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Urban Climate Trends – The Indian Scenario

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ABSTRACT

The growth of population in India during the past few decades has been stupendous. Some of the biggest megalopolis of the world are located in India with population in excess of 10 million.

The study focuses on the trends in the climatic parameters in major cities of India, which have population in excesses of 1 million (10 lakhs). The "Urban heat island" is well known. Apart from this long term trends in rainfall, temperature and aerosols have also been noted (Pillai 1999).

Total suspended particles (TSP) in major Indian cities vary from 200 - 500 mg/m^3 and these are generally basic (soil origin) in nature. However, the major urban airports are faced with increased load of aerosols as reflected in the long-term deterioration of visibility especially during winter months (De & Dandekar 2001). Studies in the long-term trends of rainfall in several cities such as New Delhi, Kolkata, Mumbai and Chennai show significant increasing trends in annual and monsoon rains. These may be due to changes in the meso scale circulations near the cities as reported in studies done else where such as project Metro Max in USA. Changes in frequencies of occurrence of warmer days (Maximum temperature above certain threshold) and colder days (Minimum temperature below certain threshold) have also typical signatures of urbanization (Rao, Jaswal & De 2000).

With a shift in demography towards urban areas deterioration of air quality, formation of 'heat islands' and poorly constructed dwelling units make over urban centers prone to weather hazards (De & Dandekar 2001). We have an urgent need to plan our urban growth to overcome these problems.

INTRODUCTION

The climate system has a natural variability in different time scales. In recent years the climate change and variability due to anthropogenic causes have received considerable attention IPCC (2001).

The climate change and global warming as a result of increase in the concentration of green house gases and aerosol load in the atmosphere has been studied and documented. Industrialization, increasing use of fossil fuels, urbanization, deforestation and changes in land use patterns are some of anthropogenic activities related to development, which impinge on the climate system. The study examines the climate trends in urban areas of India and tries to establish a link between urbanization and such changes. Some of the urban locations in India are becoming increasingly vulnerable to natural hazards related to extreme events in weather and climate related to global warming including floods and water logging (De & Dandekar 2001).

DATA USED

The annual and season rainfall data for 14 major cities (1901-2000) which have a population in excess of 1 million (10 lakhs) have been used. The cities under study are Hyderabad, Patna, Ahmedabad, Surat, Bangalore, Mumbai, Nagpur, Pune, Jaipur, Chennai, New Delhi, Kanpur, Lucknow and Kolkata. The data set is divided into two subsets 1901-1950 and 1951-2000. The climatic trends of these sub sets have been studied separately. Monsoon being the main rainy season in India, the analysis is restricted to Monsoon season (JJAS) and annual rainfall only. Analysis for the full period 1901-2000 has also been done in the same way.

METHODOLOGY AND DISCUSSION

The long term trend in these two sub sets as well as the original set 1901-2000 has been computed following the techniques suggested in WMO (1969) for analysis of climatic variability and trends.

It is usually found that such a technique can be used for a single station or a group of stations or spatially averaged data. Since the present study aims at examining the "urban impact" on climatic elements the study has used the data of observatories located at the 14 major cities, which have population in excess of 1 million now. However, all these cities at the start of the data period 1901 may not (did not except one) have been so populous. Thus over the data period their population has grown from a low threshold level to that exceeding the threshold.

Recent studies IPCC TAR (2001) have reported increase in surface ozone and surface load of aerosols from major urban locations. A recent study by Shende & Gaikwad (2003) has revealed that impact of urbanization is also seen in the chemical composition of aerosols and the precipitation of rainwater in India. A study by Mohapatra (2002) about the climatic trends in different meteorological parameters in Bangalore supports the findings of Rupa Kumar, Krishna Kumr & Pant (1994) about trends in maximum and minimum temperatures in some urban locations. Studies on extreme temperature events in India (Rao, Jaswal & De 2000) have shown the effect of urbanization at some important locations.

