8	Mar 23, 2004	44.0	Dec 26 & 27, 2015	6.5

Eight hottest days and coldest mornings listed in Table 5. The highest daily maximum temperature (45.0 ˚C) was recorded on May 28, 2003 and the lowest daily minimum temperature (5.0 ˚C) was recorded on 26 and 27 January 2006.

4.2 Rainfall

Baramati lies under arid to semi-arid region of western Maharashtra where water is the main limiting factor affecting crop productivity. Rainfall is the primary source of water and is the main consideration for raising the crops particularly under rainfed conditions. Rainfall is the most important factor for the plant growth and production of food crops both at the germination and fruit development stage. All crops need at least a minimum amount of water to survive; therefore rainfall is the most important means of water especially for crop growth. While a regular rain pattern is usually vital to healthy plants, too much or too little rainfall can be harmful to crops. Drought can kill crops and increase erosion, while overly wet weather can cause harmful fungus growth. Too much water force can cause injuries to plants, compacts soil, and leads to soil erosion. Root loss occurs when excess water reduces oxygen in the soil and heavy rainfall also leads to leaching of plant nutrients available in soil especially nitrogen. Plants need varying amounts of rainfall to survive. For example, certain cacti require small amounts of water, while tropical plants may need up to hundreds of inches of rain per year to survive. Besides that rainfall is important for the agriculture for the planning cropping system for the season or year, distribution of rainfall helps to design the farm ponds, irrigation tanks and also we can decide the time of sowing, irrigation schedule, weedicide, insecticides spraying, harvesting with rainfall intensity.

The distribution of rainfall daily, weekly, monthly and annual study helps the farmer to plan their cropping pattern during the season. Daily, weekly and monthly rainfall intensity helps to plan intercultural activities like spraying of insecticides, weedicides, application of fertilizers to crop, irrigation etc. Annual rainfall distribution helps to farmer management of water available for the year, save water for future use by designing farm ponds, irrigation tanks etc. for the pre and post-monsoon season crops.

Rainfall is also important for the development of insects and pests on crops. As the frequency of rainfall increases the outbreak of pest such as aphids, jassids, whiteflies, mites decreases as the inoculum is washed away by heavy rainfall and vice-versa e.g. heavy monsoon rains can cause significant mortality to whiteflies on melon crops and thrips on lettuce. In rainy season insect pests find the cool environment so they promote disease and reduces crop growth rate. Rainfall also influences livestock

production as rainfall is the major source of water for drinking purposes, growing fodder crops etc.

4.2.1 Weekly Mean Cumulative Rainfall (1986-2019)

Weekly mean cumulative rainfall distribution at Baramati showed that the main rainfall occurs during the monsoon period starting from 20th to 43rd SMW. About 80-90 % of the total rainfall occurs during this period. The wettest week across the year was found to be 37th SMW (June) with 46.7 mm (mean) rainfall. However, the highest weekly rainfall (271.0 mm) was recorded in 24th SMW of 2010 (Fig. 10)

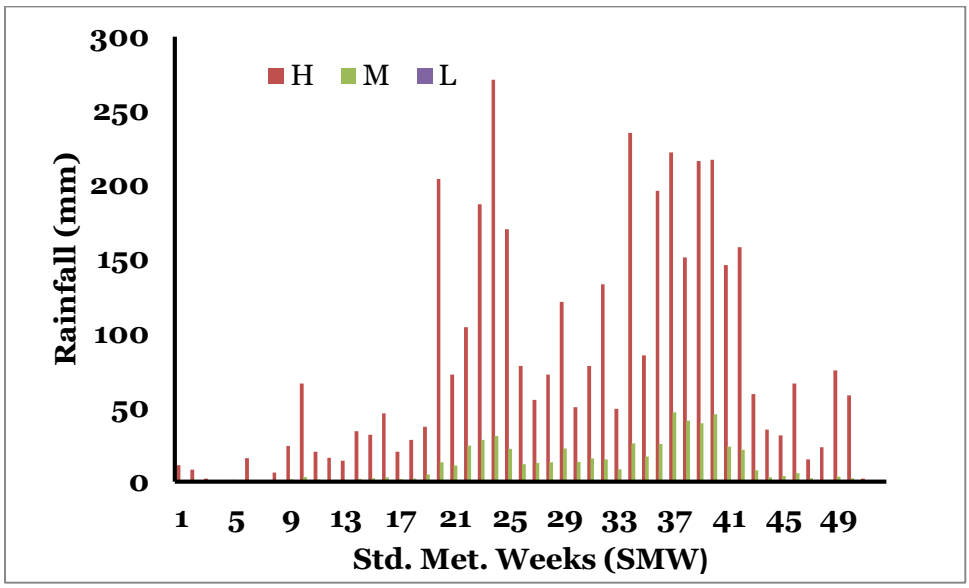

Fig. 10. Weekly mean (M), highest (H) and lowest (L) rainfall during 1986-2019.

The standard deviation (SD) of weekly rainfall was highest for 37th SMW (46.7 mm/week). The coefficient of variation (CV) was maximum for 3rd, 5th, 6th, 8th, 12th, 51st and 52nd SMW (574.4%) (Table 6).

Table 6. Weekly mean, maximum, minimum rainfall with standard deviation (SD) and coefficient of variation (CV) (1986-2019)

SMW	Mean	Maximum	Minimum	SD	CV
1	0.4	11.0	0.0	1.9	535.2
2	0.4	8.0	0.0	1.6	419.3
3	0.1	2.0	0.0	0.3	583.1
4	0.0	0.0	0.0	0.0	0.0

SMW	Mean	Maximum	Minimum	SD	CV
5	0.0	1.0	0.0	0.2	583.1
6	0.5	15.8	0.0	2.7	583.1
7	0.0	0.0	0.0	0.0	0.0
8	0.2	6.0	0.0	1.0	583.1
9	1.4	24.0	0.0	5.5	388.8
10	3.0	66.0	0.0	11.6	387.1
11	1.3	20.0	0.0	4.2	320.4
12	0.5	16.0	0.0	2.7	583.1
13	0.4	14.0	0.0	2.4	544.4
14	1.6	34.0	0.0	6.0	363.9
15	2.2	31.6	0.0	6.3	290.8
16	2.8	46.0	0.0	8.7	304.6
17	1.4	20.0	0.0	4.2	296.0
18	1.9	28.0	0.0	5.3	283.1
19	4.7	37.0	0.0	9.2	195.3
20	12.9	204.0	0.0	38.7	300.8
21	10.9	72.0	0.0	20.8	191.6
22	24.1	104.0	0.0	29.4	121.6
23	28.1	187.0	0.0	38.5	137.0
24	30.8	271.0	0.0	51.9	168.7
25	22.0	170.0	0.0	37.5	170.5
26	11.6	78.0	0.0	17.6	151.7
27	12.5	55.0	0.0	14.4	115.9
28	12.9	72.0	0.0	15.8	122.8
29	22.2	121.0	0.0	30.8	138.8
30	13.1	50.0	0.0	15.0	114.5
31	15.5	78.0	0.0	19.2	123.4

SMW	Mean	Maximum	Minimum	SD	CV
32	14.9	133.0	0.0	28.2	190.0
33	8.2	49.0	0.0	13.0	158.9
34	25.8	235.0	0.0	49.8	193.3
35	16.9	85.0	0.0	22.3	132.4
36	25.3	196.0	0.0	42.5	167.9
37	46.7	222.0	0.0	56.9	121.8
38	41.0	151.0	0.0	39.6	96.7
39	39.2	216.0	0.0	49.0	124.8
40	45.3	217.0	0.0	51.0	112.5
41	23.6	146.0	0.0	38.1	161.2
42	21.4	158.0	0.0	36.3	169.1
43	7.5	59.0	0.0	16.0	213.4
44	2.7	35.0	0.0	8.4	308.9
45	3.7	31.0	0.0	7.7	206.6
46	5.6	66.0	0.0	14.6	262.0
47	2.1	15.0	0.0	4.2	203.6
48	1.0	23.0	0.0	4.1	422.5
49	3.3	75.0	0.0	13.4	407.4
50	2.3	58.0	0.0	10.1	444.0
51	0.1	2.0	0.0	0.3	583.1
52	0.0	0.4	0.0	0.1	583.1

Importance to Agriculture

Major crops sowing take place in June-July i.e. *kharif* season and it coincides with the main rainfall period (monsoon) i.e. 23 to 42 SMW. The arrival of rainfall marks the beginning of the cultivation of rainfed kharif crops which are heavily dependent on the monsoon the quantity of rainfall determines agricultural production. Early showers help farmers start planting major crops such as soybeans, bajra and pulses. SD and CV show the distribution of rainfall in the same week over

different years is different. Delay or break in monsoon is common but now change in the monsoon cycle has an adverse effect on crop production. Rabi or winter season (43rd to 15th SMW) is associated with post-monsoon rainfall and few spells due to western disturbances. But the amount and distribution is not regular. The crops can be grown here with the residual soil moisture of monsoon plus assured supply of irrigation water.

4.2.2 Monthly Mean Cumulative Rainfall (1986-2019)

The monthly mean cumulative rainfall during different months for Baramati has been given in Fig.11. It is evident from the figure that monthly rainfall had a unimodal peak. September received the maximum rainfall of 158.8 mm and January received the minimum amount (0.6 mm). However, September of 2008 received the highest rainfall (377 mm) during 1986-2019. The standard deviation of monthly mean cumulative rainfall varied between 2.6 mm/month (January) and 107.3 mm/month (September) and the coefficient of variation varied from 67.1% (June) to 446.9% (February) (Table 8).

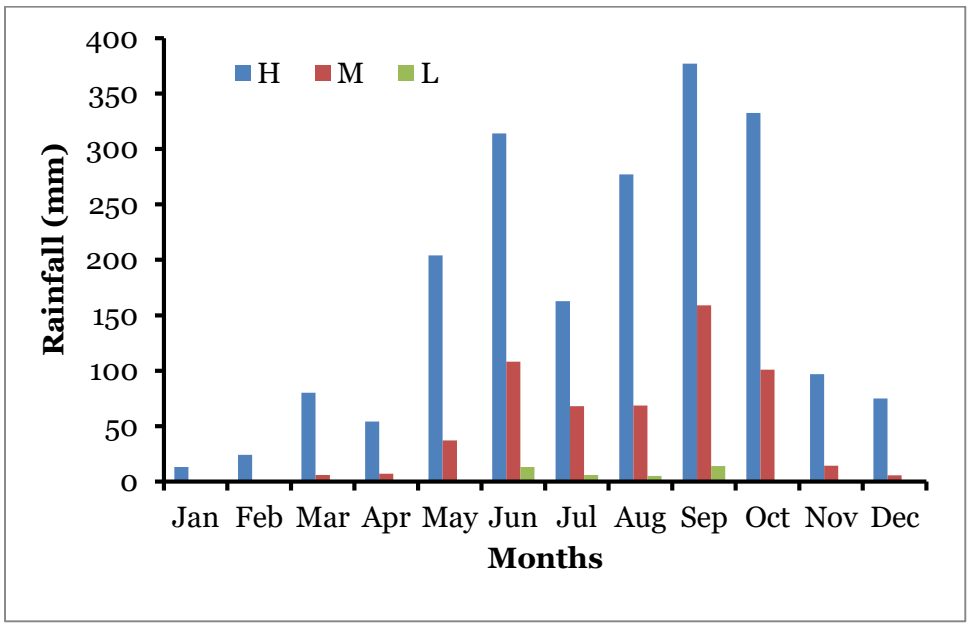

Fig.11. Monthly mean (M), highest (H) and lowest (L) rainfall (1986-2019).

Table 7. Season wise distribution of rainfall (mm)

Season	LPA (1986-2019)	Last 10 years (2010-2019)	Last 5 years (2015-2019)	Last year (2019)
SW Monsoon (Jun-Sep)	398.8	402.6	376.5	381.2
Pre-monsoon (Mar-May)	56.5	62.2	33.1	0.0
Post-monsoon (Oct-Dec)	120.8	107.1	136.1	358.4
Annual (Jan-Dec)	576.0	571.8	545.8	739.6

Long period average (LPA) for the last 34 years at Baramati is only 576.0 mm which is distributed in monsoon, pre-monsoon and post-monsoon seasons. It is observed that during the decade mean annual rainfall, monsoon, pre-monsoon and post-monsoon season rainfall were almost equal to normal rainfall of the region. The amount of rainfall was less in monsoon season and pre-monsoon season during last 5 years, compared to normal, however, it is recorded higher than normal in the post-monsoon season. It indicates there is a slight shifting of rainfall spells towards the end of the monsoon season (Table 7).

