Analysis of temporal temperature change pattern: case study of Damoh district in Madhya Pradesh

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Abstract: **The paper examines the long term changes in the annual mean maximum and minimum temperatures during the period of 53 years (1965-2017). It presents the trend of temperature changes in five decades (1965-2014) along with annual fluctuations during last three years of the study (2015-2017) in Damoh district of Madhya Pradesh. Impact was observed by analyzing time series data on temperature. To identify any pattern of change in mean temperatures, standard deviation and coefficient of variance were also calculated. Fluctuations observed throughout the decade with uneven rises and falls in temperature suggest that there is no specific trend of rise or fall. With regard to changes in temperature it is observed that mean maximum temperature has increased by 1.5°C in the period of these five decades. The decadal mean maximum temperature was 31°C in 1965-74 and but the same was recorded as 32.5°C in 2005-14 which reveals rise in mean maximum temperature. On the other hand, mean minimum temperature decreased by 1.2°C in the period of these five decades, as the decadal mean minimum temperature was 20.3°C in 1965-74 and the same was recorded as 19.1°C in 2005-14. This shows the falling trend in mean minimum temperature. Hence, in the past five decades summers of Damoh are getting warmer and winters are getting colder. The analysis in the present study indicated that the change point year of the significant upward shift was 2003.**

Key words: **Mean maximum temperature, mean minimum temperature, Damoh, climate change.**

I. INTRODUCTION

Climate change is one of the most serious challenges faced by the world today, and it is expected to have long term impacts on sustainable living. Climate change is considered to impact the environment, water, health, agriculture, power, transportation and other allied sectors that are vital for the existence of mankind (Sudhir *et al*., 2014). It is widely recognized that this climate change poses a grave threat to biodiversity, exacerbating existing threats because of land use change, fragmentation, and environmental degradation. In the past century, mean global surface temperature has increased by almost 1°C (Meehl *et al.*, 2007). Climate scientists had been issuing warnings about these catastrophic consequences from the very beginning of the second half of the 20th century but these warnings earlier fell on the deaf ears of the politicians and policy makers.

Since the beginning of the industrial revolution, the average surface temperature of the Earth has already risen by 0.85°C. If we take the base year as 1990, the rise in average global temperature is 0.5°C. Further, the new scientific evidences suggest stronger possibility of increased anthropogenic activity being the major cause of rise in temperature over the past 50 years. More worrisome fact is that the pace of rise in temperature is accelerating and the scientists expect this rise by 1.4°C to 5.8°C between 1990 and 2100 and by 0.5°C to 2.5°C even upto the year 2050. Therefore, the situation calls for immediate and effective measures to be taken up by all nations to curb the level of GHG emissions into the atmosphere as the 'Business As Usual' (BAU) scenario is bound to lead to disastrous consequences which may include even annihilation of all living beings on the Earth.

After precipitation, the temperature is an essential meteorological parameter of climate (Shukla *et al*., 2017). It is also considered as a good indicator to understand the global climate as it signifies the exchange of energy process over the surface of the earth with proper accuracy (Shukla *et al*., 2015 and Jhariya and Singh, 2011).

A few studies have been carried out in India as well on temperature changes and their alliance with climate change. Studies on temporal and spatial changes in annual and seasonal temperatures have been conducted in India by researchers including Shukla and Khare (2013), Mishra *et al.* (2013), Duhan and Pandey (2013), Revadekar *et al.* (2011), Indrani and Abir Altabba, (2009), Jhariya *et al.* (2009). The scientists have warned that the global warming is to some extent irreversible. Even if all the nations agree to cut down GHG emissions drastically (although it seems quite unlikely), the atmospheric temperature will still continue to rise for some more time (although its rate may be reduced). Therefore, we, in any case, have to learn to live in a higher temperature regime. It is called adaptation to climate change. Thus, to deal with this menace of climate change, a two-pronged approach, combining 'mitigation' as well as

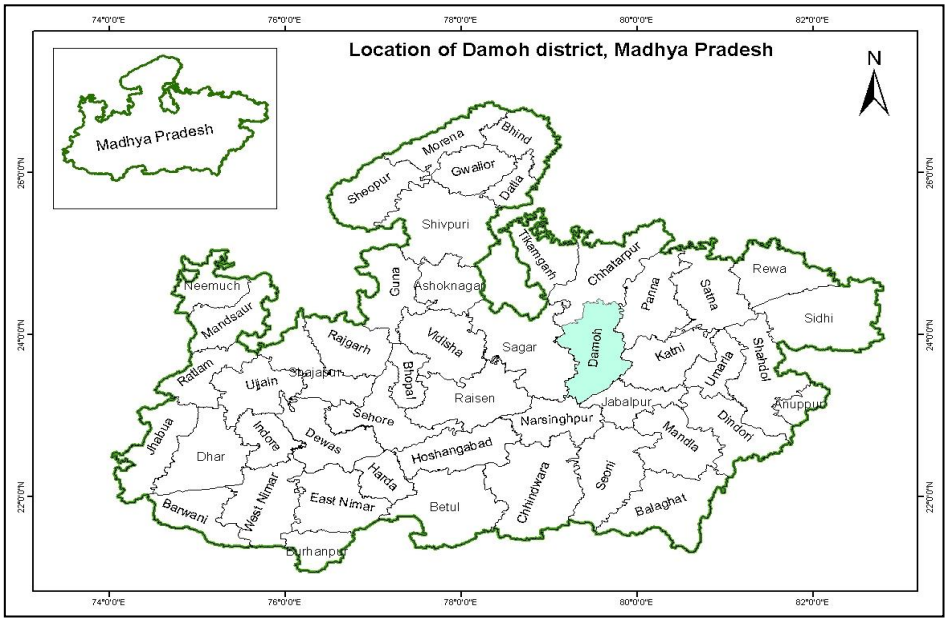
'adaptation', needs to be adopted. As far as adaptation measures are concerned, there cannot be universally applicable prescriptions. These measures have to be site-specific, depending on the locality factors which may comprise not only the prevailing climatic, edaphic and physiographic factors but also the biotic factors and these biotic factors may include the economic status, culture, traditions, food habits, patterns of agriculture and animal husbandry, dependence of the local people on forest and other natural resources, etc. Thus, the workable strategies of adaptation to climate change may be different for different areas and for this, we need to be equipped with credible data base of climatic information at the local levels.

It is in this background that a case study was conducted in Damoh district of Madhya Pradesh. In this study, besides other parameters, a long duration data on various climatic parameters was also analyzed to find out temporal change trends in the wake of climate change. Climate of an area is characterized by mainly two parameters viz. temperature and precipitation. Latitude and altitude are the main determinants of temperature. As we move from the equator towards poles, the average temperature goes on decreasing with increase in latitude. Similarly, when we move from those situated at the sea level to the places situated at higher altitudes, the average temperature again goes dropping.

The present paper gives the result of the analysis of the data on mean maximum and minimum temperatures done to find out discarnate trends, if any.