The analysis of rainfall for the monsoon season and the annual is presented in the paper with a view to determine how urbanization affects the rainfall. Table 1 gives the trends (either positive or negative) for the stations where it is significant at either 99% or 95% level. The results indicate a general significant increasing trend in the monsoon rainfall (Jun-Sep) at Patna, Bangalore, Pune and Kolkata for the period 1951-2000 which indicates the rapid growth of these cities (Fig.1). For the complete period (1901-2000) Surat, Bangalore, Mumbai, Pune, Chennai, New Delhi and Kolkata show an increasing trend while Nagpur shows a decreasing trend being the only station in set of 14 stations. Another interesting aspect of the climatic trend is that all the eight stations having significant trends in the monsoon rainfall do not have any significant trend for the period 1901-50.

Interestingly Mumbai and Nagpur show significant trends in the annual rainfall during 1901-50. The trend in the annual rainfall is seen in five out of eight stations for period 1901-2000. Only three stations show significant trend for the period 1951-2000.

The increasing trend in the Monsoon season rainfall is most rapid over Kolkata for the period 1951-2000, increasing at the rate of 83 mm/10 years. This is also reflected in the annual rainfall where the rate of increase is 124-mm/10 year. During the period 1901-2000 rapid increasing trends are seen over

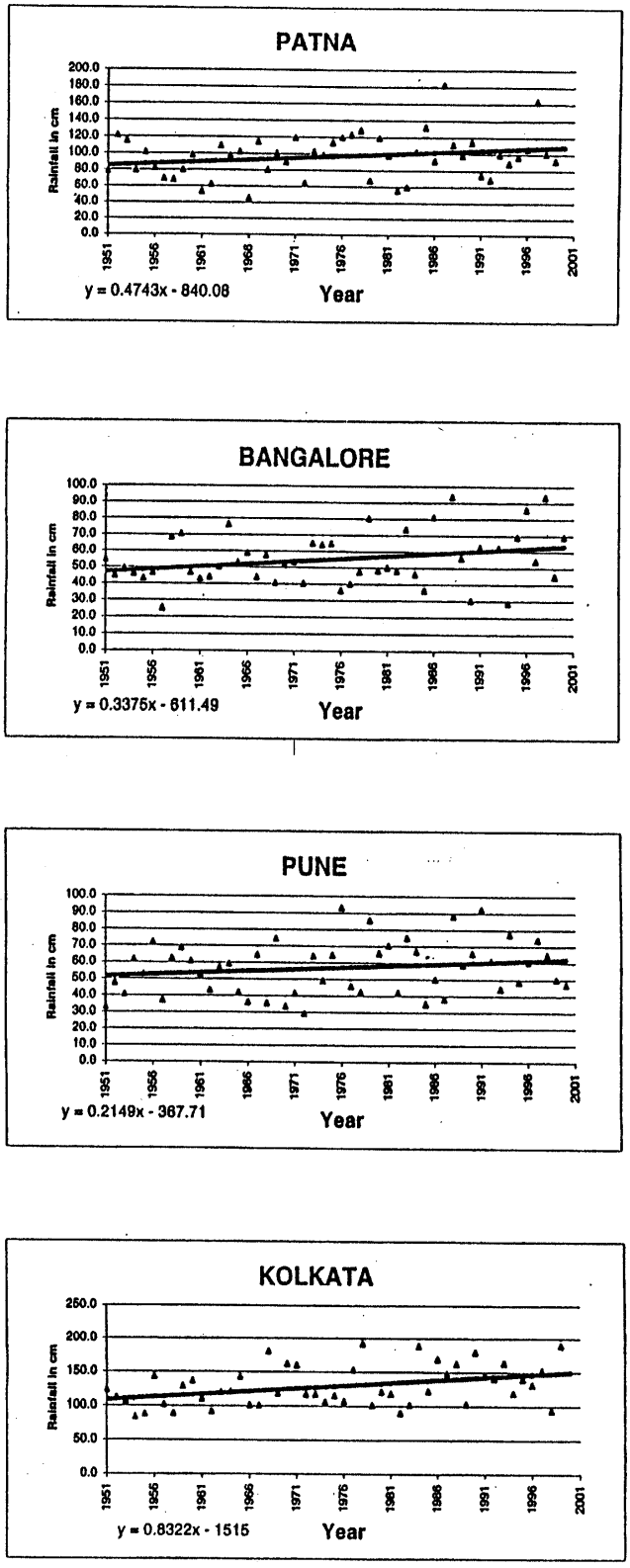

Figure 1. Trends in monsoon rainfall series (1951-2000)