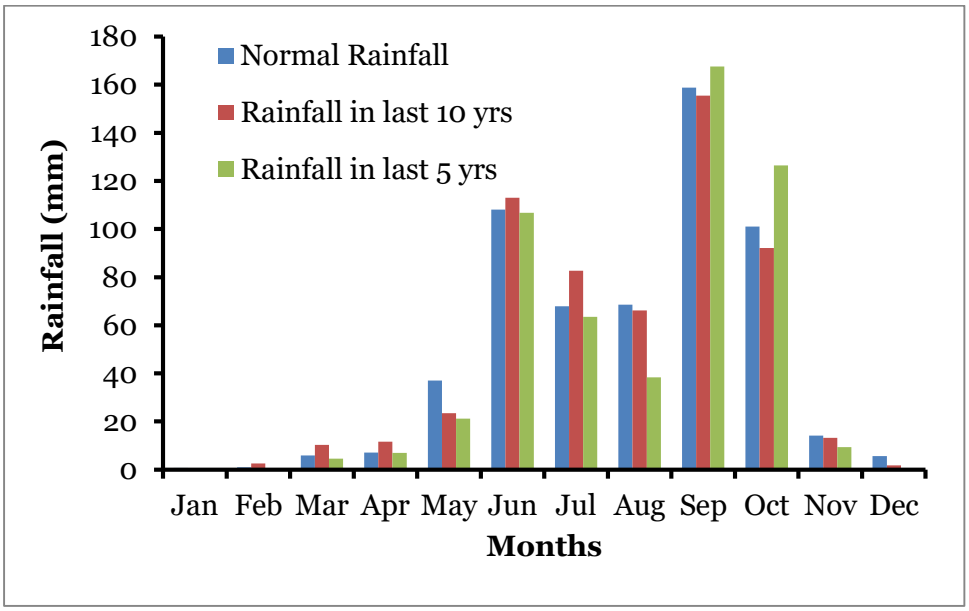

Fig.12. Monthly rainfall (1986-2019).

Long-term monthly mean cumulative rainfall varied between 0.6 mm (January) and 158.8 mm (September). During the last ten years and five years average monthly cumulative rainfall remained highest in September i.e. 155.5 mm and 167.6 mm, respectively while the lowest was recorded in January (Fig. 12).

Importance to agriculture

As we see the monthly distribution of rainfall is between five months from June to October and it is mostly due to monsoon and post-monsoon. Some amount of pre-monsoon rain in May helps to in land preparation and sowing *kharif* crops. The development of *kharif* crops depends on the monsoon rainfall of July-August. The *rabi* season crops are grown with the residual soil moisture of monsoon and post-monsoon rainfall received in October with assured supply of irrigation water. Rainfall which occurs due to western disturbance after monsoon season saves one or two irrigations during this season.

Table 8. Monthly mean, highest and lowest rainfall (mm) along standard deviation (SD) and coefficient of variation (CV) (1986-2019).

Months	Mean	Highest	lowest	SD	CV
Jan	0.6	13.0	0.0	2.6	398.8
Feb	0.9	24.0	0.0	4.2	446.9
Mar	5.9	80.0	0.0	14.8	251.4
Apr	7.1	54.0	0.0	13.2	185.3
May	37.0	204.0	0.0	45.6	123.2
Jun	108.1	314.0	13.0	72.5	67.1
Jul	67.9	162.6	6.0	46.0	67.7
Aug	68.6	277.0	5.0	63.1	91.9
Sep	158.8	377.0	14.0	107.3	67.5
Oct	101.0	332.4	0.0	93.6	92.7
Nov	14.2	97.0	0.0	21.4	150.8
Dec	5.7	75.0	0.0	16.3	287.6

4.2.3 Rainfall Probability

4.2.3.1 Normal and Dependable Rainfall

The expected occurrence of monthly, seasonal and annual rainfall at different probability levels is given in Table 9. At 75% probability, the monthly rainfall in the SW monsoon season ranges between 9.9 and 16.6 mm. Similarly, at 75% probability, the rainfall in the pre-monsoon season ranges between 2.7 and 7.6 mm. In the post-monsoon season, the chances of occurrence of rainfall range between 2.8 and 12.6 mm at 75% probability. The expected rainfall at 75% probability in SW monsoon, pre-monsoon and post-monsoon season are 67, 13 and 19 mm respectively. At 90% probability, the rainfall in SW monsoon, pre-monsoon and post-monsoon season are 16, 4 and 5 mm, respectively. The rainfall at 75% probability can be good enough in the SW monsoon and pre-monsoon season to take season crops with low water requirements.

Monthly rainfall means were computed along with dependable rainfall at various probability levels using incomplete gamma distribution (Fig. 13). Rainfall of 7.6 and 15.9 mm at 75% probability level can be expected to occur during the month of May and June respectively. Hence, the Baramati region has good potential for growing early *kharif* crops.

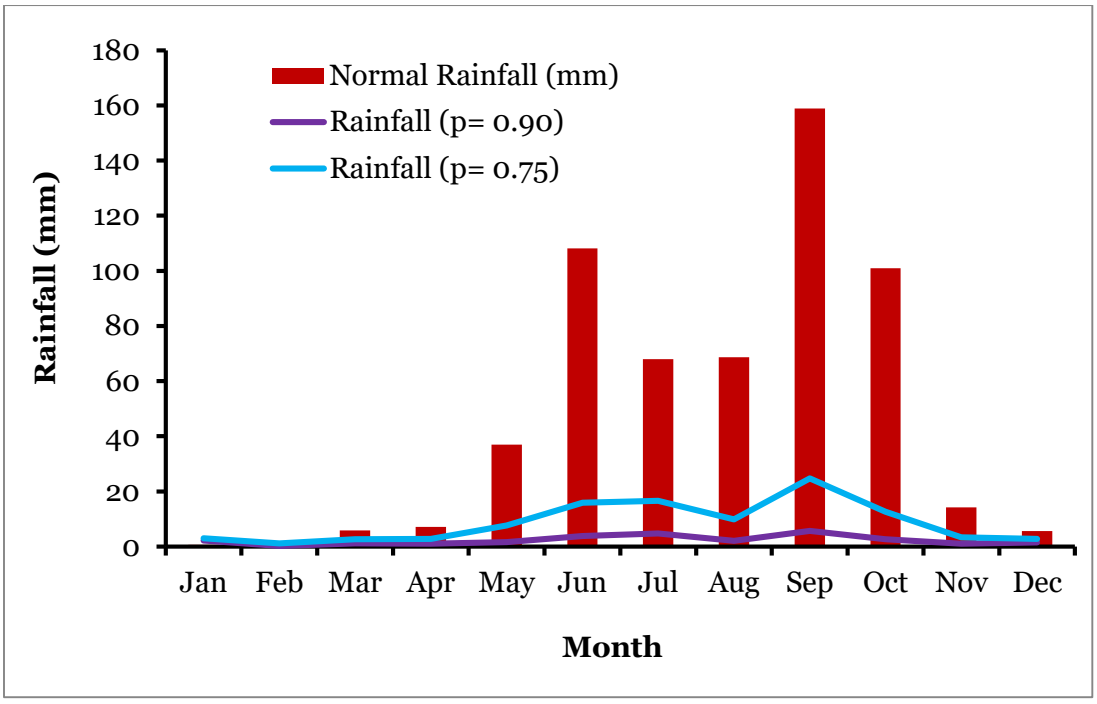

Fig.13. Monthly average and dependable rainfall (p =0.90 and 0.75).

The month of September have an average of about 25 mm rainfall at 75% probability level. However, at 50% probability, there is a definite rainfall receipt of more than 80 mm during September while during October more than 45 mm rainfall can be expected. Agricultural strategies, farming operations can be planned on this type of analysis and advisories should be planned accordingly.

Table 9. Expected rainfall amount (mm) at different probability levels.

Month/Season	Probability levels				
	90 %	75%	50%	25%	10%
Jan	2.2	3.0	4.3	6.1	8.1
Feb	0.2	1.1	2.3	10.8	16.4
Mar	1.1	2.7	6.3	12.9	21.7
Apr	1.0	2.8	7.9	17.0	29.6
May	1.6	7.6	29.7	81.3	162.4
Jun	3.8	15.9	54.0	133.7	251.3
Jul	4.7	16.6	48.0	107.9	192.1
Aug	2.1	9.9	36.8	96.3	186.8
Sep	5.7	24.7	85.0	212.5	401.1
Oct	2.6	12.6	48.6	131.4	259.7
Nov	1.0	3.4	9.7	22.3	40.5
Dec	1.5	2.8	6.0	13.0	22.9
Monsoon	16.3	67.1	223.8	550.4	1031.3
Pre-monsoon	3.7	13.1	43.9	111.2	213.7
Post-monsoon	5.1	18.8	64.3	166.7	323.1
Annual	27.5	103.1	338.6	845.2	1592.6

Importance to agriculture

Considering the wet months, the amount of monthly rainfall has a positive value. The monthly and seasonal pattern of rainfall and their probabilities are helpful in crop planning by identifying the period of drought, normal and excess rainfall. Prior knowledge of the probable date of onset of effective monsoon and probabilities of dry spell occurrences during the growing season are therefore valuable in crop planning. The continuous dry spells hint regarding the need of *in-situ* moisture conservation measures and supplemental irrigation in dryland agriculture and successive wet spells hint for water harvesting as well as the need for erosion control measures on the other side. Such knowledge of dry and wet spells in advance helps in deciding the cropping pattern and also to plan comprehensive strategies for proper and efficient rain water management in dryland areas for improving crop production per unit of available water. Markov Chain probabilities model has been recognized as a suitable model to explain the long term frequency behaviour of wet and dry weather spells. The minimum expected rainfall at different probability levels will be helpful in planning various agricultural operations.

4.2.4 Annual Total Rainfall (1986-2019)

Annual total rainfall along with its trend is shown in Fig. 14. Annual rainfall of Baramati varied from 151.4 mm (2003) to 1144.7 mm (2009) with a mean of 576.0 mm for the period of 1986-2019. The standard deviation (SD) and the coefficient of variation (CV) were found to be 208.7 mm/year and 36.2%, respectively. Very high rainfall (>1000 mm) occurred only once in 2009 (1144.7 mm). Annual rainfall showed that it was alternatively increasing and decreasing in nature, consisting of a period of five or six years. There was wide variability and changes in inter-annual rainfall. However, long term annual rainfall shows as lightly increasing trend (Fig. 14).

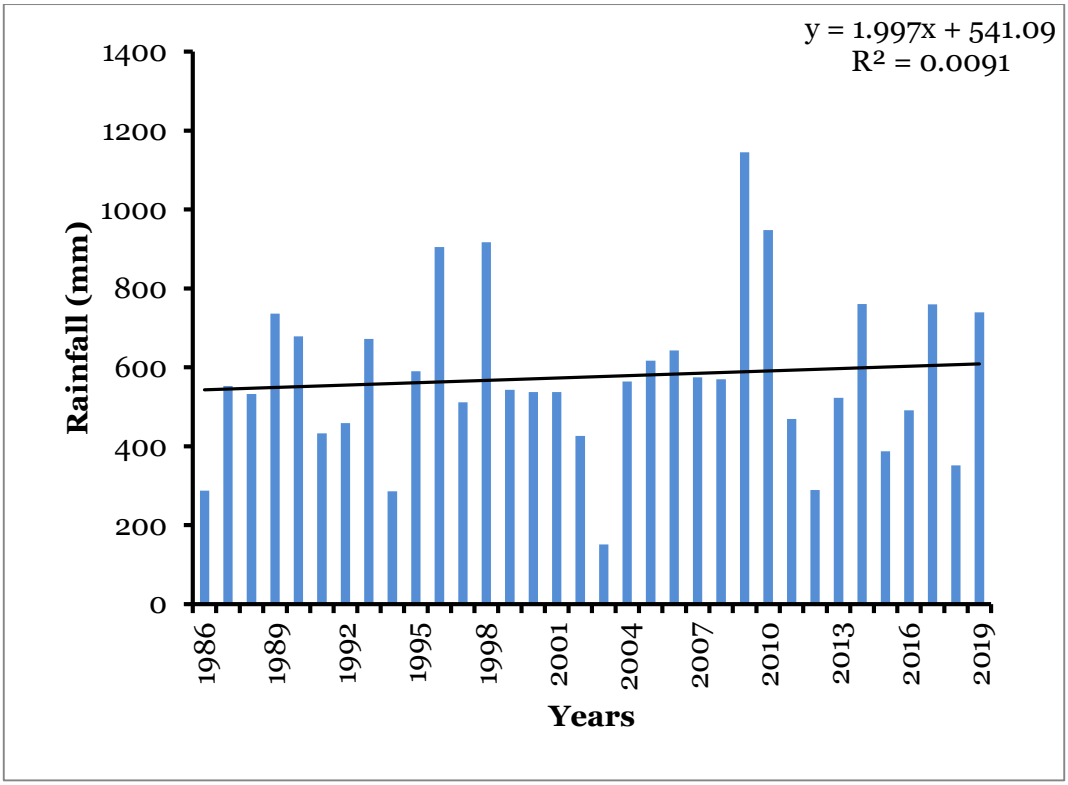

Fig. 14. Annual Rainfall during 1986-2019.