II. MATERIALS AND METHODOLOGY

Study area: Study area is Damoh district of Madhya Pradesh which falls in Bundelkhand region and Vindhyan plateau agro-climatic zone of the state. There are three distinct seasons viz. summer, rainy and winter. May and June are the hottest months with maximum temperature rising even upto 46°C, whereas December and January are the coldest months with minimum temperature dipping upto 4°C. Climate of Damoh is hot and dry. The range of variation in maximum temperature during summers is 40ºC-47.5ºC, usually in June and that for minimum temperature in winter is 0ºC-11ºC, usually in January. Because of the horizontally bedded impervious sandstones, availability of water becomes acutely deficient, especially during summer season (Shrivastava, 2005). Map 1 shows the location of Damoh district in the map of Madhya Pradesh state.



Map 1.1: Location of Damoh district in Madhya Pradesh

Methodology: To assess the impact of climate change in the study area, particularly to find out the long term changes in climatic variables like temperature, time-series data on temperature was taken for past 53 years (1965-2017) and this time series data was analyzed to calculate decadal trend of changes. Standard Deviation (SD) and Coefficient of Variance (CV) were also calculated. Interestingly while doing the perception based study on Damoh similar observations were recorded in the study (Bhatnagar *et al.*, 2019)

Temperature data for Damoh district for the period from 1970 to 2013 with some data gaps was provided by Indian Institute of Tropical Meteorology IITM, Pune. There were data gaps on temperature for the years 1965-1969, 2003, 2007-08 and 2014-2017 which were taken from the website www.climatechange.mp.gov.in of Environmental Planning and Coordination Organization (EPCO), Bhopal and also from www.worldweatheronline.com (Table- 1).

Table 1: Information on type of data on temperature and its sources

Type of data	Information for the decades/years	Secondary data source
Mean maximum and minimum temperatures in °C for 53 years (1965-2017)	Decade 1 (1965-1974)**	IITM, Pune and www.climatechange.mp.gov.in
	Decade 2 (1975-1984)	IITM, Pune
	Decade 3 (1985-1994)	
	Decade 4 (1995-2004)	
	Decade 5 (2005-2014)*	IITM, Pune and www.climatechange.mp.gov.in
	Current years (2015-2017)	www.worldweatheronline.com

***** Data for the years 2003, 2007-2008 has been taken from www.climatechange.mp.gov.in and rest of the data has been taken from IITM, Pune

****** Data for the years 1965-1969 has been taken from www.climatechange.mp.gov.in and data for the years 1970-1974 has been taken from IITM Pune.

The whole study period has been grouped into the decades 1965-1974, 1975-1984, 1985-1994, 1995-2004, 2005-2014 and also for the remaining period of 2015-2017.Besides the mean values, standard deviation (SD) and coefficient of variation (CV) have also been worked out separately for each decade.

For the sake of convenience, graphical presentation of fluctuations in values of climatic parameters over the years has been made separately for different decades. Then, the grouped averages for different decades have also been depicted graphically to facilitate indication of discernible change trends, if any, during the whole study period.

III. RESULT AND DISCUSSION

Mean maximum temperature: Mean annual maximum temperature i.e. the average of daily maximum temperatures in a year, is an important climatic parameter from the view point of climate change, especially in warmer regions.

In order to study the pattern of this parameter over the years, the data were first depicted graphically for each decade separately and the graphs drawn showing annual variations in the mean maximum temperature during the decades 1965-1974, 1975-1984, 1985-1994, 1995-2004 and 2005-2014 are shown in figures 1 to 5, respectively.

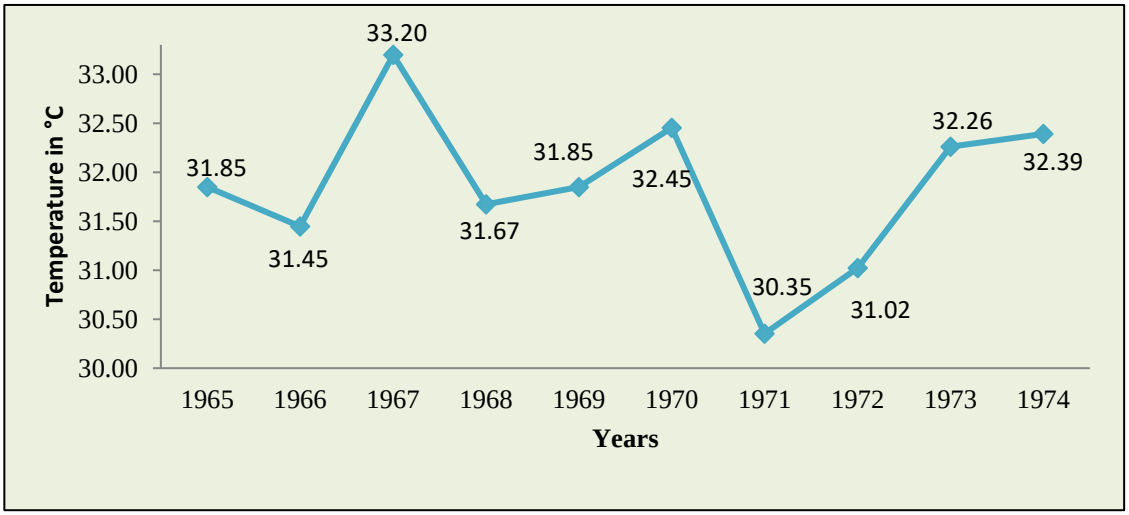


Fig. 1: Annual mean max. temperature in years 1965-1974

It can be seen from the graph shown in Fig 1 that the mean maximum temperature during the decade 1965-1974 has varied within the range 30.35°C–33.20°C. The warmest year during this period was 1967 and the coolest was the year 1971, while fluctuations with range width 2.85°C were noticed during this period. The mean maximum temperature first decreased marginally from 31.85°C in the year 1965 to 31.45 °C in the next year, i.e. the year 1966. Then, it suddenly shot up to 33.20°C (the maximum value in the decade) in the very next year i.e in the year 1967. Again, a rapid decline was observed in the next year i.e. the year 1968, with mean maximum temperature dropping to the level of 31.67°C. From 1968 to 1970, a gradual rise was observed with mean maximum temperature rising to 31.85°C in 1969 and 32.45°C in 1970. This phase of short rise was followed by a phase of steep decline and the mean maximum temperature plummeted to its minimum value i.e. 30.35°C in the year 1971. This brief phase of steep decline was followed by a phase of steep rise again from the year 1971 up to the year 1973 with the values of this parameter rising to 31.02°C in 1972 and 32.26°C in 1973. Then, there was a marginal increase in the year 1974 with mean maximum temperature reaching upto 32.39 °C. Thus, wide fluctuations in mean maximum temperature were witnessed with general trend of rise, except in the years 1968 and 1971when sudden falls in mean maximum temperature were observed. The year 1971 was an exceptional year when the value of mean maximum temperature nosedived to as low as 30.35°C.

