Study of Temperature Trends of Nanded, Maharashtra, India

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Abstract: In recent past uncommon behavior of climate specially temperature and rainfall attracted attention of not only climatologist but also all the citizens living in developing and developed country alike since climate change increase temperature of urban area as well as It increased extreme condition like heat wave, extreme rainfall etc. So taking this fact in consideration this paper attempt to study temperature trends of Nanded by analyzing data of annual maximum, minimum, mean temperature and by taking anomalies from 1969 to 2007. This analysis in linear trends reveals that maximum temperature, mean temperature, and minimum temperature of Nanded increased during this periods.

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1. Introduction

Climate change and global warming are recognized worldwide as the most crucial environmental dilemma that world experiencing today (working group 123 IPCC, 2007) (Anser khan et al., 2014). In recent past due to Climate change and global warming extreme events increased adversely affecting the economic activities like agriculture in developing countries. So most of the scientist, researcher, and climatologist focus their view on urban climate change. Since cities are the fundamental units for Climate change mitigation and adaptation. Some of the urban location is becoming increasingly vulnerable to natural hazard related to weather climate De and Dandekar, (2001).

The worlds 60% of population will be residing in cities by 2030 Bureau (2004), Amit Dorde et al., (2009). According to World Bank (2002) 80 % percent of future economic growth will occur in cities. So due to that urbanization land use and land pattern get changed. Urbanization transform natural landscape to artificial land scape and therefore alter radioactive, thermal roughness and moisture properties of the surface and the atmosphere above (Hung et al 2006). Urban areas have warmer air temperature relative to rural or suburban areas (Tayanc and Toros, (1997), Chung et al., 2004a and Trasilvova et al., 2008) heat islands is that cities tend to have lower albedos than the unbuilt (Oke, 1982). Compounding this albedo difference is the underlying morphology of cities (Golany, 1996). When solar radiation is reflected from a street surface some of it escapes the urban canopy, but some is intercepted and partially absorbed by exterior building walls. So, the effective albedo of a city can be significantly lower than that of the of any individual component surface (Sailor and Fan, 2002).

Several studies have attempted to assess the effect of urbanization and industrialization on temperature trends (Chung et al., 2004b, Gadgil and Dhorde 2005, Kumar et al., 2009, Dash and hunt 2007, Dhorde et al., 2009, Sajjad et al., 2009 and Tigga and Hema Malini, 2011). All over the world the urban areas are being affected by urban climate change. Increasing temperature of Dhaka (Alam and Golam Rabbani 2007), increasing of 2 ºC temperature of Sao Paolo since 1993, Edmilson et al., (2007). Increasing temperature tendency of Beijing temperature from 1977-2000 Liu et al., (2007) and Increasing annual mean temperature of Seoul during last 29 years Chung et al., (2004), increasing annual mean temperature of Beijing and Wuhan are the global example of urban climate change.

In India several studies conclude the same results like increase in annual mean temperature of Dehradun (Omvir Singh et al., 2013). Increase in annual maximum and mean temperature of Parbhani (Karnewar et al., 2015), increase in temperature of Buldhana (Deshmukh et al., 2013), Rupa Kumar and Hingane, (1988) investigated long term variation of seasonal and annual surface air temperature at six industrial and non-industrial cities each and concluded that the non-industrial station did not show significant trends and their either cooling tendency or cessation of warming after late 1950s at most of the industrial cities.

In this study population of the city has been used as an index of urbanization. Several other parameter such as land cover, land use change, automobile

registration, and energy consumption and construction activities can be used as indices to indicate the degree of urbanization (Dorde et al., 2009). The increasing growth rate of Motor vehicle population observed on road in Nanded as on 31st march 1980-2000.

Table 1. Increasing growth rate of Motor vehicle observed on road in Nanded as on 31st march 1980-2000

years	1980	1985	1990	1995	1996	1997	1998	1999	2000
No of vehicles	5353	10908	23549	36084	40970	44939	52116	57803	63803

Source RTO office Nanded.