Importance to agriculture

Annual distribution of rainfall is variable and needs management of water for better irrigation practices for crop production to combat annual variability. For seasonal crop planning and production, there is a need for alternate water resource planning other than the ground water source. Long-term annual rainfall trend is very much needed for agriculture production view. To overcome the annual variability suitable contingency planning is required. For this situation, monsoon water management is essential with better field water management systems and crops with high water use efficiency are the need of the future.

4.2.5 Rainfall Intensity

Annual time series of the number of rainy days under various intensity classes is presented in Fig 15. Total number of rainy days per year during the study period was 34 in which the frequency of light rainy days (2.5-10 mm) was highest (17 days) followed by moderate light rainy days (10-25 mm) and moderate rainy days (25-50 mm) 10 and 5 days respectively. The occurrences of heavy precipitation day (rainfall >50 mm) are more during September, June and October than July and August resulting in considerably lower rainfall totals during the later months.

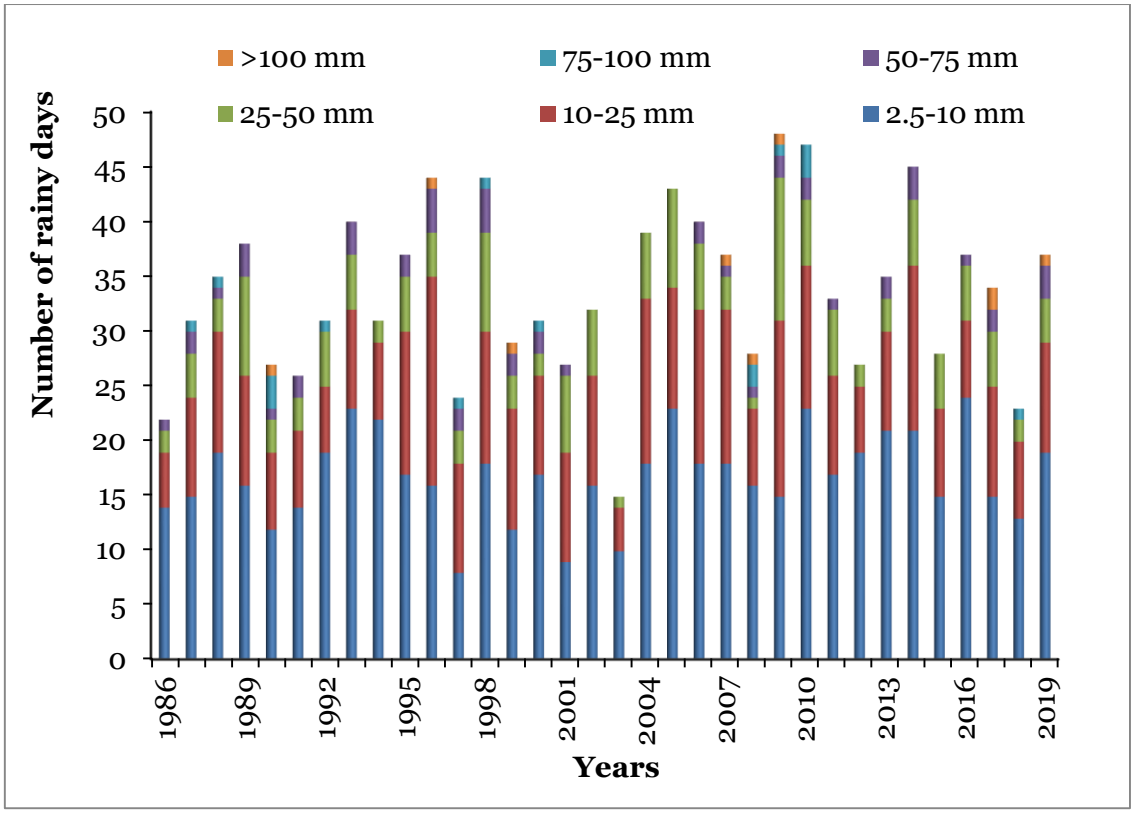

Fig. 15. Rainfall intensity distribution (1986-2019).

The number of rainy days during monsoon season was more in the decade in comparison with normal. However, fewer rainy days were witnessed during the last 5 years in monsoon and post-monsoon period while in pre-monsoon season number of rainy days was more compared to normal (Table 10).

Table 10. Number of rainy days under various classes.

Season	Normal (1986-2019)	Last 10 years (2010-2019)	Last 5 years (2015-2019)	Last year (2019)
SW Monsoon	24	26	24	24
Pre-monsoon	3	3	2	0
Post-monsoon	6	6	6	13
Annual	33	35	32	37

In trend analysis studies, the results showed that there is a slight increase in the long-term annual frequency of rainy days (Fig. 16).

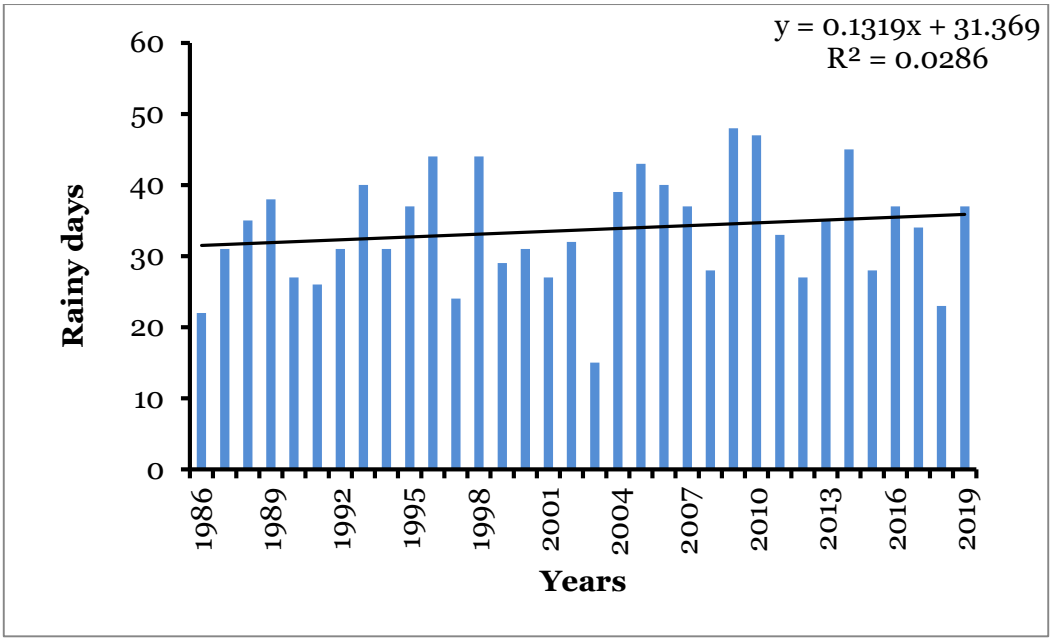

Fig. 16. Number of rainy days (1986-2019).

4.2.6 Rainfall Extremes

4.2.6.1 Month wise highest rainfall

The individual months with the highest monthly rainfall across the year were elected and it was found that the highest rainfall of different months occurred in different years (Table 11). September 2008 was the wettest month with 377mm of rainfall. Individual dates with the highest rainfall within 24 hours within every month were also selected and it was found that 23rd June 2007 was the wettest day with 136mm of rainfall.

Table 11. Highest monthly rainfall of different months (1986-2019).

Months	Highest rainfall			
	Month wise		Date wise	
	Amount(mm)	Year	Amount(mm)	Date
Jan	13.0	1995	11.0	07.01.1995
Feb	24.0	2011	24.0	28.02.2011
Mar	80.0	2014	56.2	10.03.2014
Apr	54.0	2008 & 2014	43.4	19.04.2014
May	204.0	1990	118.0	18.05.1990
Jun	314.0	2010	136.0	23.06.2007

Jul	158.0	1992 & 2011	84.8	17.07.1992
Aug	277.0	2009	86.0	07.08.1987
Sep	377.0	2008	114.0	10.09.1999
Oct	332.0	2019	108.8	21.10.2019
Nov	97.0	2009	40.0	17.11.2009
Dec	75.0	1993	72.0	06.12.1993

4.2.6.2 Year wise highest rainfall (1986-2019)

Variability in rainfall during (1986-2019) was assessed based on the deviation from the long term average rainfall. The four rainfall groups considered following the criteria of India Meteorological Department (IMD) were excess (>20%), normal (19 to -19%), deficit (-20 to -59%) and scanty (< -59%). Number of years under each category, extreme rainfall years and amounts that occurred during the southwest monsoon (June-September) and post-monsoon (October-December) seasons are given in Table -12. During these last 34 years, SW and post-monsoon rainfall were in the normal range in 14 and 7 years, respectively. In the case of annual total rainfall, 17 years received normal rainfall while in 8 years it was excess.

Table 12. Years under various rainfall classes and extremes (1986-2019).

Season	Number of years in rainfall category					Total rainfall (mm)	
	Excess	Normal	Deficit	Scanty	No rain	Highest (year)	Lowest (year)
SW Monsoon	8	14	10	2	0	762 (2010)	137 (2012)
Post-monsoon	11	7	4	11	1	358 (2019)	46 (2011)
Annual	8	17	8	1	0	1145 (2009)	221 (2012)

Importance to agriculture

The maximum amount of rainfall during a particular season and frequency of rainy days are the criteria for the determination of the size of the water harvesting structures at the farm and other levels for the conservation of water to combat annual variability of rainfall. To reduce water losses during the post-monsoon season and to fulfill the need for rabi season crop management knowledge of extreme rainfall events and frequency of rainy days is necessary.

4.2.6.3 Heaviest rainy days (1986-2019)

The days with the highest daily rainfall were selected from 1986-2019 and reported in Table 13. The highest rainfall (136 mm) was reported on 23rd June 2007. Out of 10 rainiest days, 5 occurred in the nineties (1990-2000) and 3 occurred in the 1st decade of the century (2000-2009) and 3 were occurred in the year (2017 and 2019) of this century (Table 13).

Table 13. Ten heaviest rainy days (1986-2019).

S No.	Amount (mm)	Dates
1	136.0	23.6.2007
2	128.0	3.10.1996
3	118.0	18.5.1990
4	114.0	10.9.1999
5	112.0	9.9.2008
6	110.0	3.10.2009
7	108.8	21.10.2019
8	104.2	2.6.2017
9	100.6	13.9.2017
10	98.0	12.9.1998

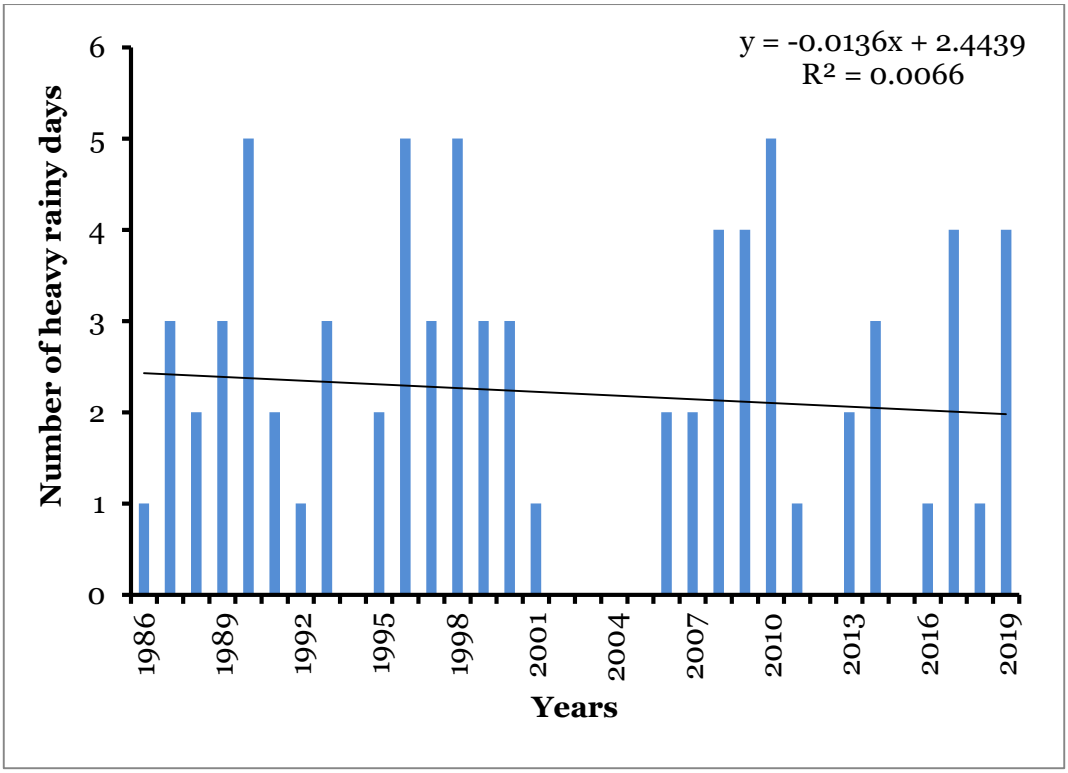

Fig. 17. Number of heavy rainy days (>50 mm) (1986-2019).

