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TEMPERATURE AND RAINFALL VARIABILITY: A CASE STUDY OF GANGA BASIN

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ABSTRACT:

The present paper attempts to analyze the climate variability in different physiographic regions of Ganga Basin between 1909 and 2002. Temperature and precipitation are the most crucial weather components and can be examined in order to assess climatic variability. The results obtained using elementary statistics exhibit an increasing trend of temperature. Rainfall, however, has shown quite variable pattern throughout the region. It has remained persistent in mountainous area, declined in plain region while increased in coastal area. This changing nature of climate can adversely affect the people and economy of the region which is predominantly agrarian.

KEYWORDS: *Ganga Basin, Climate, Rainfall, Temperature.*

INTRODUCTION

Climate is a dynamic phenomenon and has remained changing throughout the geological history. However, the magnitude of climate change has appeared to increase manifold.During pre- industrial period climate was governed by natural phenomena, as variation in solar irradiance etc. where man had very limited role to play. The modern climate, on the other hand, is thought to be a result of both natural as well as anthropogenic factors where the later has gained even more influence. Their relative role,however, is still unknown and to some extent debatable (de Jager and Usoskin, 2006;Rampelotto et al., 2012). The exceptionally cold conditions during sixteenth and seventeenth centuries, termed as Little Ice Age, are often linked with decrease in solar activities. After which the global temperature is continuously rising. There have been two distinct periods of warming. The first period of warming existed from 1925 to 1945 when the global temperature increased by 0.37oC and second warming phase remains from 1975 to 1997 when the temperature raised to 0.32oC (Jones et al., 1999). It has been argued that during colder months the warming is more prominent as compared to the summer months similarly the warming is more for minimum temperature as compared to maximum temperature (Jones et al., 1999;Xiaodong, 2006). With this the future projection of climate change by IPCC, using various models predicts an increase of about 5 to 10 per cent in summer monsoon rainfall over India (Subhash et al., 2011). There have also emerged regional patterns of climatic variability because latitudinal position, nearness to ocean and to some extent the regional physiography also has a bearing on local climate (Dobrowski et al., 2009). The magnitude and frequency of extremes has also increased with spatial variation (Kiran, Krishnamurthy and Lall, 2009). According to WWF- India report (2011), a majority of the districts falling in the Ganga basin have shown an increase in temperature. This rise is more in Western Uttar Pradesh as compared to Eastern part. However, there has not been marked variation in precipitation pattern, with short term

fluctuations.

For a country like India whose considerable share of GDP still comes from agriculture sector, even a slight change in weather parameters can bring havoc as agriculture is still dependent, in most of the regions, on the mercy of rain god. With this the rich biodiversity of India can also be badly affected. Thus, analysis of climatic variability becomes very significant in Indian context in order to examine and prevent the consequences of climate change in the region. However, there has appeared a lack of comprehensive study covering the entire basin. The unavailability of required data as well as missing data is another problem affecting broad analysis.

AREA OF STUDY

The river Ganga has a great importance not only in religious perspective but also in economy of the country including its environmental significance. Originating from Gangotri in the Himalayas, Ganga drains to Bay of Bengal forming in its way an extensive alluvial deposit of about 2500 km. making it one of the most fertile regions of the world. Ganga flows through the states of Uttarakhand, Uttar Pradesh, Bihar, Jharkhand and West Bengal, traversing through temperate, tropical and sub- tropical climatic divisions of India. Its numerous tributaries drain in other various states of North and Central India and thus make Ganga basin the largest river basin of the country.