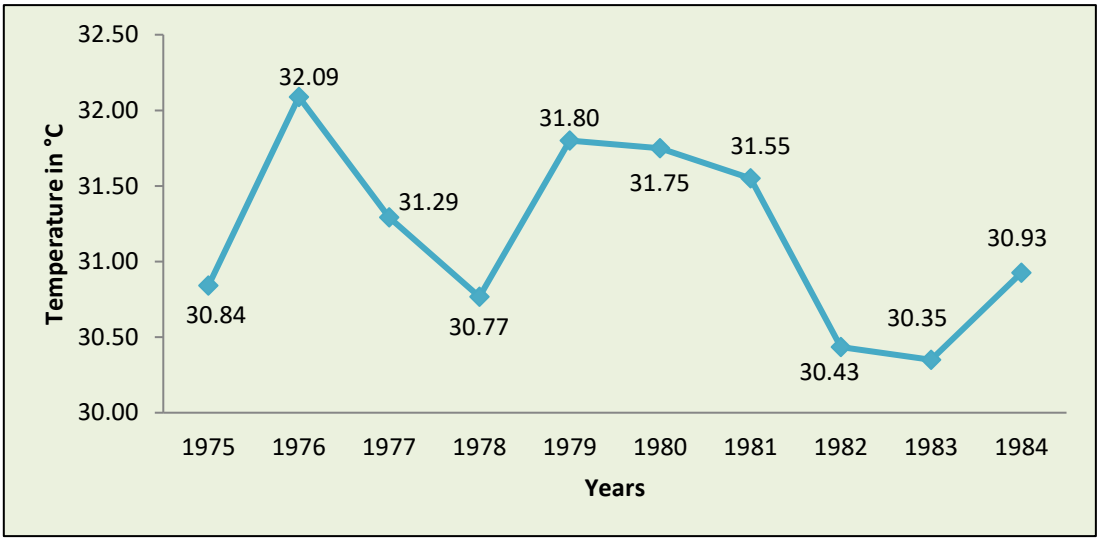


Fig. 2: Annual mean maximum temperature during the decade 1975-1984

As can be seen from the graph in Fig.2, the decade 1975-84, much like its previous decade also witnessed fluctuations in the value of this parameter. However, the rises and falls were not as steep as in the previous decade. The maximum

value of 32.09°C as against the much higher value of 33.20°C in the previous decade was observed in the year 1976 and the minimum value of 30.35°C, same as in the previous decade, was observed in the year 1983. The range width in this decade was 1.74°C only as against 2.85°C in the previous decade. Alternate phases of rises and falls were witnessed. There were three phases of rises- (i) from 30.84°C in 1975 to 32.09°C in 1976 (a steep rise of 1.25°C), (ii) from 30.77°C in 1978 to 31.80°C in 1979 (again a steep rise of 1.03 °C) and (iii) from 30.35 °C in 1983 to 30.93°C in 1984 (a modest rise of 0.58°C). Two alternate phases of fall - (i) from 32.09 °C in 1976 to 31.29°C in 1977 and 30.77°C in 1978, and (ii) from 31.80°C in 1979 to 31.75°C in 1980, 31.55°C in 1981, 30.43°C in 1982 and 30.35 °C in 1983 were also witnessed. The earlier phase (1976 to 1978) of fall was quite steep. There was very gentle fall in temperature from 1979 to 1981 whereas it was quite steep from 1981 to 1982. This decade also witnessed fluctuations in mean maximum

temperature, although these were not as wide as in the previous decade. Unlike previous decade, no discernible overall trend of rise in mean maximum temperature was witnessed in this decade.

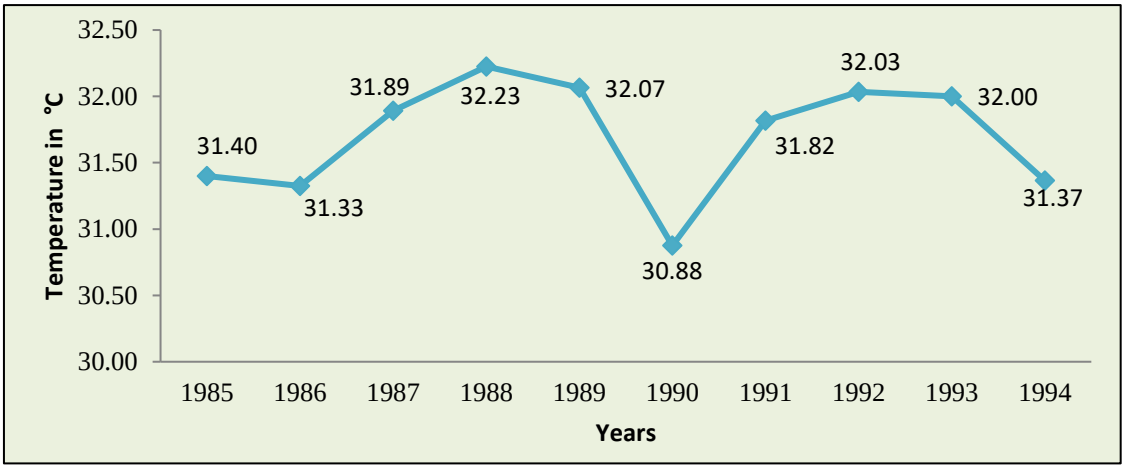
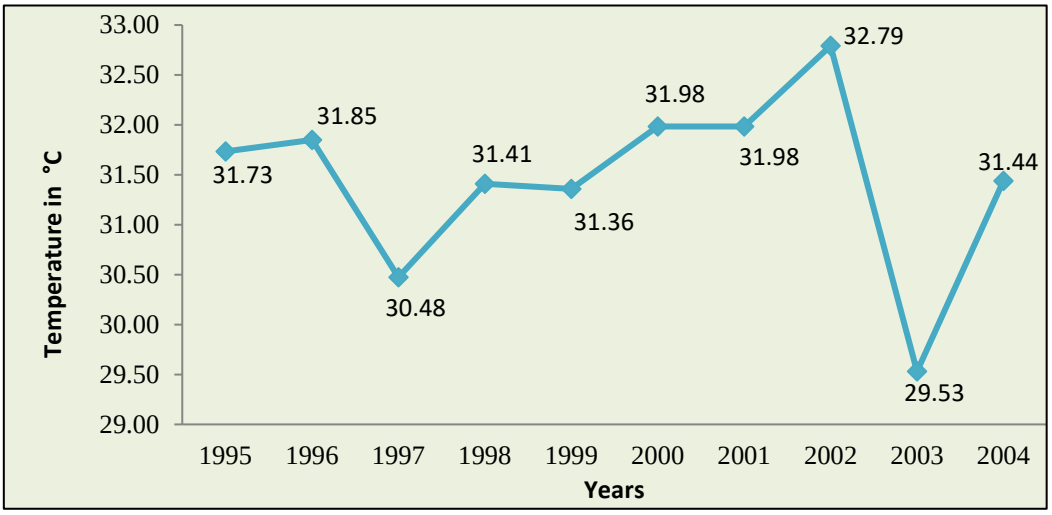


Fig. 3: Annual mean maximum temperature during the decade 1985-1994

Variations in mean maximum temperature during the decade 1985-94 are shown in Fig. 3. As can be seen from the graph, this decade too witnessed fluctuations in the value of this parameter. The value of this parameter ranged from 30.88 °C in the year 1990 to 32.23°C in the year 1988. Thus, the range width was 1.35°C, less than 1.74°C in the decade 1975-84 and much less than 2.85°C in the decade 1965-74. Thus, we can say that fluctuations in this decade were comparatively gentler. Alternate phases of rise and fall were witnessed during this decade. There was first a marginal fall from 31.40 °C in 1985 to 31.33°C in 1986. It was followed by a period of rise to 31.89 °C in 1987 and 32.23 °C (the maximum value in the decade) in 1988. Then, there was again a modest fall to 32.07°C in 1989 and a steep fall to 30.88 °C (the minimum value in the decade) in 1990. Thereafter, again a period of rise to 31.82°C in 1991 (a steep rise of 0.94°C) and to 32.03°C in 1992 (a gentle rise of 0.21°C). Again, the mean maximum temperature dropped to 32.00°C (a marginal drop of only 0.03°C) in 1993 and to 31.37°C (a drop of 0.63°C) in the year 1994. Thus, the mean maximum temperature during this decade kept on fluctuating with alternate phases of rises and falls. No discernible overall trend of rise or fall in the value of mean maximum temperature was visible during this decade.