In trend analysis, the results showed that there is a slight decrease in the annual frequency of heavy rainfall events (Fig. 17).

5. APPENDIX-I

Weekly Weather Data

5.1 Weekly Maximum Temperature (1986-2019)

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	29.4	27.4	20.7	27.1	28.6	28.6	28.9	31.9	28.7	29.2	30.3	28.4	29.4	29.3	30.7	29.3	28.6
2	28.1	29.3	22.0	28.4	28.7	31.9	31.4	34.1	28.9	26.4	31.1	28.3	29.3	29.4	30.9	31.0	29.9
3	26.7	30.3	22.1	27.7	29.7	31.9	30.7	32.7	29.7	26.3	30.9	30.1	29.3	30.7	32.4	32.4	31.4
4	30.1	31.6	22.7	29.3	32.4	33.9	32.7	33.9	31.0	27.6	32.3	28.9	29.6	31.9	33.3	32.1	31.9
5	30.3	24.9	24.9	28.0	33.4	33.3	32.1	33.6	32.0	29.1	33.6	30.4	30.9	32.1	33.9	34.1	31.7
6	31.9	19.7	28.6	27.9	32.9	34.4	33.0	34.1	32.6	33.1	32.6	32.0	30.0	33.1	32.9	36.3	33.9
7	31.1	23.6	30.3	28.1	32.3	35.3	33.4	34.6	33.6	32.7	32.4	32.1	29.4	33.0	32.4	36.0	33.7
8	33.6	24.4	31.1	29.7	31.7	35.6	32.4	33.7	33.3	34.0	35.0	33.0	29.3	34.1	32.9	37.4	35.9
9	34.7	23.1	29.6	33.1	33.6	35.7	36.0	34.0	35.1	35.4	36.5	35.3	29.7	35.0	33.5	38.0	37.0
10	36.6	25.1	33.6	35.1	32.9	37.6	37.9	35.9	37.4	35.9	36.0	37.1	35.3	37.1	34.3	37.3	38.3
11	37.4	25.7	33.7	33.7	36.1	38.6	38.3	37.0	39.1	35.9	38.7	37.1	36.1	38.4	34.1	36.7	37.6
12	38.9	26.7	32.9	35.9	36.	38.9	40.3	38.6	40.1	36.9	38.6	34.9	36.7	38.7	36.9	38.9	38.9
13	38.7	28.4	32.4	30.7	37.0	40.3	39.7	37.9	40.3	36.9	39.9	35.0	39.4	39.0	39.3	39.4	39.1
14	38.6	29.9	31.4	33.3	38.6	36.9	39.6	39.0	38.7	38.4	39.7	34.6	40.9	39.4	41.3	39.1	39.9
15	40.6	27.3	34.4	37.3	39.9	39.3	41.0	39.1	34.3	39.3	38.4	33.9	40.7	40.7	42.4	41.0	39.6
16	40.9	31.0	34.3	37.4	40.1	40.9	41.0	40.6	39.3	39.0	38.3	36.6	41.3	40.4	42.7	40.3	41.3
17	40.0	29.1	32.3	39.3	41.3	40.6	39.9	41.3	40.0	40.6	40.1	37.7	40.3	40.9	39.4	42.1	41.9
18	39.4	30.0	36.1	38.1	39.4	40.1	41.0	42.0	39.9	38.6	42.1	37.7	41.0	40.7	37.6	43.0	42.7
19	39.9	30.9	38.9	38.7	39.7	40.6	41.4	41.7	40.3	37.1	40.3	39.0	41.4	39.6	37.3	40.3	40.4
20	39.0	31.7	38.7	39.1	37.4	40.9	40.9	41.3	42.0	34.6	38.4	40.3	40.1	39.4	37.9	38.6	40.0
21	39.0	31.4	37.4	36.6	36.4	40.3	40.4	40.7	40.1	37.4	39.3	39.7	39.3	37.0	36.7	36.3	39.0
22	38.0	31.7	37.9	35.6	33.6	41.1	40.3	39.3	38.1	40.0	38.3	38.6	40.7	37.0	36.1	35.4	37.3
23	34.6	31.7	35.4	31.7	34.0	31.7	40.0	40.0	34.3	38.9	38.1	29.7	38.3	39.1	33.6	36.4	36.9
24	35.3	31.9	33.6	30.0	31.6	34.4	36.6	34.3	31.4	36.9	33.4	35.9	33.0	34.0	30.6	31.0	35.3
25	31.1	30.9	32.7	29.3	32.3	33.0	29.6	32.3	32.3	34.9	31.9	34.0	34.4	28.0	33.6	33.6	32.3
26	33.6	30.9	32.1	28.6	30.4	31.9	31.6	33.7	31.6	32.7	33.1	33.4	33.0	30.1	34.3	33.0	29.7
27	32.0	29.9	32.0	30.4	31.6	30.7	34.1	33.4	30.6	34.4	30.6	30.3	31.1	32.9	33.0	33.1	33.1
28	31.0	30.7	32.3	32.0	31.4	30.0	32.6	30.6	28.9	32.6	32.0	29.6	31.9	32.1	30.1	30.6	34.0
29	28.4	29.7	28.9	29.1	30.1	28.7	28.0	29.6	29.0	29.6	30.4	29.6	33.1	30.6	31.3	30.9	32.9
30	29.4	30.4	27.0	27.6	29.6	28.6	29.4	31.3	29.3	29.7	27.7	30.1	32.6	31.9	33.0	31.7	33.0
31	30.3	31.0	28.3	28.4	30.	30.0	29.7	31.3	30.0	32.1	29.3	30.1	29.6	31.7	33.1	32.0	32.3
32	30.1	29.4	30.3	28.4	29.	29.4	31.4	31.7	31.1	32.4	31.3	30.7	29.6	32.7	31.7	28.4	28.9
33	28.4	30.4	31.1	27.3	28.1	29.3	27.0	30.6	30.4	32.3	31.7	29.9	28.1	32.6	32.0	30.0	30.6
34	28.9	28.0	31.4	27.4	29.9	30.1	30.1	30.7	30.7	34.0	31.1	29.1	32.7	33.9	30.3	32.3	29.7
35	31.0	28.0	28.7	29.7	29.3	29.6	28.3	30.9	28.4	31.9	29.7	28.6	30.0	32.3	29.9	33.1	31.4
36	30.7	29.0	29.6	31.6	30.	32.4	29.4	30.3	29.1	30.6	31.0	28.7	30.6	33.0	30.6	33.3	30.6
37	31.6	30.4	30.6	28.0	33.0	33.4	32.0	33.0	31.6	30.4	31.9	28.4	29.7	29.7	33.7	34.3	33.4
38	32.1	31.6	28.6	30.3	34.6	31.4	35.1	31.3	32.0	32.7	31.9	28.4	30.4	30.7	35.7	30.7	33.7
39	33.7	30.1	29.1	29.0	30.	32.6	33.9	30.7	35.1	31.4	33.3	29.6	30.4	32.0	33.4	32.9	33.9
40	34.0	28.3	30.0	29.3	33.0	33.0	33.1	31.6	33.9	33.0	29.6	29.4	30.0	31.9	34.0	33.4	34.9
41	33.9	27.7	30.7	33.1	29.3	35.3	32.3	30.1	34.6	30.7	33.0	31.9	30.3	33.3	34.1	30.7	34.9
42	36.0	26.6	32.4	33.1	31.7	34.3	32.9	30.3	32.4	30.9	32.9	30.3	29.3	32.3	34.3	33.1	34.1
43	33.7	25.6	31.4	32.3	30.7	33.6	34.9	30.7	32.1	32.0	30.0	30.1	28.7	33.0	35.6	33.9	34.0
44	32.1	24.3	31.3	30.9	29.9	32.4	32.4	32.0	30.1	32.4	31.4	30.4	27.4	33.7	33.7	34.9	33.0
45	30.6	24.9	29.1	29.6	31.6	32.4	33.0	31.1	30.7	31.6	30.9	31.1	28.3	33.9	31.4	33.3	32.4
46	33.4	26.6	27.4	30.0	30.7	30.6	30.6	31.9	30.3	32.4	31.1	31.1	30.9	33.0	30.6	33.3	32.1
47	30.3	25.4	28.9	30.1	31.0	31.0	30.3	30.9	29.6	29.7	30.7	31.1	31.1	31.1	29.4	32.6	32.7
48	29.7	22.1	27.6	29.1	31.7	32.3	31.7	29.6	31.3	30.9	31.0	31.1	31.1	30.4	29.3	30.9	34.0
49	29.4	22.1	27.9	27.7	30.7	30.7	30.9	24.6	30.4	30.9	30.0	29.7	31.1	29.3	26.4	31.0	32.3
50	30.4	23.7	26.3	26.1	30.1	29.1	30.1	28.9	30.9	30.3	30.1	29.4	28.1	29.1	30.1	32.1	31.6
51	29.4	17.4	26.7	27.3	29.4	30.4	30.1	27.7	29.1	30.6	29.9	29.9	29.9	29.1	29.6	30.7	32.6
52	28.9	22.6	26.8	27.0	29.4	28.8	30.5	27.6	28.3	29.8	30.4	29.4	29.4	30.4	30.9	30.3	31.8