DATA AND METHODOLOGY

Temperature and Precipitation data has been obtained from India Meteorological Department (IMD) for the year 1901- 2002. The data has been collected for following 10 stations located in the Ganga basin -Uttarkashi, TehriGarhwal, Kannauj, Kanpur, Fatehpur, Varanasi, Patna, Bhagalpur, Hugli and South 24 Parganas, representing various topographic and climatic divisions of the region. Table 1.1 shows stations selected for the study and data availability period-

Table 1. Stations Selected for the Study

S.No.	STATION	GEOGRAPHIC LOCATION	DATA SPAN
1.	Uttarkashi	$30^0 72' N, 78^0 43' E$	1901-2002
2.	Tehri-Garhwal	$30^0 30' N, 78^0 56' E$	1901-2002
3.	Kannauj	$27^0 05' N, 79^0 91' E$	1901-2002
4.	Kanpur	$26^0 44' N, 80^0 33' E$	1901-2002
5.	Fatehpur	$25^0 85' N, 80^0 89' E$	1901-2002
6.	Varanasi	$25^0 31' N, 82^0 97' E$	1901-2002
7.	Patna	$25^0 59' N, 85^0 13' E$	1901-2002
8.	Bhagalpur	$25^0 34' N, 86^0 98' E$	1901-2002
9.	Hugli	$22^0 89' N, 88^0 24' E$	1901-2002
10.	South 24 Parganas	$22^0 13' N, 88^0 40' E$	1901-2002

The study is based on simple statistical approaches. Firstly the missing data of temperature and rainfall has been replaced by normal of the respective station. To show variability in temperature the averages for maximum and minimum temperatures have been calculated for summer and winter months separately. Along with this to analyze rainfall variability, average rainfall for monsoon and non-monsoon months have been calculated (Table 1.2). Along with this, to examinethe significance of trend r2has been used.

Table 2. Classification of Season

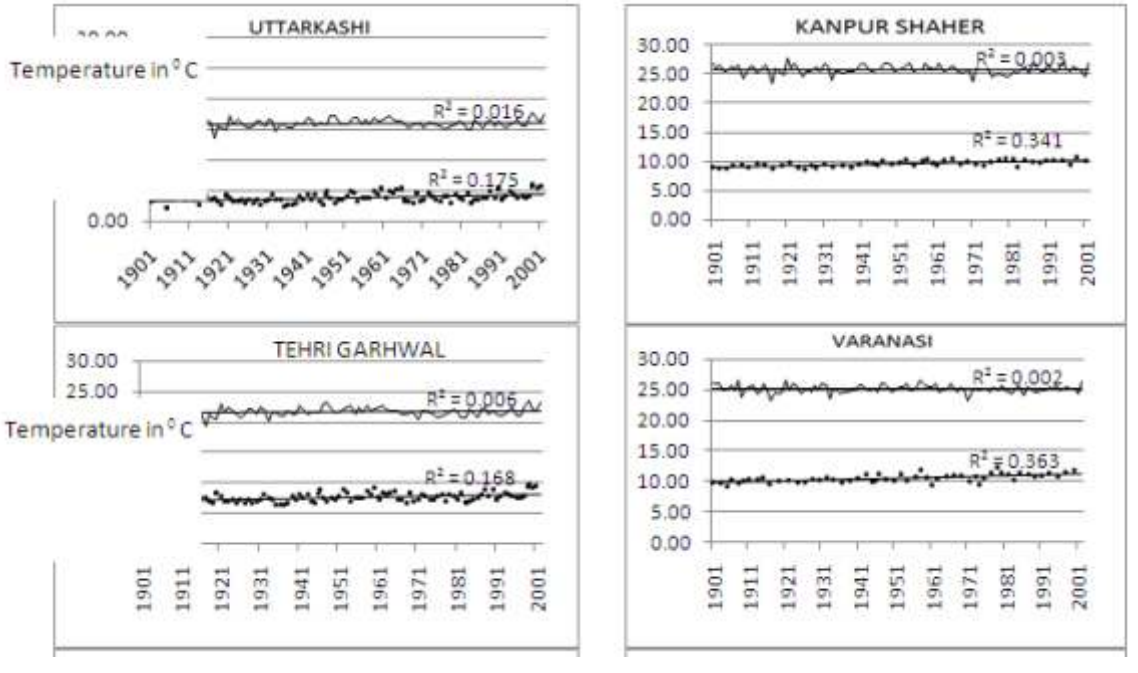
Temperature	Season	Months
	Summer	April- July
	Winter	November- February
Precipitation		
	Monsoon	June – September
	Non monsoon	October- May

RESULTS

Through the analysis of data one very crucial fact has emerged that climatic parameters not only have temporal variation but they also vary significantly over space. As the analysis shows, from mountainous to coastal locations temperature and precipitation have their regional trend which has also been influenced by local physiographic factors.