Table 1. Significant Rainfall trends for Annual and Monsoon season

Sr.No.	Station	Annual Rainfall – Significant Trends		
		1901-2000	1901-1950	1951-2000
1.	Patna			+ *
2.	Surat	+ *		
3.	Bangalore	+ **		
4.	Mumbai (Colaba)	+ **	+ *	
5.	Nagpur		+ *	
6.	Chennai (Nungambakkam)			+ *
7.	New Delhi (Safdarjung)	+ *		
8.	**Kolkata (Alipur)**	**+ ***		**+ ****

Sr.No.	Station	Monsoon season Rainfall – Significant Trends		
		1901-2000	1901-1950	1951-2000
1.	Patna			+ *
2.	Surat	+ *		
3.	Bangalore	+ *		+ *
4.	Mumbai (Colaba)	+ **		
5.	Nagpur	- *		
6.	**Pune**	**+ ****		**+ ***
7.	Chennai (Nungambakkam)	+ **		
8.	New Delhi (Safdarjung)	+ *		
9.	**Kolkata (Alipur)**	**+ ***		**+ ****

* Significant at 95% level of confidence
** Significant at 99% level of confidence

Mumbai, Pune and Chennai. Of particular interest is that New Delhi (Safdarjung) does not show significant trend during sub period 1901-50 and 1951-2000 but has a significant increasing trend (at 95% level) in full data period (Table 2). De et al. (2001) have noted increase in the atmospheric aerosol over many cities in India leaving to poor atmospheric visibility (Fig 2). Rapid development of industries, increase in automobiles and increase in anthropogenic aerosols in the urban areas from other sources of pollution may provide the necessary increase of cloud condensation nuclei. This could facilitate formation and growth of rain bearing clouds causing enhanced precipitation. In the coming decades a greater concentration of population in these major cities are bound to make them more vulnerable to the weather hazards associated with increased rainfall such as flooding and water logging.