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	30.6	30.6	30.9	29.7	31.4	32.0	32.1	29.4	29.6	34.6	33.0	27.9	26.4	30.9	29.2	28.9	30.0
2	31.7	30.1	31.6	31.4	31.1	31.3	31.9	31.0	24.0	32.1	30.6	28.9	27.7	29.6	28.1	29.2	30.0
3	29.9	32.3	30.6	33.4	32.4	32.1	31.4	31.7	24.9	31.4	30.	29.4	28.9	28.8	28.4	31.1	30.8
4	33.6	31.9	32.7	31.7	33.0	31.6	33.0	31.4	30.	32.6	31.4	28.7	29.5	29.9	30.7	29.6	29.1
5	34.1	32.3	28.7	32.4	33.1	31.9	34.4	32.0	31.0	31.5	31.4	28.5	30.3	33.6	31.5	30.8	29.1
6	34.6	33.1	33.7	34.0	34.4	31.7	35.0	33.9	31.6	30.7	31.8	31.8	31.0	32.9	31.9	30.0	30.3
7	35.4	34.4	36.0	34.4	33.9	32.6	33.7	34.0	32.0	33.6	32.0	28.9	32.8	32.6	31.6	31.4	32.7
8	35.4	36.4	33.7	36.6	34.0	34.7	34.6	35.9	32.0	34.6	34.4	30.5	33.4	35.3	35.4	33.9	35.6
9	36.9	36.3	36.7	37.0	35.1	35.6	37.4	36.6	32.1	35.4	34.3	30.9	32.9	35.2	34.7	34.7	33.2
10	37.3	37.9	35.6	35.4	35.7	36.7	37.9	38.3	33.9	34.5	35.6	30.	33.1	35.1	34.0	36.0	34.7
11	36.7	39.9	36.7	33.6	36.0	37.1	36.1	38.4	35.3	36.0	35.8	32.9	33.1	36.4	34.1	34.2	36.3
12	37.6	43.3	38.4	37.0	37.6	37.4	38.4	39.4	36.0	38.	36.7	35.8	36.1	38.0	36.4	35.6	37.1
13	39.0	39.9	39.7	38.3	38.4	36.1	38.3	40.1	37.6	37.9	37.6	36.8	36.9	38.4	39.2	38.2	39.6
14	39.0	40.3	40.	39.6	40.3	38.0	39.9	41.0	37.6	38.5	38.4	36.4	36.8	38.4	38.7	38.0	39.4
15	39.6	41.3	39.9	40.0	40.9	38.4	40.1	41.4	38.1	38.4	39.2	36.5	34.7	39.1	39.4	37.2	39.8
16	39.9	40.9	39.9	39.7	39.1	41.6	41.3	41.9	38.1	37.9	36.7	36.4	36.2	40.9	40.4	38.9	37.7
17	41.1	41.1	38.3	40.7	39.0	41.1	40.4	41.0	38.0	38.1	39.4	37.8	38.5	39.7	37.9	39.3	41.2
18	40.3	41.4	39.1	41.2	40.	41.1	42.1	38.4	38.7	38.6	40.4	37.9	40.4	40.1	39.3	40.6	38.6
19	40.7	38.1	39.4	41.9	41.0	40.3	41.7	40.6	39.0	37.6	39.7	35.2	38.4	38.3	39.9	39.7	38.8
20	41.1	37.9	39.3	41.9	40.6	40.3	40.9	41.9	39.0	39.6	38.6	36.2	37.1	40.6	39.2	39.4	40.
21	39.7	35.3	42.0	38.0	39.9	39.9	37.4	41.7	39.0	39.3	37.9	37.6	38.6	37.7	39.4	39.5	40.9
22	39.9	37.6	38.3	32.0	40.4	40.4	38.7	40.7	36.0	37.5	36.5	38.2	38.6	37.3	36.3	37.3	41.5
23	39.4	35.3	39.4	33.7	38.9	35.0	36.3	37.9	30.7	34.2	31.7	34.4	35.1	34.1	34.6	33.9	39.0
24	36.1	32.4	36.4	36.6	36.3	31.6	37.4	34.0	28.9	34.6	29.6	34.0	31.9	33.1	31.0	33.2	34.6
25	32.4	28.7	35.0	34.3	34.9	33.7	35.7	31.7	31.4	34.0	31.3	32.6	29.4	32.1	33.2	32.6	34.2
26	31.7	32.6	30.3	32.0	30.0	33.6	33.6	31.9	29.1	32.9	29.6	34.4	31.2	29.3	31.4	30.6	31.1
27	30.9	32.6	30.1	29.1	29.9	31.9	31.6	30.1	30.	31.6	29.8	32.6	32.1	28.3	31.5	30.8	29.9
28	31.3	32.4	31.9	30.7	30.6	31.4	30.	31.4	29.9	33.2	27.9	29.4	32.6	28.5	30.7	28.6	30.6
29	31.0	32.3	33.4	31.7	31.3	30.0	29.3	30.7	27.4	31.2	26.7	29.4	31.0	29.9	29.4	28.4	32.9
30	29.9	30.7	28.4	29.9	33.3	31.4	29.7	28.3	27.7	30.3	27.6	29.1	30.5	30.5	30.0	28.8	29.2
31	30.7	27.7	28.7	28.9	31.4	30.6	31.9	28.9	28.	28.7	27.9	27.8	30.3	28.7	30.7	30.8	27.0
32	29.1	28.1	28.4	27.1	31.1	28.3	32.1	30.9	28.	29.9	30.	29.6	30.5	28.9	31.9	30.1	27.9
33	30.1	28.6	30.4	31.0	31.4	30.4	33.0	31.3	28.	31.6	31.0	30.4	31.4	30.5	31.4	28.1	30.4
34	29.4	29.6	31.0	30.7	32.3	33.0	30.6	30.1	28.	32.4	29.5	31.9	32.6	31.3	28.7	29.0	32.1
35	29.4	32.1	33.1	30.6	30.9	32.6	30.6	28.7	26.0	31.7	32.6	28.6	31.9	30.9	29.6	29.8	31.3
36	29.7	31.4	31.4	33.9	31.0	32.4	30.4	30.1	26.3	29.3	31.5	28.5	33.6	31.4	32.1	30.3	30.0
37	30.4	30.7	29.7	33.1	31.9	29.9	32.9	31.0	27.1	30.	31.3	29.6	31.3	29.1	31.2	33.3	30.9
38	31.7	32.1	30.4	30.6	30.6	30.7	33.6	31.0	29.0	31.2	28.8	31.1	29.4	27.8	28.2	31.6	31.0
39	31.0	32.6	30.9	33.4	30.7	32.6	33.9	28.	29.7	32.8	30.3	32.5	33.6	29.6	32.4	33.7	30.8
40	32.0	33.6	32.4	31.6	32.9	33.9	29.7	26.4	28.7	29.3	31.6	33.8	32.0	28.1	33.4	32.6	31.7
41	34.4	34.0	33.4	34.0	33.4	34.0	31.4	27.4	32.9	32.4	31.5	32.7	32.8	31.9	31.0	33.7	31.0
42	35.0	34.4	31.0	34.6	34.0	34.0	33.6	30.3	33.4	32.3	33.4	33.4	34.1	31.8	32.5	33.2	29.0
43	33.6	34.1	32.7	34.1	33.0	34.0	34.0	26.7	34.4	31.2	31.9	28.8	33.9	31.6	32.7	33.2	28.0
44	32.9	31.1	32.3	32.1	33.1	34.0	34.6	26.9	34.3	30.4	31.4	31.1	32.6	31.1	31.2	31.9	29.6
45	32.6	31.3	31.6	31.7	33.9	34.0	32.7	29.9	34.0	32.5	30.	31.9	32.5	30.2	30.4	33.2	31.1
46	33.0	33.9	31.4	30.9	32.7	33.7	29.6	32.0	34.4	29.4	29.5	28.9	31.9	29.9	30.2	32.3	29.7
47	32.7	32.7	32.0	30.6	31.3	33.3	32.0	32.0	33.3	30.9	30.	29.7	29.9	29.5	31.4	30.1	30.0
48	32.3	31.6	32.0	32.0	31.6	31.1	31.4	31.3	32.9	31.2	30.	29.0	31.6	30.8	29.9	29.1	30.1
49	31.1	30.0	31.3	31.9	30.7	32.0	31.7	29.9	34.4	31.3	28.9	29.2	30.7	29.5	28.9	30.5	27.9
50	31.0	30.9	30.0	31.6	31.6	32.0	31.7	29.6	34.0	31.3	29.0	29.3	32.8	29.1	30.4	29.9	30.5
51	30.6	31.1	31.0	31.1	31.3	31.4	30.9	29.0	33.3	29.4	28.5	26.6	32.3	29.7	28.7	27.4	29.0
52	30.5	30.4	29.6	31.1	33.4	32.6	30.1	29.8	32.9	29.7	27.7	28.3	29.2	30.	28.6	28.9	28.7

5.2 Weekly Minimum Temperature (1986-2019)

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	13.4	13.7	14.4	13.4	18.1	11.9	10.3	14.9	14.6	10.8	13.9	20.6	23.6	16.4	15.1	18.6	10.4
2	16.6	14.6	14.0	14.4	15.3	13.7	12.3	14.9	15.7	13.5	13.7	19.3	24.6	17.4	17.1	17.4	11.3
3	14.1	18.6	16.1	14.0	12.9	17.0	14.1	15.0	13.7	12.4	13.7	20.3	16.4	19.7	16.7	19.4	10.7
4	15.3	17.9	15.3	15.9	14.1	17.3	13.7	16.0	17.4	11.1	13.9	20.1	19.9	22.6	18.4	17.3	10.3
5	15.4	14.3	16.3	17.1	15.1	14.4	15.1	15.0	16.0	13.7	13.7	21.4	24.1	21.7	17.3	15.0	12.3
6	15.9	14.0	14.4	14.4	16.7	17.0	15.0	15.7	16.9	17.4	13.9	21.4	21.0	20.	17.6	26.6	16.3
7	16.1	15.0	16.9	14.6	17.0	15.6	14.4	18.4	17.3	16.3	13.4	22.0	22.9	22.9	15.7	27.6	16.1
8	19.0	18.0	19.0	13.1	15.0	17.9	14.4	15.9	16.9	14.4	14.4	21.6	21.3	24.	19.0	28.0	15.9
9	20.7	18.1	17.0	17.6	16.6	18.7	16.1	17.3	18.0	14.5	14.3	22.9	22.	24.1	18.1	26.4	14.9
10	22.	19.7	19.6	19.7	18.1	19.7	17.4	19.4	21.0	15.3	13.9	19.1	19.9	24.1	18.1	23.3	15.7
11	21.3	19.1	22.1	19.3	22.	20.3	19.3	21.1	22.4	15.3	14.6	19.4	20.1	17.7	23.7	20.	17.1
12	20.	20.	21.4	22.4	23.6	22.4	20.4	21.9	22.4	19.1	15.9	16.7	20.	19.3	25.4	23.0	16.1
13	22.6	22.6	19.3	21.1	22.	24.3	21.9	22.	22.4	21.0	18.0	17.3	22.	18.4	26.	25.7	17.0
14	23.3	24.4	19.7	22.7	21.6	22.7	23.1	24.1	24.3	20.3	18.1	14.3	27.4	15.6	26.	24.6	19.0
15	24.9	22.7	21.0	22.9	24.7	24.0	22.9	24.	22.1	22.0	18.3	15.3	27.9	14.9	25.4	21.4	18.9
16	27.0	26.9	22.7	25.4	25.7	25.1	24.0	26.7	24.9	22.1	17.4	19.3	26.9	17.3	24.1	23.4	21.0
17	27.1	23.7	19.6	26.	26.7	25.3	25.6	27.6	26.3	23.7	18.1	20.4	27.6	17.3	21.9	23.6	21.9
18	27.0	24.4	26.	25.9	26.3	24.6	26.9	29.1	26.6	23.6	19.6	20.6	26.	20.	21.6	24.9	22.9
19	25.7	24.3	29.6	27.7	26.6	26.1	27.6	28.1	26.6	23.4	27.6	21.6	25.9	21.6	20.	24.3	22.6
20	27.3	26.	27.7	27.6	25.6	28.6	25.1	26.1	25.6	24.1	23.3	22.3	25.7	21.9	22.1	24.7	21.3
21	26.4	26.7	27.3	26.3	24.9	27.3	24.9	26.3	26.	22.3	18.1	20.0	23.6	20.3	23.9	24.7	22.1
22	26.1	27.3	27.9	25.9	23.7	25.7	25.9	26.4	25.6	22.4	18.9	21.1	23.1	20.7	24.7	21.9	21.3
23	24.9	26.4	26.1	24.1	25.6	22.7	25.3	26.7	25.4	22.1	19.7	21.6	24.4	22.	23.1	22.7	21.6
24	25.4	26.	26.1	25.9	24.7	25.3	24.3	22.4	24.9	22.6	18.1	22.3	23.6	26.3	22.4	22.7	21.1
25	24.6	25.0	26.1	24.6	25.4	25.1	22.7	22.1	25.3	21.1	16.0	22.4	22.4	23.0	24.3	24.0	20.7
26	23.6	24.7	25.7	24.7	23.1	24.0	25.0	24.4	24.1	22.1	19.2	21.9	23.7	21.9	24.7	24.6	19.4
27	24.1	25.3	25.4	24.4	24.1	23.9	24.1	24.1	24.1	23.9	23.6	21.7	23.1	22.7	23.3	27.3	20.7
28	24.4	25.9	25.9	24.6	23.6	23.4	23.3	23.9	22.	22.4	24.	22.1	23.1	22.7	21.6	22.9	21.3
29	24.4	24.4	24.	24.6	23.4	23.6	23.6	23.7	22.7	21.9	23.4	22.6	24.4	23.6	22.3	21.7	20.7
30	24.	24.1	24.1	23.3	23.1	23.6	24.0	22.6	23.3	21.9	22.	22.4	24.	20.7	22.6	22.3	20.4
31	24.	24.9	24.4	23.7	23.6	23.6	23.9	23.4	23.6	21.4	21.9	21.9	23.7	23.1	19.9	21.0	20.9
32	22.4	22.4	24.6	23.4	23.0	23.1	23.3	23.7	23.6	21.0	21.7	21.9	22.9	23.0	20.1	20.7	20.3
33	21.7	23.9	24.6	23.7	23.0	23.4	22.6	22.7	22.7	20.7	22.9	23.1	23.6	21.4	22.4	22.0	21.1
34	22.1	23.9	24.1	23.7	23.9	23.1	22.7	23.4	22.6	20.7	23.9	22.4	22.4	23.1	22.6	21.9	20.9
35	23.1	24.	24.	23.1	23.1	22.9	22.1	21.4	21.4	21.1	22.4	24.0	22.	22.1	21.9	22.3	19.7
36	23.0	24.	24.3	23.0	23.6	22.1	23.4	23.1	21.9	20.0	22.6	22.0	21.9	23.1	22.6	21.3	19.3
37	22.9	23.7	24.1	22.6	23.6	23.0	22.1	23.1	22.	21.7	22.7	22.0	22.6	22.7	22.	22.1	19.1
38	23.1	24.4	23.7	23.3	23.3	23.1	23.6	22.4	21.4	22.0	22.	22.6	22.1	23.6	21.3	20.9	19.7
39	22.9	24.4	22.7	22.6	23.4	24.7	24.3	22.6	21.9	19.4	22.4	22.3	20.7	22.7	21.3	20.4	19.7
40	24.	24.1	23.3	22.9	24.	23.0	23.4	23.1	21.7	20.3	21.1	22.6	22.9	20.7	20.3	21.4	18.1
41	23.4	22.9	21.4	23.7	22.6	22.7	22.4	21.3	24.	20.0	21.4	22.4	22.6	22.7	21.7	20.7	18.7
42	22.6	23.6	22.6	23.0	20.	23.6	22.1	21.7	21.6	20.4	20.	21.9	23.1	21.1	23.1	20.4	20.7
43	20.	22.3	20.1	21.9	22.3	20.4	23.0	21.0	21.3	19.9	20.7	22.9	22.9	23.3	21.9	17.9	16.1
44	21.1	19.0	21.6	20.	21.1	20.0	20.0	17.0	20.	18.3	20.7	23.0	23.0	22.	19.7	15.4	12.9
45	22.7	20.	19.1	19.7	21.0	20.0	20.6	19.9	20.	16.9	20.	22.0	21.6	20.7	17.7	13.7	13.4
46	19.4	23.0	15.7	22.1	22.6	19.6	20.0	22.1	20.	16.6	22.1	22.0	21.4	17.4	15.9	14.3	14.9
47	16.1	20.	17.1	18.3	21.1	19.7	21.1	17.4	15.0	15.6	21.7	21.6	20.7	14.4	17.6	14.6	10.4
48	16.4	17.6	14.3	18.6	21.6	16.7	18.4	15.0	13.7	15.7	21.7	21.4	17.7	14.0	16.6	13.0	12.6
49	13.6	16.4	16.4	15.6	19.6	14.3	17.3	15.3	13.6	14.4	21.3	21.0	17.1	13.7	15.3	10.9	14.0
50	15.3	19.3	16.1	14.1	17.1	12.9	15.0	19.1	12.0	13.7	20.	21.3	11.7	14.3	15.4	11.9	11.6
51	16.4	13.1	15.1	14.1	15.3	12.9	15.3	11.6	12.3	14.1	20.1	22.5	15.6	14.0	14.4	9.8	11.4
52	14.1	17.0	14.8	17.8	14.0	11.6	13.5	13.9	10.3	13.5	20.	23.1	16.1	17.8	15.9	9.5	11.5