TEMPERATURE

Almost all the stations are showing temperature anomaly over past 100 years where, in most of the cases, temperature has increased significantly. As compared to maximum temperature, minimum temperature hasmarked increased in both summer and winter months. However, during winters this rise is more prominent. Considering regional pattern of temperature variability, in the plain areas of eastern Uttar Pradesh and Bihar temperature has increased more significantly than mountainous and costal locations. A typical pattern has been emerged in Fatehpur, Kanpur and Varanasi where minimum temperature in both the seasons has increased with almost equal significance. This may be because of heat island impact in the city (figure 1).



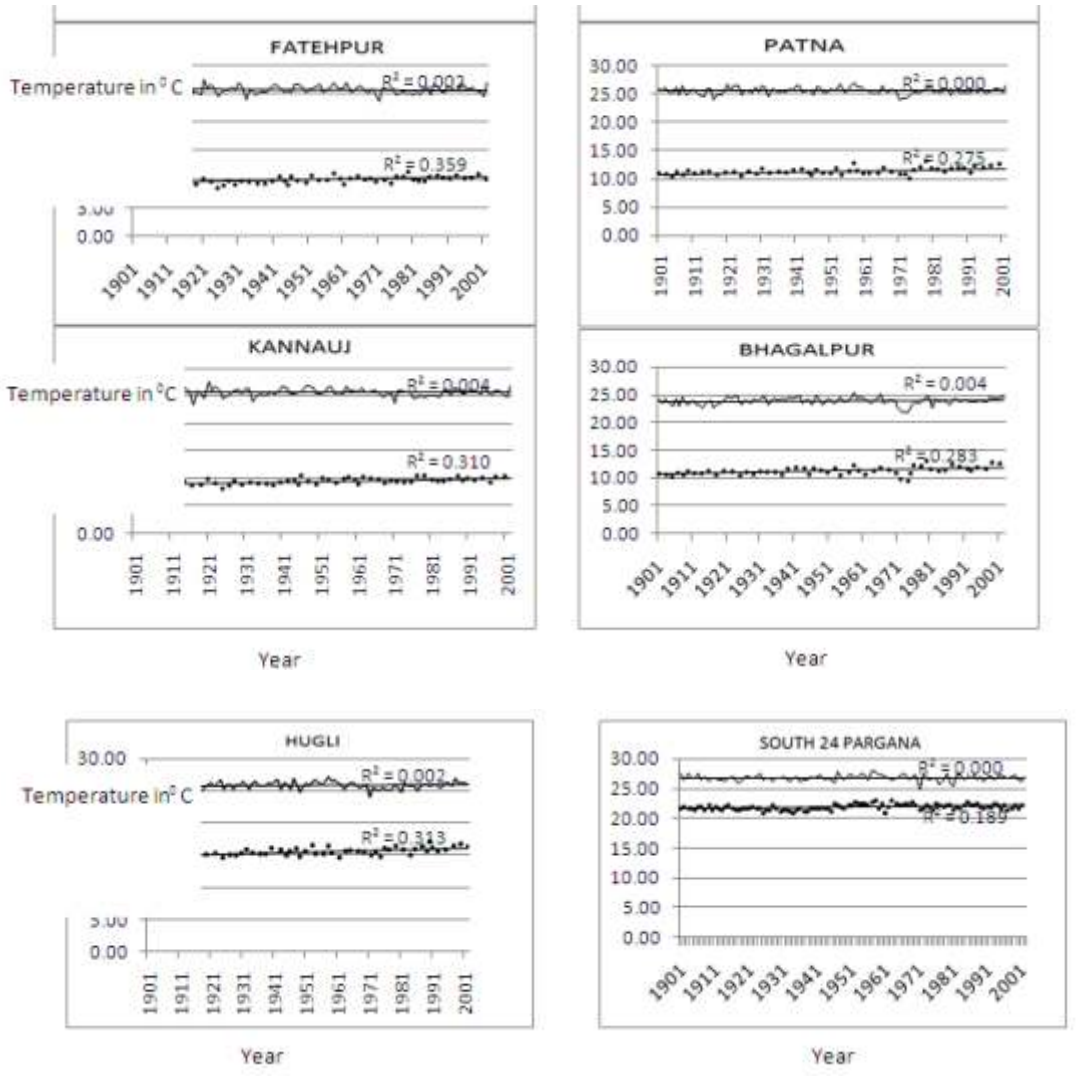


Figure1.Showing variability in minimum temperature. Summer temperature has been shown by solid line while dotted line has been used for winter temperature.

The maximum temperature, on the other hand, is not showing any particular increasing or decreasing pattern in almost all the locations. The analysis exhibits that over the time maximum temperature has remained comparatively stable (figure 2).

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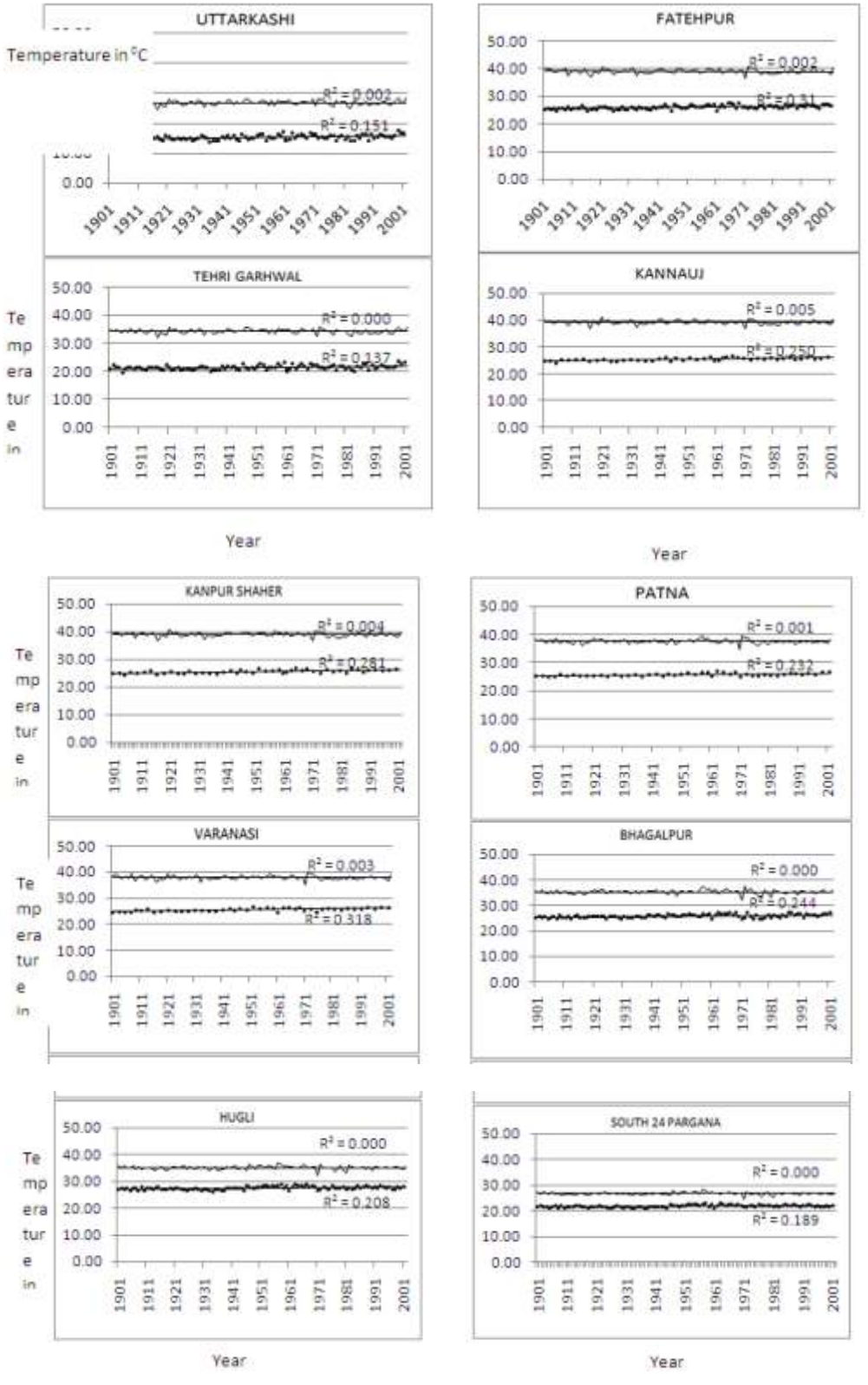