The population of Nanded at 1971 was 126,518 and it is 550,564 and observed increase is near about 430%. The increasing growth rate of population as decadal manner in Nanded district as for last six decades shown below in the following table.

Table 2. Farmers' distribution by reasons for sustaining the adoption of maize – cassava intercrop technology

Year	Population (census)	Decadal growth	CAGR	CAGR from 1971
1971	126,518	--	----	----
1981	191269	51	4.22	4.22
1991	309,316	62	4.92	4.92
2001	430,733	39	3.37	4.17
2011	550,564			

Taking all this fact in consideration it would be interesting to study long term variation of surface air temperature at Nanded which is more urbanized city in Marathwada region of Maharashtra.

2. Data and methodology

2.1 Study area

Nanded is the second largest city in Marathwada division of Maharashtra situated on the bank of Godawari, having elevation 362m above sea level. , is the headquarters of Nanded District in the Marathwada. Nanded district is part of Marathwada Region in Maharashtra. Nanded district has a geographical area of 10,528 Sq. Km., which forms 3.41% of the total geographical area of Maharashtra State. The district is situated in the Deccan Plateau. The district of Nanded has between 18°.15' and 19°.55' North latitude and 77°.7' to 78°.15' east longitudes Yannawar et al., (2013).

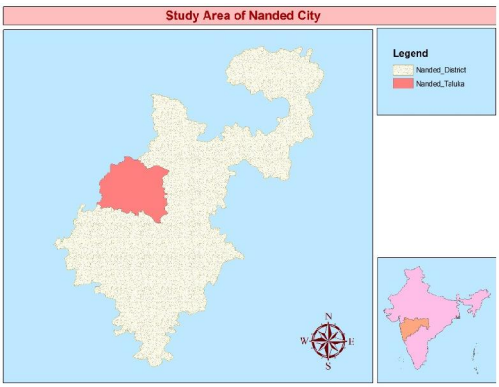

Figure: 1 showing study areas map of Nanded District

The daily temperature date recorded by IMD Pune for period 1969-2007 was collected. From daily time series data annual maximum and minimum and mean temperatures were derived to find out the possible changes in temperature. To determine a yearly variation in temperature series and to identify the warmest and coldest phases of 5 year moving average technique was adopted (Omvir et al., 2013). The linear regression method was used to analyze the behavior of annual maximum and minimum and mean temperatures for 39 years (1969-2007).

Additionally, for better understanding of the observed trends in temperature, anomalies of annual maximum and minimum and mean temperatures were also calculated. Anomalies are more accurate than absolute temperature to describe climatic variability. To analyze anomalies in maximum, minimum, mean temperature, the average annual maximum and minimum and mean temperatures were calculated for entire periods (1969-2007) and it was subtracted from yearly average maximum, minimum and mean temperatures Folland et al., (1990) and World meteorological organization (Lal, 2002) suggested 30 year period as standard period for calculating the average used to analyze anomalies and comparison were made with the result obtained using average from whole dataset. The temperature anomalies obtained were plotted against the linear trends observed were represented graphically. The linear trends value represented by the slope of simple least square regression line with time as the independent variable show the magnitude of rise or fall.

Result and discussion

4.1 Trends and anomalies in annual maximum temperature

The annual maximum temperature trends with 5 year moving average have been presented in figure 4.1 (a). The long term annual maximum temperature at Nanded found to be 34 °C during the study period. Four periods of warming and two periods of cooling during 1969-2007 figure 4.1 (a). Remarkable cooling period was during 1971-1975 figure 4.1 (a). The warmest year was 1971 with annual maximum temperature 35.8° C which was 1.8°C warmer than normal. The coolest years were 1975 with annual maximum temperature 32.7°C when drop was 1.3°C below normal. The linear trends in annual maximum temperature from 1969-2007 indicated the increasing trends. Observed increase was found 0.61° C. The increasing trends observed in annual maximum temperature is good agreement with finding of other urban studies on climate change (Bhutiani et al., 2007, 2010 and Omvir, 2013**)**