Variations in mean maximum temperature during the decade 1995-2004 are shown in Fig. 4. This decade also witnessed fluctuations in mean maximum temperature without any discernible overall trend of increase or decrease. The mean maximum temperature fluctuated between as low as 29.53°C in 2003 to 32.79°C in the year 2002. Thus, the range width was of the order of 3.26°C which was more than those witnessed in the previous three decades. The mean maximum temperature marginally rose from 31.73°C in the year 1995 to 31.85°C in the next year i.e. the year 1996.



This trend of rise in temperature proved to be transient and was reversed in the next year itself with mean maximum temperature plunging to 30.48°C in 1997 (descent of 1.37°C in a year). From 1997 onwards, it was again a rising trend up to the year 2002 but for a brief interlude of one year from the year 2000 to 2001 when the mean maximum temperature remained unchanged at the level of 31.98°C. The year 2003 witnessed unusually very low value of 29.53°C, which is the lowest value during the whole study period. In the year 2004, the mean maximum temperature again ascended to 31.44°C. Thus, this decade proved to be quite tumultuous, especially during its last leg from the year 2001 to 2004.

Variations in mean maximum temperature during the decade 2005-14 are presented in Fig. 5. This decade witnessed an

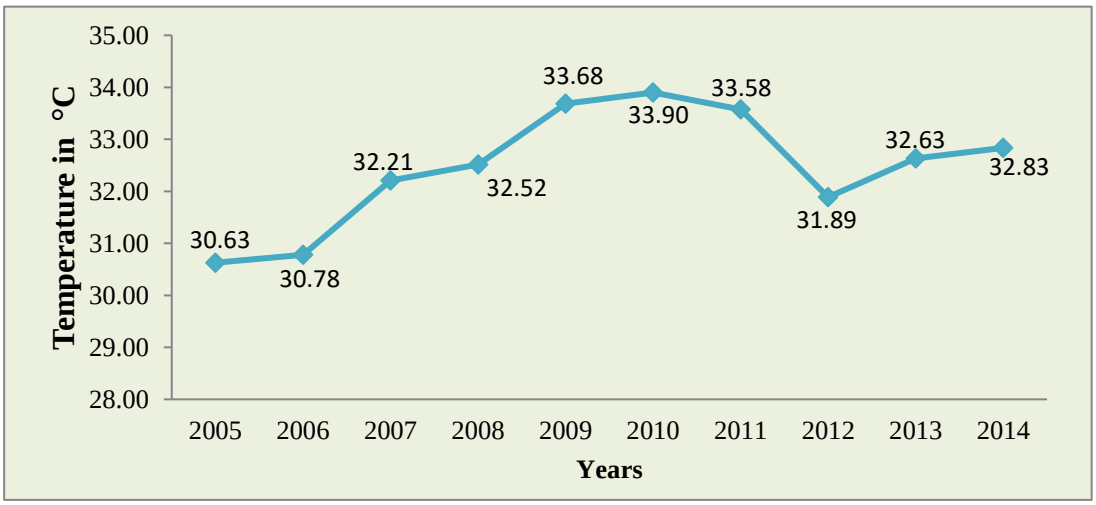


Fig. 5: Annual mean maximum temperature during the decade 2005-2014

overall rising trend except for a brief interlude of two years from 2010 to 2012 when the mean maximum temperature showed a temporary descent from 33.90°C in 2010 to 33.58°C in 2011 and 31.89°C in 2012. The minimum value of this parameter (30.63°C) during the decade was in the beginning itself in the year 2005. Then, it started rising to 30.78°C in 2006, 32.21°C in 2007, 32.52°C in 2008, 33.68°C in 2009 and reaching to the maximum value of 33.90°C in 2010.After a period of decline from the year 2010 to 2012, it again started rising from 31.89°C in 2012 to 32.63°C in 2013 and 32.83°C in the year 2014. The range width of variation in the decade was 3.27°C which is more than those in all the previous four decades.

After reviewing the five decades of mean maximum temperature, it was found that the changes and fluctuations are not shaped in systemic pattern, although the decline or rise in temperature was recorded in almost every year. If we take on record for the first year (1965) to the fiftieth year (2014), we find an increase of 0.98°C has been witnessed in these 50 years. However, in our study, we have also studied the SD and CV for the comparative study during these five decades. In the next paragraph the current scenario of mean maximum temperature for the years 2015 to 2017 has also been discussed.

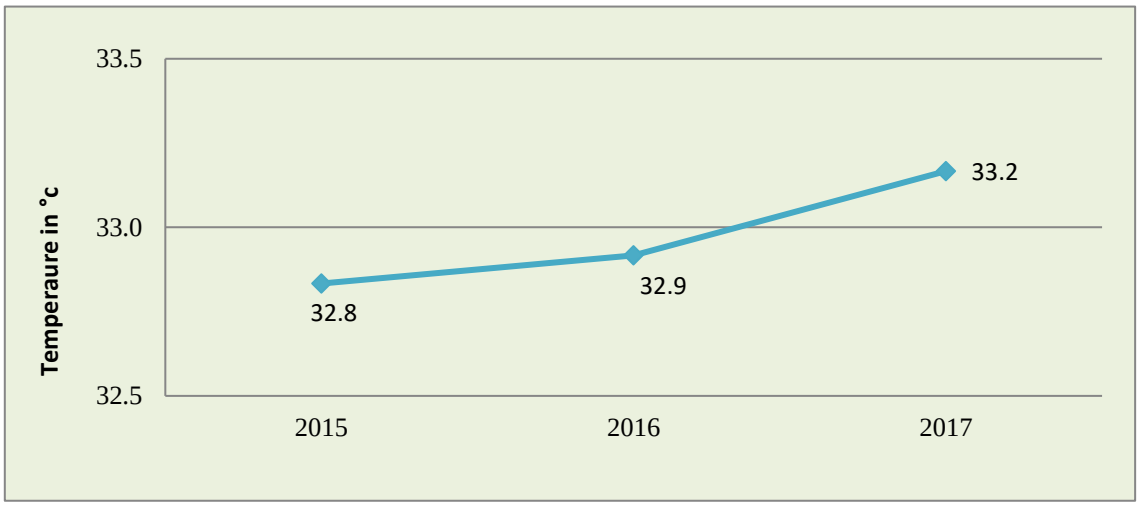


Fig. 6: Annual mean maximum temperature during the decade 2005-2014

Variations in annual mean maximum temperature during last three years of the study period i.e. from 2015 to 2017 are shown in Fig. 6. As can be seen from the graph, the rising trend started during the previous decade continued further in this period as well with annual mean maximum temperature rising to 32.8°C in 2015, 32.9°C in 2016 and reaching to the level of 33.2°C in 2017.