Figure 2.Showing variability in maximum temperature. The solid line has been used to show summer temperature whereas dotted line is representing winter temperature.

Precipitation

The mountainous regions of Uttarkashi and Tehri-Garhwal are not showing any fluctuation in precipitation over 100 years.However, in plain areas; mainly in Varanasi, Patna and Bhagalpur precipitation has recorded to be decreased significantly. Contrary to this, in coastal locations there has been slight increase in rainfall although it is not of much significance (figure 3).

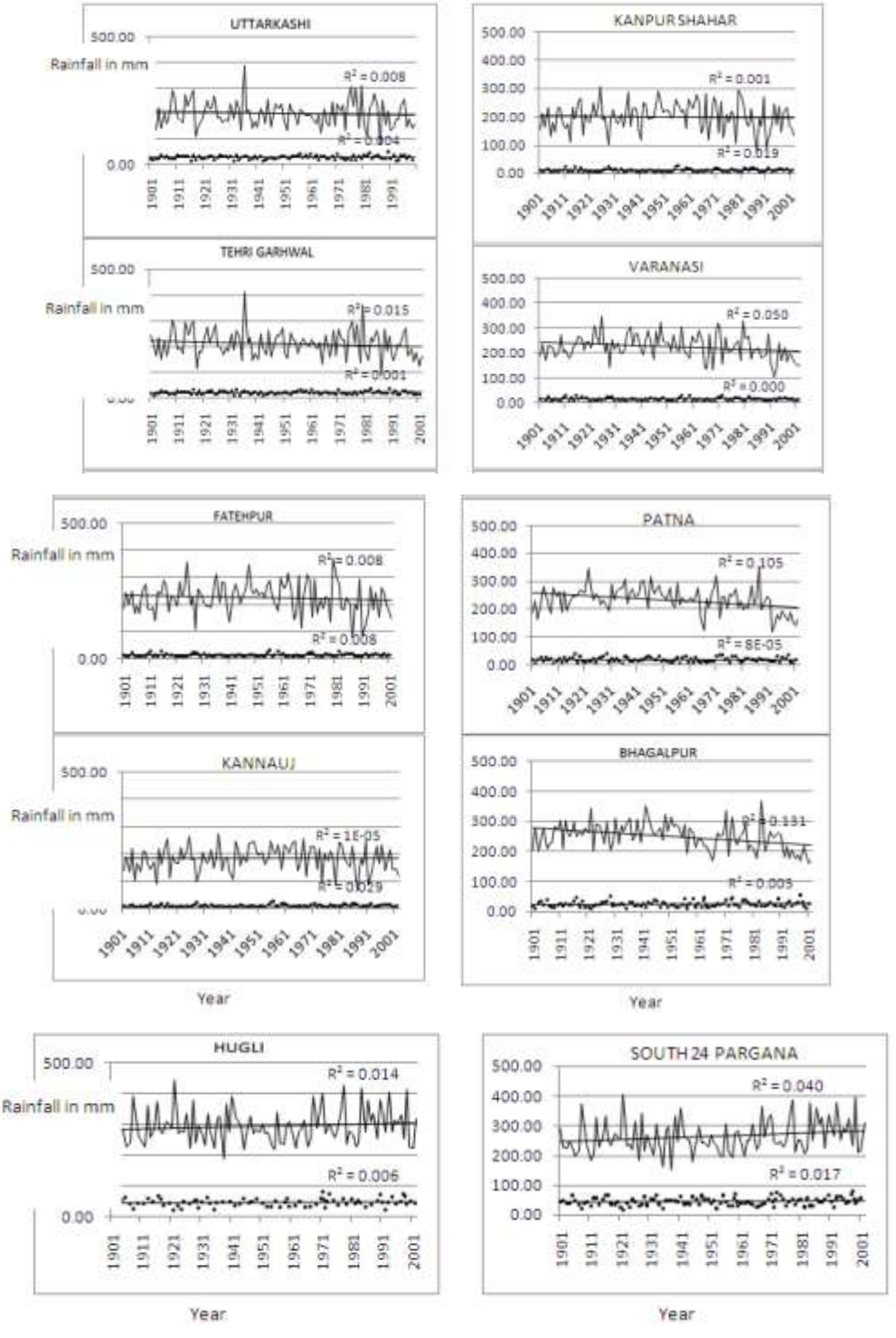

Figure 3.Showing precipitation variability in different stations. Solid line is showing monsoonal precipitation whereas dotted line is representing non- monsoon precipitation.

Table 3. Showing Significance of Trend (r2 values) for weather parameters

	TEMPERATURE				PRECIPITATION	
	min		max			
	Summer	Winter	Summer	Winter	Monsoon	Non-monsoon
UTTARKASHI	0.016	0.175	0.002	0.151	0.008	0.004
TEHRI GARHWAL	0.006	0.168	0	0.137	0.015	0.001
FATEHPUR	0.002	0.359	0.002	0.311	0.008	0.008
KANNAUJ	0.004	0.31	0.005	0.25	0	0.029
KANPUR SHAHAR	0.003	0.341	0.004	0.281	0.001	0.019
VARANASI	0.002	0.363	0.003	0.318	0.05	0
PATNA	0	0.275	0.001	0.232	0.105	0
BHAGALPUR	0.004	0.283	0	0.244	0.131	0.005
HUGLI	0.002	0.313	0	0.208	0.014	0.006
S 24 PARGANA	0.006	0.27	0	0.189	0.04	0.017

CONCLUSION

Therefore, from the analysis it becomes clear that the temperature and precipitation has spatio-temporal variation in Ganga basin as the temperature and precipitation anomalies vary from one place to another. In general the temperature, basically minimum temperature, has risen from 1901 to 2001 in the Ganga basin. Precipitation, contrary to temperature, has exhibited more regional pattern of variations. In mountainous areas precipitation has almost been invariable while in plain regions it has decreased significantly. In coastal areas, in contrast, rainfall has increased although it is not very significant. However, according to the findings in different literatures mountainous regions have recorded more climatic variability which has not come up in the present study. The reason behind this can be the local factors as elevation and perspective etc. The selected mountainous regions are not having very high altitude (<2000 mt) as compared with Tibetan plateau (>5000 mt). The location of Tibet in Trance Himalayan region can also be the reason of its different climatic pattern as the monsoon winds are not able to reach in these interior locations.

In the Ganga basin a positive departure in temperature and negative departure in precipitation can cause major environmental and socio- economic threat to the country.This can have a harmful impact on the rich flora and fauna of the region affecting precious diversity of the Indian sub- continent.

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