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	11.4	11.6	15.1	9.6	10.4	12.0	11.0	13.9	9.9	15.0	15.5	12.6	14.5	11.9	9.6	11.8	9.2
2	12.0	9.3	10.6	11.6	10.4	10.7	13.0	14.3	7.7	7.3	14.8	12.5	7.5	11.5	9.2	14.3	10.1
3	10.4	12.3	9.4	13.4	11.6	11.7	11.0	14.3	10.4	7.1	14.2	13.7	11.0	12.4	14.0	13.9	12.1
4	13.3	13.7	14.0	7.6	11.7	8.7	12.0	10.6	11.0	11.6	15.5	14.4	14.3	11.3	13.3	10.7	11.7
5	14.4	13.3	11.3	9.4	13.9	9.0	14.3	12.7	11.7	13.2	17.5	11.8	13.1	12.6	13.2	11.3	12.5
6	15.3	12.1	13.3	10.0	13.1	9.1	13.6	14.4	12.0	13.6	18.0	12.5	11.5	13.4	14.7	13.3	11.1
7	14.6	14.7	12.9	12.4	12.1	13.1	12.7	16.3	11.7	15.5	17.3	10.8	13.0	14.5	13.6	14.9	15.1
8	13.9	14.7	11.4	14.3	12.7	15.0	15.0	14.9	12.9	16.8	16.9	16.0	13.5	18.2	14.4	16.0	16.7
9	17.4	15.8	16.3	17.0	13.3	13.4	15.3	16.0	16.4	14.7	17.2	13.4	13.7	18.4	14.3	15.5	13.5
10	16.0	15.9	16.7	13.6	14.4	14.4	16.4	16.9	16.9	15.3	19.4	16.2	15.2	17.8	14.1	19.4	15.1
11	15.4	17.4	15.1	15.3	16.1	15.7	16.6	17.1	18.0	17.5	19.5	19.1	17.2	17.1	15.7	19.3	17.2
12	16.0	20.3	17.6	19.1	18.1	19.0	17.4	18.7	17.4	19.4	19.4	18.1	19.9	18.9	17.7	17.2	17.7
13	19.6	21.0	16.4	18.1	17.7	19.0	17.4	19.7	17.0	20.1	21.0	19.9	20.4	20.1	21.6	18.6	20.1
14	19.3	21.1	19.4	18.0	20.3	16.6	20.4	18.7	16.6	21.1	18.8	21.3	17.6	21.9	19.1	19.7	20.0
15	19.4	23.7	17.6	19.7	19.3	19.4	19.0	21.7	18.0	22.4	23.3	18.5	19.2	22.1	19.0	19.5	21.0
16	20.	19.3	21.1	19.6	20.0	20.9	20.7	21.6	20.0	22.6	19.1	20.9	22.1	23.9	20.1	22.1	19.7
17	21.0	21.4	20.1	20.4	18.4	21.1	20.3	21.7	20.0	22.5	23.8	22.5	20.9	21.2	19.8	20.8	24.6
18	20.4	22.6	20.3	22.6	22.0	19.0	22.1	20.7	22.3	21.4	24.2	21.6	18.6	21.9	22.9	21.4	20.3
19	20.6	23.9	20.7	23.1	20.3	19.3	21.6	21.6	23.0	21.9	23.6	21.1	22.9	22.6	23.2	24.1	22.1
20	21.4	23.7	20.	21.1	21.4	20.3	21.4	22.9	23.0	22.4	24.6	22.8	23.4	25.0	23.	23.8	21.6
21	21.0	22.6	22.6	21.0	21.7	22.3	21.9	23.9	23.0	22.4	24.5	22.2	22.4	24.1	23.	23.9	24.1
22	21.9	22.7	22.4	20.4	21.9	22.0	21.7	22.7	20.9	22.9	23.0	22.1	22.0	23.1	23.2	23.7	23.4
23	21.9	22.6	21.4	20.6	21.4	21.7	21.6	22.0	17.1	23.1	22.8	21.9	22.0	22.0	23.3	23.0	25.2
24	22.3	23.4	21.7	21.7	22.9	20.7	22.0	20.1	16.0	23.4	22.7	22.5	22.2	23.4	22.	23.8	23.4
25	21.1	21.9	23.0	21.3	21.3	20.9	20.9	22.0	18.0	23.7	22.1	23.1	22.1	22.7	22.7	22.2	23.2
26	22.0	22.7	21.6	23.0	21.4	21.7	21.3	21.7	19.9	23.1	22.2	21.9	21.4	22.1	22.7	21.8	22.6
27	22.0	22.7	21.4	20.6	21.1	22.0	21.3	20.6	21.6	22.8	22.0	22.1	22.1	22.1	22.3	22.3	22.6
28	22.3	22.3	21.9	20.9	20.1	21.3	21.0	21.3	19.1	23.5	22.1	21.6	22.1	21.7	21.9	22.4	22.3
29	22.6	22.0	21.3	21.0	21.3	22.4	20.3	21.9	18.9	23.2	21.9	22.3	22.2	21.7	21.9	21.8	21.8
30	23.7	23.3	20.4	20.7	20.7	24.3	20.3	20.6	19.4	23.1	21.9	20.9	21.5	21.6	22.1	21.6	22.4
31	22.9	21.6	20.6	20.3	21.4	21.1	20.3	21.0	20.9	22.0	20.9	21.5	21.5	21.5	21.7	21.8	21.8
32	21.7	21.1	20.3	20.1	21.1	20.	20.6	20.7	22.0	22.4	21.3	20.8	21.6	21.1	21.9	22.2	22.1
33	21.3	20.4	20.7	21.0	19.9	21.1	20.7	21.4	20.3	21.5	22.1	20.9	21.1	21.8	21.0	21.7	21.0
34	21.3	21.9	19.3	20.7	20.6	18.9	19.9	20.7	20.0	21.6	21.9	21.4	21.4	20.6	20.5	20.8	20.3
35	21.4	21.9	20.4	19.7	20.3	20.9	20.6	19.9	22.0	22.8	20.3	21.0	16.6	21.6	21.0	20.0	21.2
36	22.0	21.9	21.0	19.6	21.1	21.0	20.7	20.9	20.9	21.9	20.3	20.9	21.7	19.1	21.3	18.9	21.9
37	22.3	20.9	20.9	21.0	20.0	20.4	21.4	19.0	20.4	21.3	21.5	20.1	21.1	21.2	21.8	19.5	21.5
38	22.0	20.4	20.	20.7	20.3	19.0	20.9	21.7	19.9	21.3	21.0	20.6	21.0	21.1	21.4	21.1	21.5
39	21.9	20.6	19.4	20.1	21.1	18.3	20.9	20.6	19.0	21.1	20.4	21.0	20.4	20.4	21.8	22.1	21.2
40	21.3	20.	20.3	20.6	19.6	18.6	19.9	20.3	22.3	22.1	21.2	21.1	20.4	20.1	22.	20.8	21.2
41	22.6	21.6	19.1	20.1	19.3	19.9	19.1	20.1	22.4	20.7	20.7	19.6	20.9	20.	22.	20.1	21.4
42	18.6	17.0	19.3	17.4	15.9	17.4	19.4	21.4	21.3	19.0	22.1	20.6	20.1	18.1	19.6	20.0	20.6
43	19.9	17.7	16.4	16.6	16.0	14.0	15.6	20.	22.4	20.5	21.3	18.8	20.7	17.9	19.4	19.1	20.8
44	21.1	19.3	14.7	18.1	16.4	14.3	13.3	18.6	18.4	18.8	19.0	15.0	19.1	15.6	16.2	17.2	20.4
45	19.1	19.0	12.6	16.6	18.7	14.0	18.6	18.9	16.6	19.2	16.5	16.9	17.9	12.9	15.6	19.3	19.0
46	17.4	19.7	11.4	14.6	13.7	16.1	19.1	19.3	14.4	15.6	13.9	19.9	14.9	15.1	14.4	14.3	18.2
47	15.4	14.7	11.1	17.0	8.6	17.3	15.1	20.4	12.7	16.2	15.7	16.0	19.1	10.6	18.7	17.5	16.9
48	14.4	13.0	13.0	17.7	10.6	16.1	13.1	20.	17.6	17.3	18.8	11.7	17.2	11.0	13.3	12.6	17.5
49	14.0	10.0	14.4	12.9	10.6	19.3	14.1	19.6	13.7	18.4	14.2	12.0	14.5	13.1	18.2	15.9	18.1
50	12.4	9.7	9.1	12.0	13.3	14.6	13.6	13.6	12.9	14.7	9.6	15.6	16.2	12.9	15.2	13.6	16.6
51	11.1	9.7	9.0	9.1	11.3	13.6	13.7	8.6	9.9	15.0	10.9	9.6	15.6	11.8	11.9	12.0	16.2
52	10.5	12.0	9.4	10.8	12.1	10.1	11.6	8.9	9.8	14.7	13.8	10.3	9.4	10.1	10.3	10.9	17.8