Standard deviation, co-efficient of variance of mean maximum temperature for five decades

Table 2: Decadal mean maximum temperatures along with SD and CV for five decades

Decades	Mean maximum temperature in °C	SD	CV
1965-1974	31.0	2.43	7.8
1975-1984	31.2	1.53	4.98
1985-1994	31.7	1.4	4.4
1995-2004	31.5	2.36	7.21
2005-2014	32.5	3	9.29

As can be seen from the Table 2 that mean maximum temperature has ranged between 31.0°C to 32.5°C. Standard deviation has been found the lowest (1.4) for the decade1985-1994 in which the mean maximum temperature rose by 0.5°C from its previous decade. Standard deviation was the highest (3) in the last decade of the study that is 2005-2014 in which the temperature was increased by a margin of exactly 1°C. This standard deviation was obtained on account of the variations in each month of every decade. The higher SD represents that the particular decade has witnessed a significant amount of fluctuations.

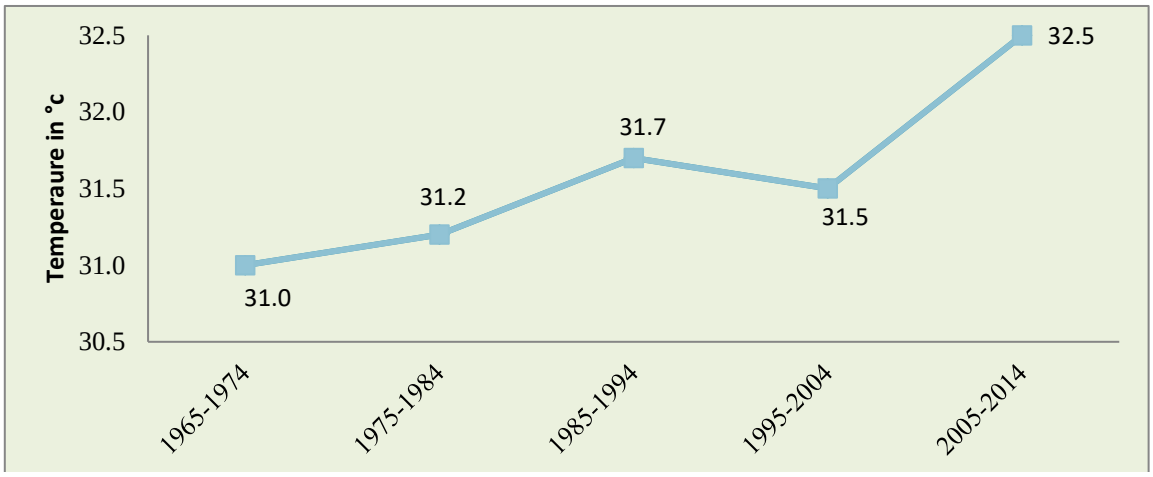
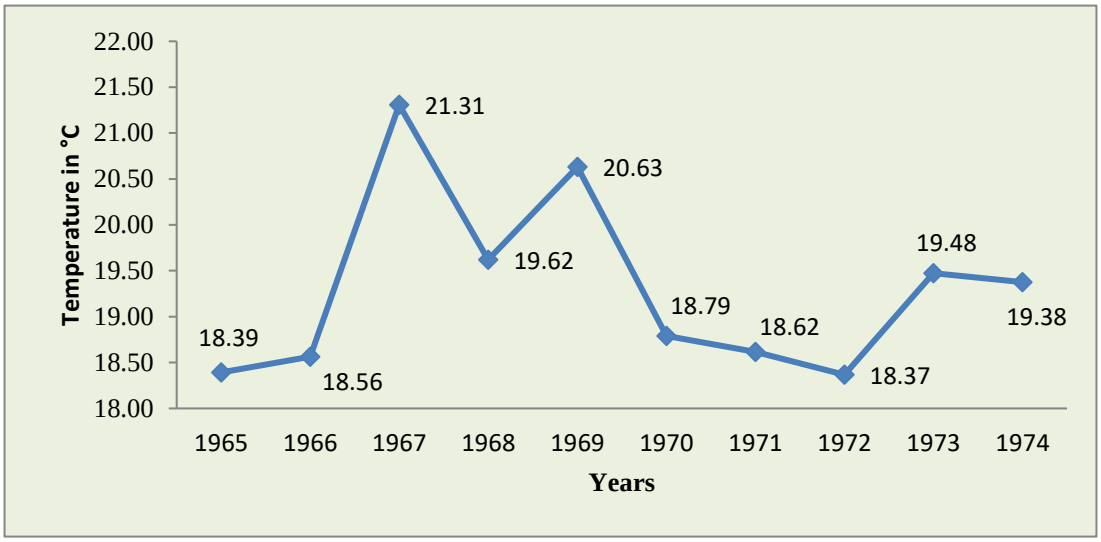


Fig. 7 Decadal mean maximum temperature in Damoh district during the five decades of study period

As can be seen in Fig 7, there is certainly a rising trend in the decadal mean maximum temperature from 31.0°C in the first decade (1965-74) to 32.5°C in the fifth decade (2005-14), except for a minor dip (31.5°C) in the fourth decade (1995-2004). The annual mean maximum temperature varied from a minimum of 29.53°C in the year 2003 to 33.90°C in the year 2010 with a range width of 4.37°C. The maximum temperature has been steadily rising since 2012 till now and it has risen by 1.3 °C in a period of 5 years with an average rate of 0.26 °C per year which is much higher than the global average rate of rise in temperature. This rising trend is likely to continue in near future as well. This is definitely an alarming situation which calls for concrete and effective mitigation and adaptation measures. These decadal mean values have been plotted in a graph and are shown in Fig. 7.

Mean Minimum Temperature: Mean annual minimum temperature i.e. the average of daily minimum temperatures in a year, is also an important climatic parameter from the view point of climate change as climate change is expected to have made impact on this parameter also. Although it has potential to be more critical factor in colder climatic regions, it can be of some significance in warmer climatic regions also during winter season as it may be a causative factor for the incidences of frost and fog which affect the regeneration of certain vulnerable species. In order to study the changing pattern of this parameter during the study, the same methodology as used in case of mean maximum temperature was adopted and applied. In the Fig. 8 to 12 variations in mean minimum temperature in each decade have been discussed and documented. As shown in Fig 8 it can be seen that during the decade 1965-74, the annual mean minimum temperature has varied between 18.37 °C and 21.31°C. Thus, the range width during this period was 2.94°C. Lot of

fluctuations in annual mean minimum temperature were witnessed during this period with alternate phases of rises and falls. It started with 18.39°C during the first year i.e. 1965 and marginally rose to 18.56°C in the next year i.e. 1966. The following year i.e. 1967 was the year of steep rise of 2.75°C and the annual mean minimum temperature reached the highest level of 21.31°C. Then, in 1968, it descended to 19.62°C with a significant decrease by 1.69°C. Again, it



increased to 20.63°C in the year 1969. The following three years witnessed successive fall in annual mean minimum temperature. There was a sharp fall of 1.84°C in 1970. It further marginally dropped to18.62°C in 1971 and 18.37°C in 1972. In 1973, it rose to 19.48°C and again marginally dropped to 19.38°C in 1974. Overall, a trend of slight increase in annual mean minimum temperature was noticed during the decade.