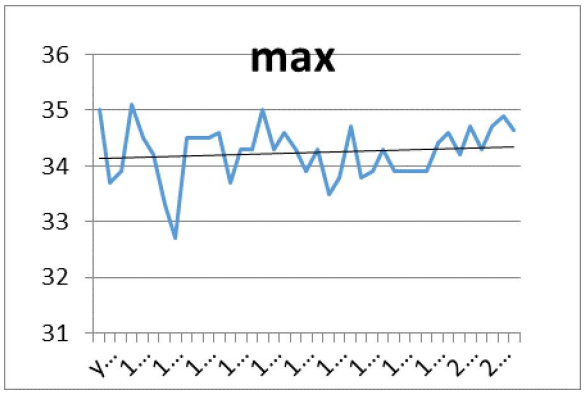

Fig 4.1 (a): Detected maximum temperature

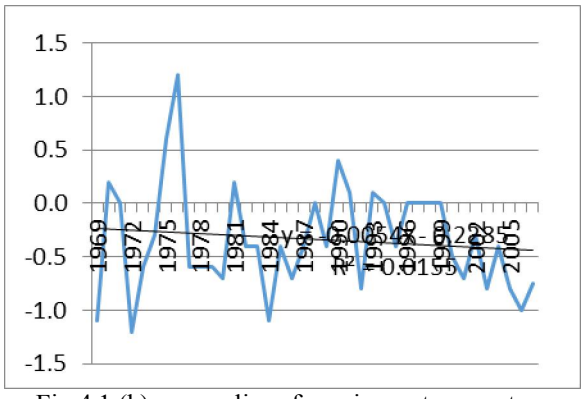

Fig 4.1 (b): anomalies of maximum temperature

4.2 Trends and anomalies in annual minimum temperature

The anomalies of temperature series data for annual maximum temperature have been presented in in figure 4.1(b). Positive anomalies of about 1. 2° C in annual maximum temperature was observed in 1976 and negative anomalies of about -1.2°C was observed in 1972.

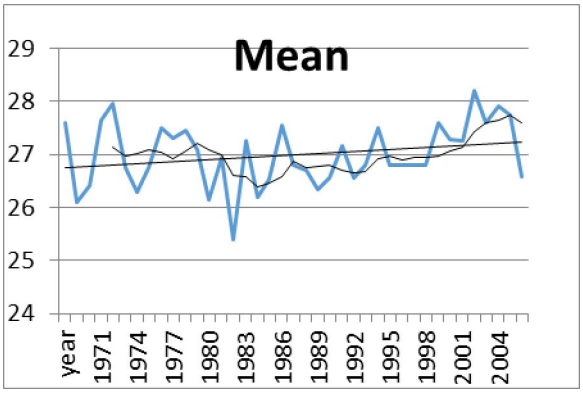

Fig 4.1 (c): Detected mean temperature

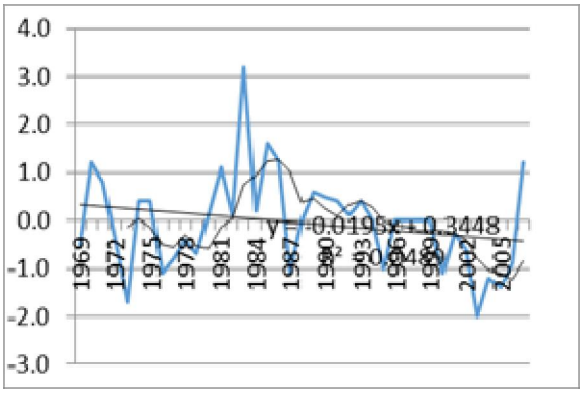

Fig 4.1 (d): Observed anomalies minimum temperature

The annual minimum temperature trends with 5 year moving average have been presented in figure 2 (b). The long term annual minimum temperature at Nanded found to be 20° C during the study period. Remarkable warming period was during 1976-1983 figure 4.2 (b). The warmest year was 2003 with annual minimum temperature 21.7 ºC which was 1.7°C warmer than normal. The coolest year was 1983 with annual minimum temperature 16.5 ºC when drop was 3.5°C below normal. The linear trends in annual minimum temperature from 1969-2007 indicated the increased trends. Observed increased was found –C the anomalies of temperature series data for annual maximum temperature have been presented in figure 4.2 (c) positive anomalies of about 3.2°C in annual maximum temperature was observed in 1983 negative anomalies of about -2.0º C was observed in 2003 of about -2 ºC. It was also observed from figure 4.2 (b) that positive anomalies are more seen. This is due to more urbanization since the population of Nanded increased.