5.3 Weekly Rainfall (1986-2019)

Year	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
1	0	0	0	0	0	0	0	0	0	11	0	0	0	0	0	1	0
2	0	0	0	0	0	0	0	0	0	0	0	8	0	0	0	0	0
3	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	0	0	0	2	0	0	0	10	0	0	0	0	0	0	0	0	0
11	0	0	0	2	0	0	0	0	0	20	0	0	0	0	0	0	0
12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	14	0	0	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	7	3
15	0	0	0	0	0	0	0	0	16	0	0	0	0	0	0	0	7
16	0	0	0	11	0	0	0	0	0	0	0	0	0	0	0	0	0
17	0	0	13	0	0	0	0	4	0	0	0	0	0	0	0	0	0
18	2	0	0	11	0	0	0	0	0	28	0	0	0	0	0	0	0
19	0	4	0	0	0	0	0	0	0	7	0	0	0	0	5	0	14
20	0	0	0	5	204	4	11	0	0	44	2	0	2	0	0	0	11
21	0	8	35	0	0	20	0	14	0	0	72	0	30	0	65	39	0
22	37	0	0	36	0	0	0	0	89	4	22	40	0	0	65	0	11
23	18	0	11	87	28	187	21	7	10	0	29	0	48	0	104	14	4
24	9	3	8	3	35	2	52	3	3	11	87	100	77	54	0	5	63
25	11	34	0	2	0	6	12	28	2	0	12	64	14	17	6	0	11
26	3	15	0	6	8	45	2	0	3	78	0	0	4	20	10	0	26
27	0	3	0	2	4	13	0	23	32	4	30	0	0	4	24	0	0
28	3	0	9	14	2	24	35	9	20	2	72	0	0	0	15	8	0
29	3	8	6	29	10	10	121	4	26	10	37	0	39	43	0	0	17
30	0	0	34	48	8	11	0	10	3	4	14	0	50	0	0	0	42
31	14	2	8	1	1	2	8	48	0	0	0	15	16	0	0	78	59
32	3	133	0	2	62	3	72	1	2	0	0	0	0	0	35	46	11
33	10	49	3	3	41	2	24	10	3	4	0	0	0	0	0	15	0
34	0	1	10	9	0	1	0	3	2	12	43	11	154	0	41	4	4
35	0	0	21	0	3	0	31	20	21	15	2	0	16	13	7	0	0
36	0	3	68	2	11	0	0	16	9	28	17	0	101	0	13	0	7
37	55	15	104	59	0	2	0	0	4	108	101	0	106	130	0	35	12
38	72	25	83	151	0	73	4	44	0	36	7	77	22	0	78	42	13
39	24	12	101	138	11	0	42	8	0	69	90	10	32	118	40	39	0
40	0	95	8	94	95	23	16	103	21	50	179	0	53	46	0	35	0
41	0	0	0	0	105	0	1	102	0	27	0	0	77	90	30	146	46
42	0	65	0	0	0	0	1	101	14	18	42	29	62	3	0	0	66
43	0	1	0	0	48	0	0	14	0	1	41	59	0	3	0	0	0
44	0	0	0	0	0	0	0	0	2	0	0	4	8	0	0	0	0
45	24	5	0	0	0	0	0	0	0	0	3	5	4	0	0	0	1
46	0	3	0	0	2	3	3	0	2	0	0	41	0	0	0	21	0
47	0	0	0	0	1	0	1	15	0	3	0	0	0	0	0	2	0
48	0	0	0	0	0	0	0	0	0	0	0	23	0	0	0	0	0
49	0	0	0	0	0	0	0	75	0	0	0	25	0	0	0	0	0
50	0	58	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0
51	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0
3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16	0
7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	24	0	0	1	22	1	0	0	0
10	0	0	9	14	0	0	0	0	0	0	0	66	0	0	0	1	0
11	0	0	0	0	0	2	7	0	0	0	0	14	0	0	0	0	0
12	0	0	0	0	0	16	0	0	0	0	0	0	0	0	0	0	0
13	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0
14	0	0	0	0	0	34	0	0	0	5	0	0	0	4	0	1	0
15	0	0	3	0	0	0	0	0	12	3	0	1	0	0	0	32	0
16	0	0	0	0	3	0	0	0	0	6	0	46	16	0	0	15	0
17	0	0	3	0	0	20	0	0	0	1	0	7	0	0	0	0	0
18	0	3	3	0	0	0	0	6	0	0	0	0	2	0	0	8	0
19	0	18	0	0	1	0	0	0	0	15	0	26	37	9	0	24	0
20	0	61	0	0	0	0	87	0	0	0	0	0	0	0	0	7	0
21	0	6	0	0	2	11	0	0	0	0	0	67	0	0	1	0	0
22	0	64	29	35	10	12	33	15	3	0	47	87	41	35	104	2	0
23	8	49	5	18	40	0	46	10	70	17	20	13	18	68	1	1	4
24	75	36	15	3	27	1	0	271	3	1	17	0	12	0	68	0	2
25	12	7	0	106	170	0	43	17	0	0	12	0	20	17	5	111	9
26	3	0	28	11	50	4	0	1	0	31	7	0	0	10	3	2	24
27	10	1	9	16	19	0	32	24	55	0	25	45	0	21	0	12	16
28	13	47	27	0	2	0	16	5	34	0	21	8	15	7	20	1	8
29	0	20	83	4	0	0	18	2	42	7	29	5	3	3	28	27	121
30	0	9	20	14	25	5	12	47	13	4	17	23	7	18	0	3	6
31	0	46	28	16	23	11	0	8	14	37	23	19	0	27	0	0	24
32	0	6	11	52	3	15	0	10	0	14	0	11	1	8	0	1	3
33	0	0	1	0	3	0	42	23	10	4	0	9	1	1	7	13	0
34	16	0	7	0	27	8	235	37	82	0	4	83	3	0	74	4	1
35	0	0	48	8	39	85	49	45	17	15	2	80	0	4	26	2	4
36	2	9	122	32	8	196	20	5	0	38	60	5	5	3	69	9	3
37	0	37	19	163	10	101	20	4	17	9	97	1	106	50	222	0	0
38	2	52	8	32	77	0	99	22	0	2	117	65	9	92	3	35	52
39	10	52	25	25	1	0	33	216	28	25	0	1	0	67	13	1	103
40	0	34	46	61	0	9	217	36	6	49	8	0	62	47	49	0	99
41	0	0	11	2	0	5	37	4	30	0	0	15	0	0	59	0	17
42	0	0	56	0	0	16	0	68	10	0	13	1	0	0	2	4	158
43	0	0	0	2	0	0	0	35	0	2	3	9	0	0	0	0	36
44	0	0	0	0	35	0	0	0	0	9	0	0	0	0	0	0	35
45	0	6	0	15	0	0	31	19	0	0	0	0	0	0	0	0	13
46	0	0	0	0	0	0	66	10	0	0	0	39	0	0	0	0	0
47	0	0	0	15	0	5	0	2	0	0	0	5	5	0	3	13	0
48	0	0	0	0	0	7	0	0	0	0	3	0	0	0	0	0	0
49	0	0	0	0	0	5	0	6	0	0	0	0	0	0	0	1	0
50	0	0	0	0	0	0	0	0	0	0	0	8	0	1	0	0	0
51	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0
52	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

6. APPENDIX-II
Monthly Weather Data

6.1 Monthly Maximum Temperature (1986-2019)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	28.7	32.3	37.5	39.9	39.3	34.1	30.3	29.4	32.1	34.2	31.2	29.5
1987	29.7	22.1	26.2	29.4	31.0	31.4	30.3	29.3	30.2	26.7	25.0	21.5
1988	22.0	29.5	32.7	33.1	38.0	33.9	30.0	30.1	29.4	31.2	28.9	26.7
1989	28.2	28.9	33.8	36.8	37.8	30.6	29.5	28.1	29.7	31.9	29.9	27.1
1990	30.1	32.7	35.2	39.8	37.9	32.1	30.7	29.2	32.3	31.0	31.0	30.1
1991	31.7	34.9	38.4	39.5	40.5	33.7	29.4	29.7	32.4	34.0	31.5	29.9
1992	31.0	33.1	38.8	40.3	40.8	35.1	31.0	29.4	32.3	33.1	31.6	30.5
1993	33.3	34.0	36.8	40.0	41.0	35.6	31.4	31.1	31.1	30.8	31.1	27.4
1994	30.0	33.0	38.7	38.2	40.4	32.9	29.5	30.3	31.7	33.0	30.2	29.8
1995	27.3	33.1	36.3	39.3	37.1	36.5	31.7	32.6	31.2	31.7	31.2	30.5
1996	31.3	33.9	38.1	39.3	39.6	34.7	30.2	30.6	32.0	31.3	31.1	30.1
1997	29.0	32.2	36.2	35.7	39.2	33.8	30.0	29.8	28.7	30.4	31.1	29.6
1998	29.5	29.7	35.9	40.8	40.4	35.5	31.9	30.2	30.2	29.4	29.9	29.7
1999	30.4	33.5	37.9	40.3	38.7	33.4	31.9	32.6	31.5	32.8	32.4	29.5
2000	32.0	32.9	35.7	41.3	37.2	33.2	32.0	31.5	33.1	34.6	30.5	29.3
2001	31.4	36.5	38.1	40.6	38.9	33.7	31.8	30.8	32.8	33.1	32.8	31.0
2002	30.5	34.3	38.3	40.7	40.3	33.8	33.1	30.6	32.6	34.3	32.8	32.2
2003	31.7	35.1	37.6	39.9	40.4	35.5	30.9	29.6	30.6	33.7	32.6	30.9
2004	31.4	34.6	39.6	40.9	38.0	32.7	31.9	29.0	31.8	33.7	32.4	30.6
2005	31.4	33.6	37.5	39.5	39.9	35.6	30.7	30.4	30.7	32.3	31.9	30.5
2006	31.5	35.0	36.1	40.0	39.8	33.8	30.3	29.7	32.6	33.5	31.3	31.5
2007	32.1	34.0	36.7	39.5	40.7	35.7	31.1	31.5	31.0	33.3	32.5	31.8
2008	31.7	33.3	36.6	39.8	40.4	34.2	31.2	30.8	31.5	34.0	33.3	32.0
2009	32.3	34.7	37.7	40.5	40.3	36.0	30.4	31.7	32.5	32.4	32.0	31.0
2010	30.9	34.5	38.7	41.3	40.5	34.7	30.1	30.2	29.8	27.5	30.9	29.6
2011	27.5	31.8	35.2	38.0	39.0	30.2	28.7	27.7	27.9	32.5	33.7	33.6
2012	32.8	33.0	36.3	38.3	38.7	34.3	31.3	31.1	30.9	31.2	30.9	30.4
2013	31.4	32.8	36.1	38.5	38.9	31.0	28.0	30.2	30.7	32.1	30.1	28.7
2014	28.7	30.3	33.3	36.9	36.8	34.3	30.1	30.0	30.2	32.0	30.2	28.4
2015	28.3	32.2	34.5	36.7	38.6	32.6	31.4	31.4	32.0	33.1	31.6	31.2
2016	30.1	33.9	36.6	39.5	38.9	32.8	29.3	30.1	29.5	30.9	30.2	29.6
2017	29.3	32.9	35.7	39.1	39.0	33.0	30.5	30.4	31.0	32.3	30.6	29.1
2018	29.8	31.9	35.8	38.4	39.6	32.9	29.4	29.5	32.1	33.1	31.4	29.2
2019	29.7	32.5	36.4	39.6	39.8	35.6	30.3	30.0	30.6	30.0	30.0	29.1
Mean	30.2	32.7	36.3	38.8	39.0	33.7	30.6	30.3	31.2	32.2	31.1	29.8
SD	2.1	2.5	2.4	2.4	1.8	1.6	1.1	1.1	1.2	1.8	1.5	2.0
CV	6.9	7.6	6.6	6.2	4.7	4.7	3.5	3.5	4.0	5.6	4.9	6.8