During the decade 1975-84, the annual mean minimum temperature varied between 18.69°C and 20.38°C. Thus, the range width during this period was 1.69°C, less than that in the previous decade. (Fig. 9)
Therefore, although this decade also witnessed fluctuations in the annual mean minimum temperature with alternate phases of rises and falls, the fluctuations were not as wide as had been during the decade 1965-74.

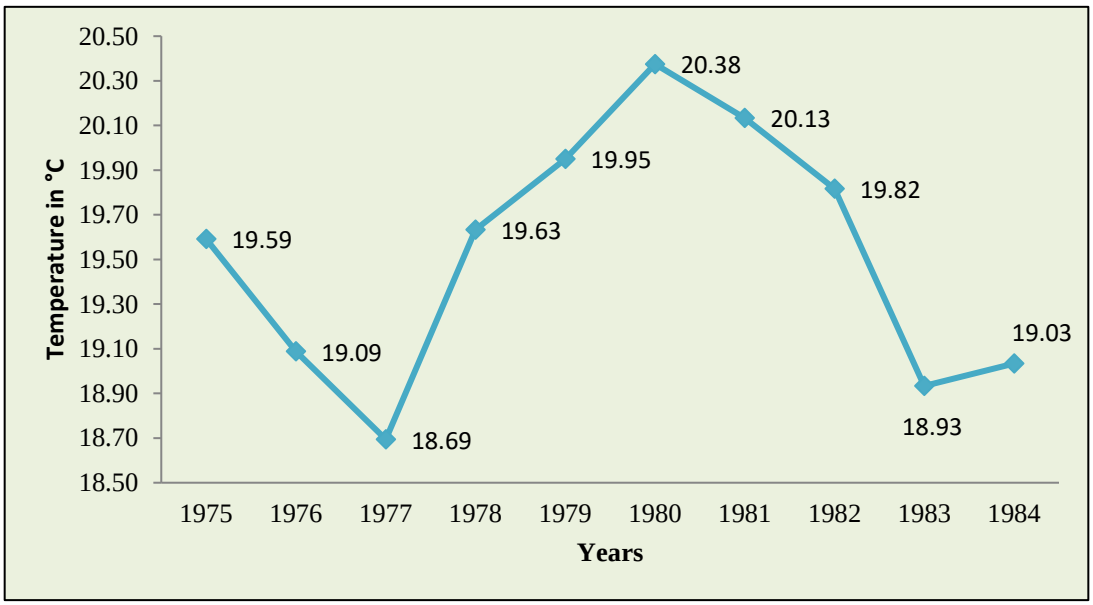


Fig.9: Annual mean minimum temperature during the decade 1975-84

The trend of fall witnessed during the last year (1974) of the previous decade reversed during the first year (1975) of this decade and it marginally rose to 19.59°C. However, this rising trend could last no longer and was replaced by a falling trend during the next two years and annual mean minimum temperature dropped to 19.09°C in 1976 and 18.69°C in 1977. This falling trend was reversed in 1978 and the rising trend continued till 1980. The values of annual mean minimum temperature rose to 19.63°C in 1978, 19.95°C in 1979 and reaching the highest value of 20.38°C in 1980. Then, the trend again reversed to falling trend which continued upto the year 1983 with the annual mean minimum

temperature dropping to 20.13°C in 1981, 19.82°C in 1982 and 18.93°C in 1983. In 1984, it marginally increased to 19.03°C. No conclusive trend of rise or fall in the annual mean minimum temperature was discernible during this decade.

During the decade, 1985-94, the annual mean minimum temperature varied between 18.39 °C in the year 1994 and 19.95 °C during the year 1991.Thus, the range width during this period was 1.56 °C which was less than even that witnessed during the preceding decade 1975-84. Thus, the amplitude of fluctuations in the annual mean minimum temperature

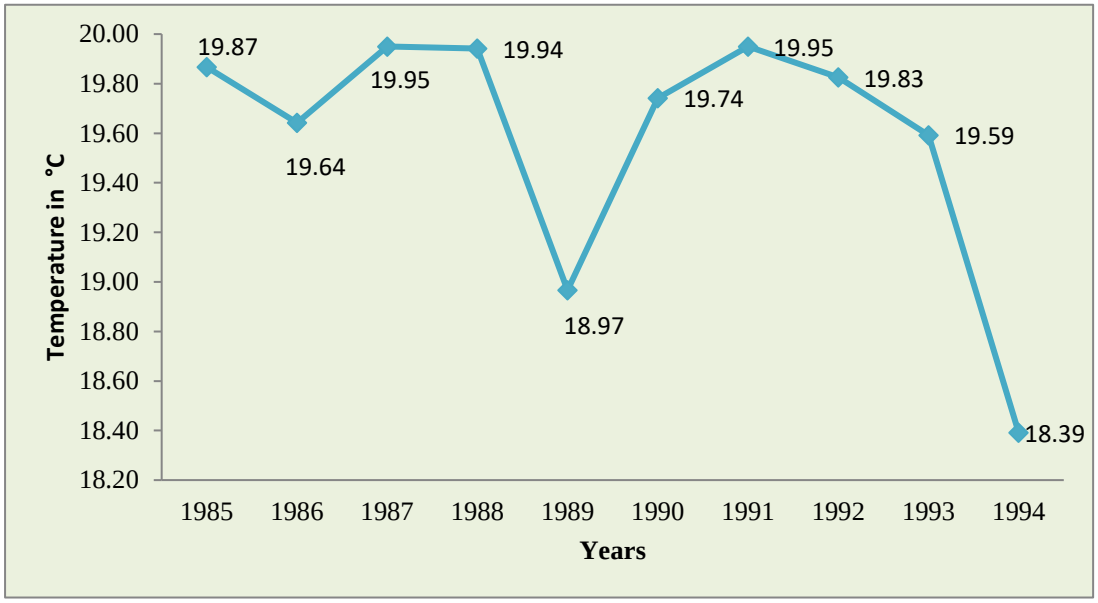


Fig.10: Annual mean minimum temperature during the decade 1985-94

was also much less. The pattern of fluctuation was typical in this decade. It comprised of one plateau during the period 1987-88 with almost the same mean minimum temperatures (19.95 °C in 1987 and 19.94 °C in 1988), one peak of equal height (19.95 °C in 1991), three troughs (19.64 °C in 1986, 18.97 °C in 1989 and 18.39 °C in 1994), two periods (1986-87 and 1989-91) of rising trend, two periods (1985-86 and 1991-1993) of gentle descent and two periods (1988-89 and 1993-94) of sharp descent. The annual mean minimum temperature hovered between 19.87 °C and 19.95 °C during the period 1985-1988. It plummeted to a very low level of 18.97 °C in 1989 rising again to 19.74°C in 1990. It hovered between 19.59°C and 19.95°C during the period 1990-93, finally dropping to the lowest level (18.39°C) at the end of the decade i.e. in the year 1994. Overall, the decade witnessed a falling trend in the annual mean minimum temperature.