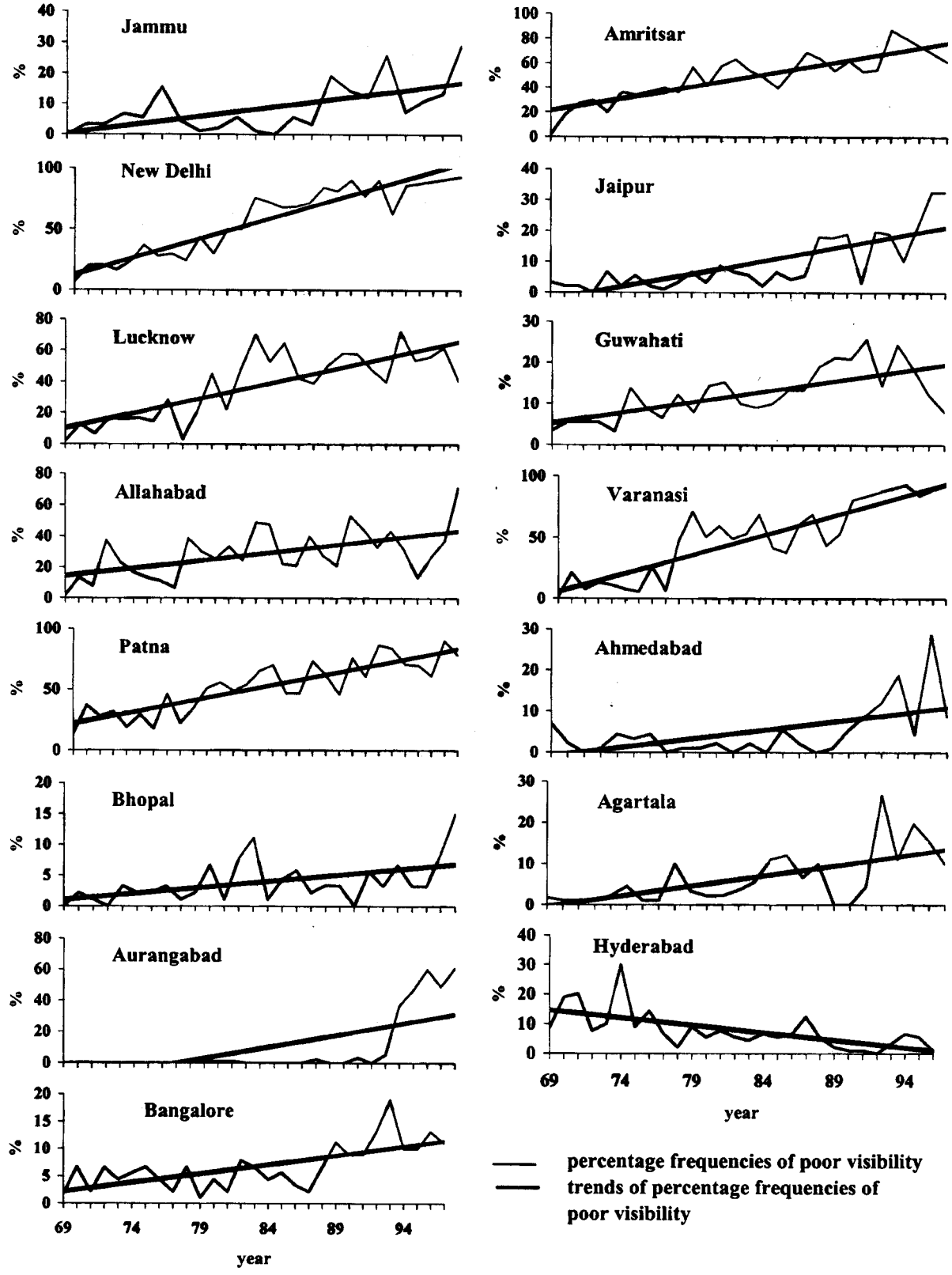

Figure 2. Percentage frequencies of number of days with horizontal visibility <2000 m at 03 UTC during winter season with significant trends at 99% level.

Table 2. Trend values for monsoon season and annual rainfall

Sr. No	Station	Monsoon season			Annual		
		1901-2000	1901-1950	1951-2000	1901-2000	1901-1950	1951-2000
1.	Hyderabad	0.04	-0.10	-0.09	0.05	-0.16	0.02
2.	Patna	-0.04	-0.21	0.47 *	0.00	-0.12	0.51 *
3.	Ahmedabad	-0.01	0.27	-0.12	0.03	0.28	-0.03
4.	Surat	0.28 *	0.53	-0.18	0.28 *	0.62	-0.20
5.	Bangalore	0.13 *	-0.08	0.34 *	0.16 **	0.00	0.26
6.	Mumbai	0.58 **	0.72	-0.40	0.60 **	0.83 *	-0.37
7.	Nagpur	-0.23 *	0.14	-0.27	-0.19	0.25 *	-0.05
8.	Pune	0.13 **	0.01	0.28 *	0.14	0.03	0.20
9.	Jaipur	0.09	0.28	-0.08	0.10	0.30	-0.09
10.	Chennai	0.12 **	-0.17	0.10	0.11	-0.53	0.52 *
11.	New Delhi	0.17 *	0.25	0.08	0.21 *	0.18	0.05
12.	Kanpur	-0.20	-0.07	-0.41	-0.17	-0.03	-0.61
13.	Lucknow	-0.04	0.04	-0.10	0.03	0.01	0.03
14.	Kolkata	0.21 *	-0.05	0.83 **	0.28 *	0.03	1.24 **

CONCLUSIONS

1.The annual and monsoon rainfall over fourteen urban locations in India shows significant trends at some locations (9) only.

2.Most of the nine stations showing increasing significant trends do so in the period 1951-2000 when rapid industrial development took place over these urban locations.

3.During 1901-50 only two stations Nagpur and Mumbai show increasing trend in annual rainfall only.

4.Changes in the nature and concentration of cloud condensation nuclei could be, perhaps, the cause for the increasing trends in precipitation noted in some cities. More analysis of data in the neighbouring stations, which are not urbanized, is needed to quantify the physical process.

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