6.2 Monthly Minimum Temperature (1986-2019)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1986	14.9	17.3	21.5	25.4	26.5	24.8	24.2	22.5	23.0	22.3	19.5	14.8
1987	15.9	15.6	20.3	24.5	25.5	25.8	24.8	23.7	24.2	23.0	20.4	16.5
1988	15.1	16.8	20.1	20.8	27.8	26.2	24.9	24.4	23.7	21.7	17.6	15.4
1989	14.5	14.9	20.3	24.2	26.8	24.9	24.2	23.6	22.8	22.8	19.8	15.7
1990	15.0	16.3	20.7	24.5	25.6	24.6	23.5	23.3	23.5	22.5	21.2	16.8
1991	15.0	16.6	21.2	24.3	26.5	24.5	23.6	23.2	23.2	22.2	19.3	13.1
1992	12.7	14.8	19.5	23.8	26.1	24.4	23.8	22.9	23.2	22.5	20.2	15.4
1993	15.3	16.6	20.4	25.6	27.1	24.3	23.5	23.1	22.7	21.6	18.5	14.7
1994	15.6	16.7	21.5	24.5	26.1	24.9	23.1	22.8	21.8	22.0	18.1	12.1
1995	11.9	15.8	17.2	22.1	23.2	22.0	22.5	20.9	20.8	20.1	16.3	14.1
1996	13.8	13.8	15.4	18.0	21.8	18.1	23.2	22.5	22.5	20.9	21.5	20.8
1997	20.2	21.6	18.9	17.4	21.1	22.0	22.1	22.7	22.3	22.5	22.0	21.9
1998	21.5	21.9	20.8	27.3	25.1	23.4	23.7	22.8	21.8	22.8	20.8	15.4
1999	19.5	22.4	20.5	16.5	20.9	23.2	22.4	22.7	23.0	22.1	17.4	15.0
2000	17.2	17.3	22.5	24.3	22.4	23.8	22.5	21.3	21.8	21.9	17.0	15.3
2001	17.8	25.7	23.2	23.3	24.3	23.2	23.5	21.5	21.2	19.8	14.0	10.6
2002	10.7	15.6	16.2	20.1	22.2	20.7	20.7	20.6	19.6	17.8	12.9	12.2
2003	12.0	14.8	16.8	20.0	20.9	21.8	22.7	21.7	21.9	20.5	17.5	12.1
2004	11.9	13.9	18.3	21.4	23.2	22.6	22.5	21.3	21.0	19.0	17.4	10.5
2005	12.4	12.6	16.4	19.5	21.1	22.1	21.2	20.2	20.4	18.3	12.4	10.6
2006	10.4	12.3	16.6	19.5	21.8	21.5	20.8	20.4	20.3	18.6	16.9	11.4
2007	11.3	13.0	16.0	19.6	21.4	21.8	20.9	20.6	20.6	17.5	13.5	11.8
2008	10.6	12.1	16.5	19.5	20.4	21.4	22.4	20.3	19.7	17.2	15.4	14.6
2009	12.0	13.9	16.7	20.1	21.8	21.4	20.8	20.3	21.0	18.1	16.3	13.1
2010	13.1	14.9	18.1	20.8	22.4	21.4	21.1	20.8	20.5	20.1	19.6	13.0
2011	9.9	12.5	17.3	18.6	22.9	17.6	19.9	21.0	20.2	22.0	15.4	11.7
2012	10.3	15.4	17.3	22.1	22.1	23.4	23.0	22.1	21.5	20.2	17.6	15.7
2013	15.1	17.4	19.5	21.4	24.3	22.4	22.0	21.3	20.8	21.1	16.2	12.7
2014	13.0	13.3	17.4	20.9	21.9	22.4	21.7	21.1	20.6	19.5	16.3	11.8
2015	12.0	12.9	17.5	19.9	22.0	21.9	21.9	20.4	21.0	20.4	17.4	14.1
2016	11.8	15.4	18.5	22.2	23.3	22.7	21.8	21.4	20.5	18.9	12.9	11.9
2017	11.5	14.2	16.9	19.4	23.2	22.8	22.0	21.3	21.5	20.5	15.6	13.7
2018	12.6	14.1	18.4	20.5	23.3	22.9	22.0	21.4	20.3	19.5	16.6	13.0
2019	10.7	14.1	17.0	21.4	22.1	23.7	22.2	21.3	21.5	20.9	18.2	17.3
Mean	13.8	15.8	18.7	21.6	23.5	22.8	22.5	21.8	21.6	20.6	17.4	14.0
SD	2.9	3.1	2.1	2.6	2.1	1.9	1.2	1.2	1.2	1.7	2.5	2.6
CV	21.2	19.5	11.1	11.9	9.0	8.1	5.5	5.3	5.7	8.3	14.6	18.7

6.3 Monthly Rainfall (1986-2019)

Year	Jan	Feb	Mar	Apr	May	Jun	July	Aug	Sep	Oct	Nov	Dec
1986	0.0	0.0	0.0	0.0	2.0	78.0	6.0	27.0	151.0	0.0	24.0	0.0
1987	0.0	6.0	0.0	0.0	12.0	52.0	13.0	183.0	55.0	161.0	8.0	58.0
1988	0.0	0.0	0.0	13.0	35.0	19.0	49.0	26.0	372.0	8.0	0.0	10.0
1989	0.0	0.0	18.0	11.0	52.0	98.0	93.0	15.0	350.0	94.0	0.0	0.0
1990	0.0	0.0	0.0	0.0	204.0	70.0	26.0	106.0	22.0	248.0	3.0	0.0
1991	0.0	0.0	0.0	2.0	24.0	240.0	58.0	8.0	75.0	23.0	3.0	0.0
1992	0.0	0.0	0.0	0.0	11.0	85.0	158.0	105.0	76.0	18.0	4.0	0.0
1993	0.0	0.0	10.0	4.0	14.0	38.0	46.0	62.0	88.0	320.0	15.0	75.0
1994	0.0	0.0	0.0	16.0	38.0	69.0	81.0	20.0	21.0	37.0	2.0	0.0
1995	13.0	0.0	20.0	0.0	79.0	93.0	20.0	22.0	250.0	96.0	3.0	0.0
1996	0.0	0.0	0.0	0.0	74.0	150.0	153.0	45.0	215.0	262.0	3.0	0.0
1997	8.0	0.0	0.0	0.0	40.0	164.0	15.0	11.0	87.0	92.0	69.0	25.0
1998	0.0	0.0	0.0	0.0	32.0	143.0	105.0	168.0	263.0	192.0	12.0	0.0
1999	0.0	0.0	0.0	0.0	0.0	91.0	47.0	13.0	248.0	142.0	0.0	0.0
2000	0.0	0.0	0.0	0.0	78.0	167.0	49.0	82.0	132.0	30.0	0.0	0.0
2001	1.0	0.0	0.0	7.0	39.0	19.0	52.0	99.0	116.0	181.0	23.0	0.0
2002	0.0	0.0	0.0	10.0	25.0	115.0	59.0	74.0	32.0	112.0	1.0	0.0
2003	0.0	0.0	0.0	0.0	0.0	98.0	23.0	16.0	14.0	0.0	0.0	0.0
2004	0.0	0.0	0.0	0.0	131.0	113.0	97.0	32.0	150.0	34.0	6.0	0.0
2005	0.0	1.0	9.0	6.0	32.0	46.0	147.0	81.0	182.0	113.0	0.0	0.0
2006	0.0	0.0	14.0	0.0	0.0	173.0	44.0	66.0	252.0	65.0	30.0	0.0
2007	0.0	0.0	0.0	3.0	3.0	289.0	54.0	95.0	96.0	0.0	35.0	0.0
2008	0.0	0.0	19.0	54.0	11.0	13.0	9.0	39.0	377.0	30.0	12.0	5.0
2009	0.0	0.0	7.0	0.0	87.0	122.0	78.0	277.0	221.0	254.0	97.0	2.0
2010	0.0	0.0	0.0	0.0	6.0	314.0	84.0	113.0	251.0	143.0	31.0	6.0
2011	0.0	24.0	0.0	12.0	0.0	76.0	158.0	109.0	45.0	46.0	0.0	0.0
2012	0.0	0.0	0.0	15.0	15.0	18.0	73.0	39.0	74.0	51.0	9.0	0.0
2013	0.0	0.0	0.0	0.0	0.0	103.0	105.0	16.0	274.0	24.0	1.0	2.0
2014	0.0	1.0	80.0	54.0	108.0	85.0	90.0	192.0	73.0	25.0	44.0	8.0
2015	0.0	0.0	22.0	16.0	80.0	50.0	25.0	5.0	120.0	62.0	5.0	0.0
2016	0.0	0.0	1.0	4.0	16.0	123.0	49.0	40.0	212.0	47.0	0.0	1.0
2017	0.0	0.0	0.0	0.0	1.0	181.0	48.0	107.0	307.0	110.0	3.0	0.0
2018	0.0	0.0	0.0	14.8	9.0	143.6	32.6	20.5	36.4	80.8	13.3	0.2
2019	0.0	0.0	0.0	0.0	0.0	36.4	162.6	19.6	162.6	332.4	25.6	0.4
Mean	0.6	0.9	5.9	7.1	37.0	108.1	67.9	68.6	158.8	101.0	14.2	5.7
SD	2.6	4.2	14.8	13.2	45.6	72.5	46.0	63.1	107.3	93.6	21.4	16.3
CV	398.8	446.9	251.4	185.3	123.2	67.1	67.7	91.9	67.5	92.7	150.8	287.6

7. APPENDIX-III
Annual Weather Data

7.1 Annual Temperature and Rainfall (1986-2019)

Year	Max. Temp. (°C)	Min. Temp. (°C)	Mean Temp. (°C)	Rainfall (mm)
1986	33.2	21.4	27.3	287.2
1987	27.8	21.7	24.8	552.5
1988	30.5	21.2	25.9	532.3
1989	31.0	21.2	26.1	735.9
1990	32.7	21.5	27.1	678.8
1991	33.8	21.1	27.5	433.0
1992	33.9	20.8	27.4	458.3
1993	33.6	21.1	27.4	671.9
1994	33.1	20.8	27.0	286.2
1995	33.2	18.9	26.1	589.8
1996	33.5	19.4	26.5	904.5
1997	32.1	21.2	26.7	511.2
1998	32.8	22.3	27.6	916.8
1999	33.7	20.4	27.1	542.8
2000	33.6	20.6	27.1	537.2
2001	34.3	20.7	27.5	537.4
2002	34.4	17.4	25.9	426.5
2003	34.0	18.6	26.3	151.4
2004	33.9	18.6	26.3	563.8
2005	33.7	17.3	25.5	617.2
2006	33.7	17.6	25.7	643.2
2007	34.2	17.4	25.8	574.5
2008	34.1	17.5	25.8	570.0
2009	34.3	18.0	26.2	1144.7
2010	33.2	18.8	26.0	947.5
2011	32.1	17.5	24.8	469.4
2012	33.3	19.2	26.3	289.2
2013	32.4	19.5	26.0	523.0
2014	31.7	18.4	25.1	760.1
2015	32.8	18.5	25.7	387.2
2016	32.6	18.4	25.5	491.0
2017	32.7	18.6	25.7	759.8
2018	32.7	18.7	25.7	351.2
2019	32.8	19.2	26.0	739.6
Mean	33.0	19.5	26.3	576.0
SD	1.3	1.5	0.8	208.7
CV	4.0	7.9	3.0	36.2

8. Standard Meteorological Weeks

Week	Dates	Week	Dates
1	01 Jan – 07 Jan	**27**	02 Jul – 08 Jul
2	08 Jan – 14 Jan	**28**	09 Jul – 15 Jul
3	15 Jan – 21 Jan	**29**	16 Jul – 22 Jul
4	22 Jan – 28 Jan	**30**	23 Jul – 29 Jul
5	29 Jan – 04 Feb	**31**	30 Jul – 05 Aug
6	05 Feb – 11 Feb	**32**	06 Aug – 12 Aug
7	12 Feb -18 Feb	**33**	13 Aug – 19 Aug
8	19 Feb - 25 Feb	**34**	20 Aug – 26 Aug
9*	26 Feb - 04 Mar	**35**	27 Aug – 02 Sep
10	05 Mar -11 Mar	**36**	03 Sep – 09 Sep
11	12 Mar – 18 Mar	**37**	10 Sep – 16 Sep
12	19 Mar – 25 Mar	**38**	17 Sep - 23 Sep
13	26 Mar – 01 Apr	**39**	24 Sep – 30 Sep
14	02 Apr – 08 Apr	**40**	01 Oct – 07 Oct
15	09 Apr – 15 Apr	**41**	08 Oct – 14 Oct
16	16 Apr – 22 Apr	**42**	15 Oct – 21 Oct
17	23 Apr – 29 Apr	**43**	22 Oct -28 Oct
18	30 Apr – 06 May	**44**	29 Oct - 04 Nov
19	07 May – 13 May	**45**	05 Nov – 11 Nov
20	14 May – 20 May	**46**	12 Nov - 18 Nov
21	21 May – 27 May	**47**	19 Nov - 25 Nov
22	28 May – 03 Jun	**48**	26 Nov - 02 Dec
23	04 Jun – 10 Jun	**49**	03 Dec – 09 Dec
24	11 Jun – 17 Jun	**50**	10 Dec – 16 Dec
25	18 Jun - 24 Jun	**51**	17 Dec – 23 Dec
26	25 Jun – 01 Jul	**52****	24 Dec -31 Dec

*** Week No. 9 will have 8 days during leap year**
**** Week No. 52 will always have 8 days**

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