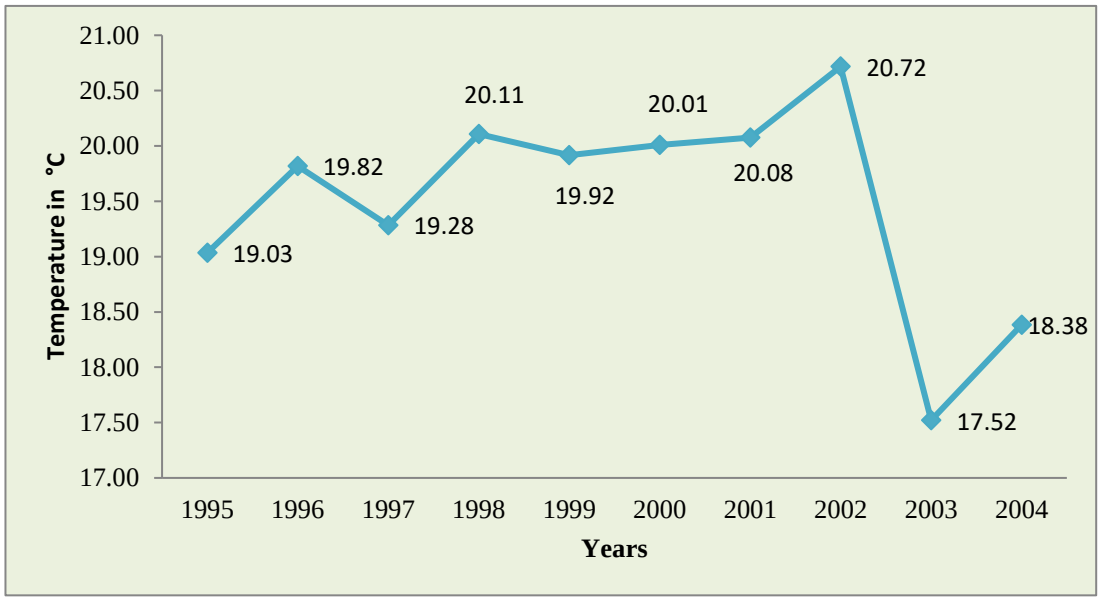


Fig.11: Annual mean minimum temperature during the decade 1995-04

During the decade 1995-2004, the annual mean minimum temperature varied between 17.52°C in the year 2003 and 20.72°C in 2002. Thus, the range width during this period was 3.2°C which was much more than that in any of the preceding three decades. The reason for this wide range width can be ascribed to unusually precipitous descent in the annual mean minimum temperature in the year 2003 when it suddenly dropped to 17.52°C from 20.72°C during the immediately preceding year 2002. Otherwise, the fluctuations during the initial 7 years (1995-2001) could be called quite moderate with annual mean minimum temperature hovering between 19.03°C and 20.11°C. The decade witnessed four phases of rise in the annual mean minimum temperature. These were 1995-96, 1997-98, 1999-2002 and 2003-04. The decade witnessed three phase of fall also and these were 1996-97, 1998-99 and 2002-03. Between 1995 and 1996, it rose from 19.03°C to 19.82°C. Then, it marginally fell down to 19.28°C in 1997. It rose to 20.11°C in 1998, dropping again in 1999 to 19.92°C. It was followed by a rising trend with annual mean minimum temperature reaching 20.01°C in the year 2000, 20.08°C in 2001 and finally reaching the maximum value of 20.72°C in the year 2002. After the precipitous descent in 2003, it again recovered to some extent in the year 2004 when the annual mean minimum temperature rose to 18.38°C from 17.52°C in the year 2003. Overall, a gentle falling trend in the mean minimum temperature can be noticed during this decade.

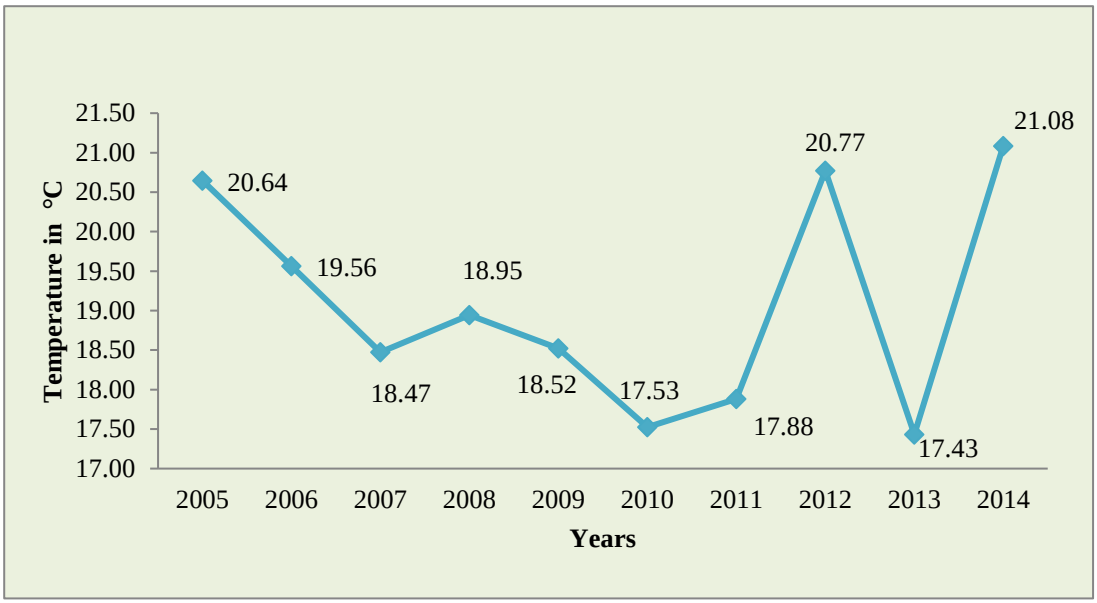


Fig.12: Annual mean minimum temperature during the decade 2005-14

During the decade 2005-2014, annual mean minimum temperature varied between 17.43°C in the year 2013 to 21.08°C in 2014. Thus, the range width during this decade was 3.65°C, maximum during the studied five decades. The reason for the high value can be ascribed to unusually violent fluctuations during the last four years of the decade from 2011 to 2014. A smooth descent in the annual mean minimum temperature was observed from 2005 to 2007 with the annual mean minimum temperature falling from 20.64°C in 2005 to 19.56°C in 2006 and 18.47°C in 2007. It was followed by a marginal rise of 0.48°C in the year 2008 when the annual mean minimum temperature rose to 18.95°C. Again, a falling trend was witnessed during the next two years with the annual mean minimum temperature descending to