4.3 Trends and anomalies in annual mean temperature

Both annual maximum and minimum temperature affect the annual mean temperature. The annual mean temperature trends with 5 year moving average have been presented in figure 4.3 (a). The long term annual mean temperature at Nanded found to be 27°C during the study period. Four periods of warming and three periods of cooling during 1969-2007 figure 4.1(a). Remarkable cooling period was during 1969-1972 figure 4.1(a). The warmest year with annual mean temperature was 2002 with annual mean temperature 28.2°C which was 1.2°C warmer than normal. The coolest year was 1982 with annual mean temperature 25.4°C when drop was 1.6° C below normal. The linear trends in annual mean temperature from 1969-2007 indicated the increasing trends. The increasing trends observed in annual mean temperature is good agreement with finding of other urban studies on climate change

The anomalies of mean temperature series data for annual maximum temperature have been presented in in figure 4. 3 (b). Positive anomalies of about 1.2°C in annual mean temperature was observed in 1982. It was also observed from figure 4.3 (b) that negative anomalies of about -1.6°C was observed in 2002.

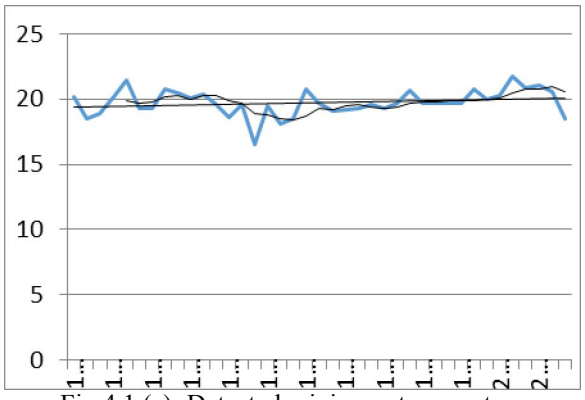

Fig 4.1 (e): Detected minimum temperature

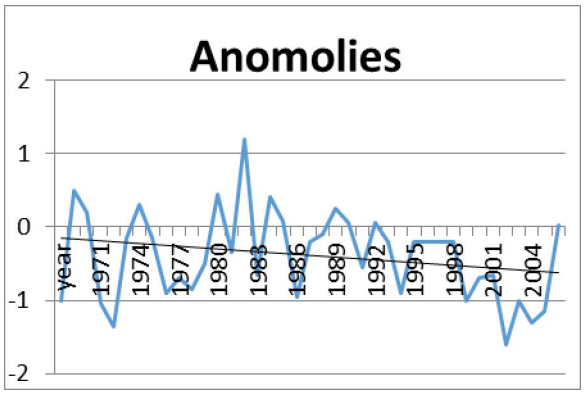

Fig 4.1 (f): Examined anomalies of mean temp

From the above result it is clear that the annual maximum and mean temperature shows increasing trends which are in good agreement with other findings Kothawale et al., (2002); Deshmukh et al., (2013) and Karnewar et al., (2015).

4. Conclusion

The present study analyzed the temperature data for 38 years from 1969 to 2007 at Nanded station for determination of temperature trends. From the above result it is clear that the annual maximum, annual minimum and annual mean temperature shows increasing trends which are in good agreement with other findings. In the linear trends the long term annual maximum temperature at Nanded found to be 34 °C during the study period. Four periods of warming and two periods of cooling were found .the long term annual minimum temperature at Nanded found to be 20° C during the study period. The long term annual mean temperature at Nanded found to be 27°C during the study period. Linear trends of mean temperature of Nanded shows increasing trends. The long term annual minimum temperature at Nanded found to be 20° C during the study period.

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