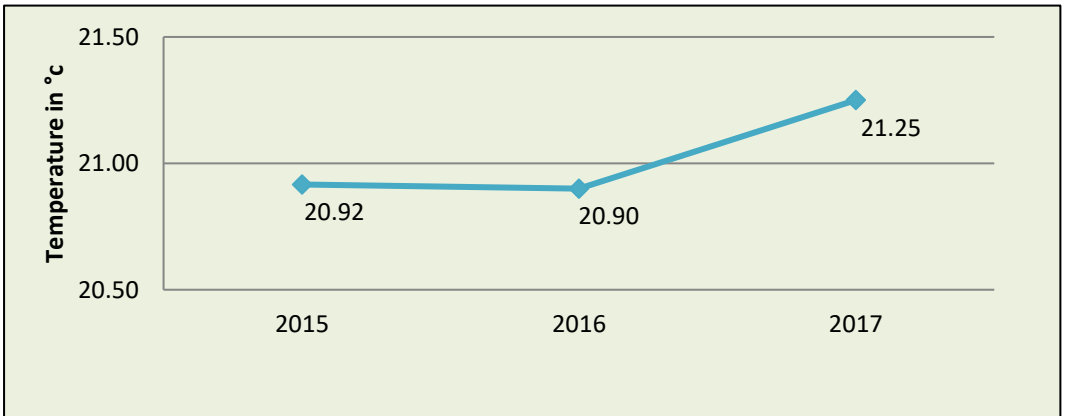


Fig. 13: Annual mean minimum temperature from the year 2015 to 2017

18.52°C in 2009 and 17.53°C in 2010. It again marginally ascended to 17.88°C in 2011. From 2011 onwards, rapid rises and falls were observed. In 2012, it shot up to 20.77°C, falling to the lowest value (17.43°C) in the very next year (2013). No definite trend of rise or fall in the annual mean minimum temperature was discernible during this decade.

Variations in annual mean minimum temperature during the last three years of the study period i.e. from 2015 to 2017 are shown in Fig. 13. As can be seen in the figure, the value of the annual mean minimum temperature which had reached the level of 21.08°C in the year 2014 dropped down to 20.92°C in the year 2015. It further marginally dropped to 20.90°C in 2016 and rose again to 21.25°C in the year 2017.

Standard deviation, co-efficient of variance of mean minimum temperature for five decades

Table- 3: Decadal mean minimum temperature along with SD and CV for five decades

Decades	Mean maximum temperature in °C	SD	CV
1965-1974	20.3	4.52	24.75
1975-1984	20.0	1.45	8.04
1985-1994	19.6	0.96	5.22
1995-2004	19.5	1.64	9.5
2005-2014	19.1	3.42	21.7

As can be seen from the Table 3, the mean minimum temperature has ranged between 19.1°C to 20.3°C. Standard deviation was found the lowest (0.96) for the decade1985-1994 in which the temperature fell by for 0.4°C from its previous decade. Standard deviation was the highest (4.52) in the first decade of the study that is 1965-1974 in which the annual temperature witnessed a lot of fluctuations. This standard deviation was obtained on account of variations in each month of every decade. These decadal mean values have been plotted graphically in Fig. 14.

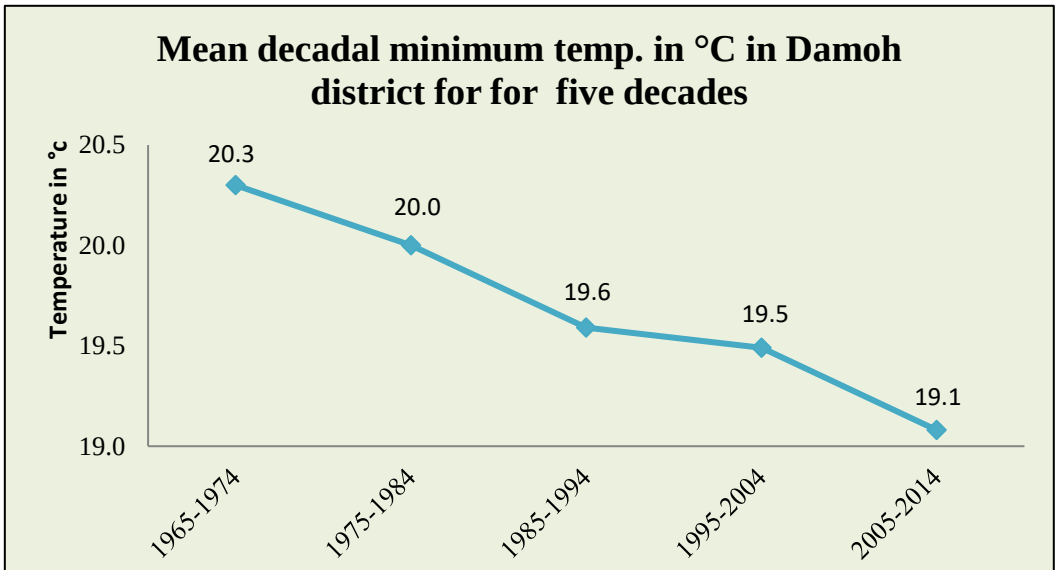


Fig. 14: Decadal mean minimum temperature in Damoh district during the five decades

The graph in Fig 14 clearly shows overall decreasing trends in decadal mean minimum temperature during the study period. The mean minimum temperature dropped by 1.2°C from 20.3°C in decade 1965-75 to 19.1°C in decade 2005-14, thus registering an average annual drop of 0.024°C.

IV. CONCLUSION

From the foregoing discussion, it is obvious that the annual mean maximum temperature in Damoh district kept on fluctuating up to the year 2003 with intermittent rises and falls. However, from 2003 onwards, it has been steadily rising except for a brief interlude of two years of shortfall from 2010 to 2012. From this scenario of fluctuating annual mean maximum temperature during the period from 1965 to 2003, it was difficult to conclude whether there was any discernible trend of rise in temperature. Therefore, in order to mask the effect of annual fluctuations for determining the trend, decadal averages of mean maximum temperature were worked out for the five decades and are shown alongwith their standard deviations (SD) and coefficients of variation (CV) in Table 2.

As in case of annual mean minimum temperature, decadal averages of mean minimum temperature were also calculated for the five decades to mask the effect of annual fluctuations for finding out the trend, if any, of rise or fall. These decadal averages, along with their standard deviations (SD) and coefficients of variance (CV) are shown in Table 3.
It is interesting to note that whereas mean maximum temperature has shown an increasing trend, the mean minimum temperature is showing decreasing trend. Thus, the difference in maximum and minimum temperatures is increasing with time. This difference in the decade 1965-74 was 10.7°C which has widened to 13.4°C in the decade 2005-14. Thus, the summers are getting warmer and winter are getting cooler, creating more extreme weather conditions for the inhabitant living beings in the study area. Similar observations were also made by the local people in perception study. This time series study on annual mean temperature can be very useful for the planning of water management in study area. This will help in providing the water in crunch situations to the farmers. The findings of the study provide more insights and inputs for the better understanding of regional temperature shifting behavior in the study area.

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