Proceedings WARMICE-2012
Sudhir Kumar, et al. (eds)
I.A.H., 2012

I-9

Climate Change and its Impact on Water Resorces - A Case Study

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Abstract : Climate change holds the potential to cause significant alterations in the water cycle which is a fundamental determinant of climate. Very little water availability results in droughts whereas too much water may result in ûoods and polluted water leads to problems with its quality concern. It is predicted that in future climate change is likely to increase both the number and magnitude of hydrological extremes. Successful strategies towards water resources management that are required to successfully adapt to the impacts and challenges associated with climate change are yet to be evolved. The water use and supply patterns are based on the Hydro-meteorological conditions. Traditionally, the design of water management systems has been based on historical climate and hydrological data, assuming stationarity of weather and water system behaviour. However, hydrological variations is driven by dynamics in the climate and the climate changes forecasted no longer allow such assumptions, and historical data are no longer adequate to meaningfully plan for variability and extremes.

Chandigarh was planned for a population of half-a-million. In Phase I, 36 sq km of land was acquired by the city administration for construction of 30 sectors. Land for seventeen additional sectors (Sector 31 to 47) was acquired and developed during the second phase to cater for a population of 350,000. However, Chandigarh has now grown beyond its planned capacity. Hence, development in the third phase has started in sectors 48 and beyond. Demographic data indicate that between 1961 and 1971, the population increased by 144.59 percent, one of the highest for urban areas in India. Chandigarh's Population was 12.97 lakh in 2009 and for this population the water requirement of the city for drinking and domestic purposes is 452.77 MLD (Million liters per day) water, whereas available supply is only 396.72 MLD. Thus there is a shortage of about 56.05 MLD. The projected water demand for the city for 2025 is 800.75 MLD and estimated supply would be 469.98 MLD. Thus leaving a gap of 331.07 MLD (CGWB,2011). Due to the increase in population and urbanization the pressure on cities water resources is ever increasing. The nature of water availability is shaped by the climate variability and climate change, thus, water resources management is going to be complex and different in future. Both mitigation and adaptation measures are presented to tackle the climate change problem.

Keywords : Climate Change , Water Resource , Hydro-meteorology, Adaptation and Mitigation

INTRODUCTION

Global warming is one of the major issue in the present century. Global warming is expected to cause major changes in major climatic variables such as temperature, precipitation and humidity etc. Such changes have the potential to alter hydrological cycle and could have major impacts on water resources affecting both the supply of, and demand for, water resources for various purposes of domestic , industrial and irrigation uses. For example, irrigation is particularly sensitive to climatic conditions during the growing season. Also, while indoor domestic water use is not very sensitive to temperature and precipitation, outdoor uses for gardens and parks are very climate dependent. And, higher water temperatures would reduce the efficiency of cooling systems and increase the demand for cooling water.(Michael Kiparsky et al.) Thus, climate change will affect overall water use directly and indirectly. The aim of this paper is to evaluate the potential impacts of climate change on city's water demand and supply for future years under changing climatic scenarios.

STUDYAREA

Chandigarh, known, as the "CITY BEAUTIFUL" is the first planned city of India and located at the foothills of the Shiwaliks and lies between north latitudes 30° 40' to 30° 46' and east longitudes 76° 42' to 76° 51'. The Union Territory of Chandigarh is located in the foothills of the Shivalik hill ranges in the north, which form a part of the fragile Himalayan ecosystem. Chandigarh falls under Koeppen's CWG category i.e. it has cold dry winter, hot summer and sub tropical monsoon. Evaporation usually exceeds precipitation and the weather is generally dry. The area experiences four seasons : (i) Summer or hot season (mid-March to Mid-June) (ii) Rainy season (late-June to mid-September); (iii) Post monsoon autumn/transition season (mid September to mid-November); (iv) Winter (mid November to mid-March). (http://chandigarhenvis.gov.in/beta/EnvisPdfFiles/19-20.pdf) The dry spell of summer is long but with the occasional drizzles or thunder storms. May and June are the hottest months of the year with the mean daily maximum & minimum temperatures being about 37°C & 25°C, respectively. Maximum temperatures can rise up to 44°C. Southwest monsoons with high intensity showers commence in late June. The variation in annual rainfall on year to year basis is appreciable i.e. 700 mm to 1200 mm. The 20 year average rainfall for Chandigarh is 1059 mm.

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According to 1981 census, it grew by another 75.55 percent, followed by 42.16 percent in 1991 and by 40.33 per cent in 2001 (with a total population of 9,00,635). By 2021 the population of Chandigarh is projected to be around 19.5 lacs (at current rate of growth) almost four times for which it was originally built. (Figure 1)

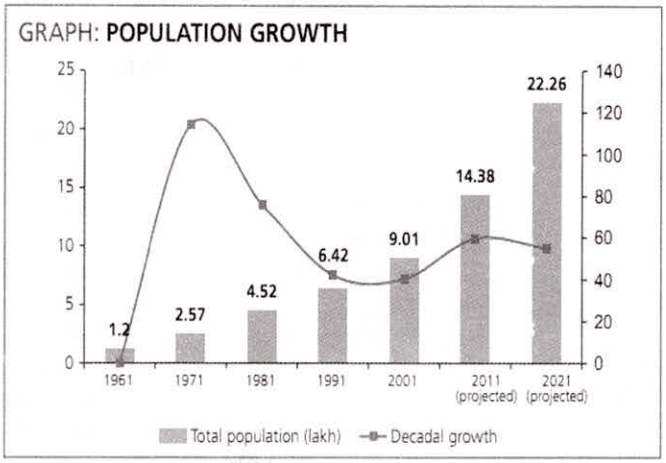


TABLE: **DECADAL GROWTH OF POPULATION**

Decade	% of decennial growth
1961	---
1971	114.17
1981	75.88
1991	42.04
2001	40.34
2011 (projected)	59.60
2021 (projected)	54.80

Fig. 1. Growth pattern of the city

HISTORIC WATER DEMAND

The responsibility of water supply rests with the Public Health Department of the municipal corporation. The city was being supplied with water from groundwater wells till 1983. The exploding population of the city forced the administration to look for a surface water source to supplement the ground water supply. Today, Chandigarh city gets 67 MGD of water from the Bhakra Main Canal and 20 MGD of groundwater from 200 tubewells in the city, making the total available water at 87 MGD or 396.72 MLD.

In Chandigarh, the use of private tubewells has been banned. Groundwater for drinking water supply and for irrigation is being provided solely by the municipal corporation. Water is pumped from the deep aquifers below 100 m. There are a total of about 219 tubewells for both urban and rural areas, of which water from 200 tubewells is used for urban water supply (Groundwater Information Booklet,Chandigarh 2007).

Chandigarh is already sourcing 22% of its water supply from groundwater and there is a considerable decline in the groundwater levels of the deep aquifers. By analysing pre- monsoon data for the period 1991 to 2006 (15 years), Sector 10 in the north shows a maximum decline of 16m and in Sector 31, the fall has been of the order of 10m. (National Data Centre, CGWB, 2009). Changes in Temperature and precipitation patterns with the climate change, the remaining parts of the city also show on average a decline of 5 to 8 m. To cope up with the decline the municipality is drilling deeper. Water table in the deeper aquifers have declined considerably (Figure 2). Every year about 10% of such tubewells become defunct (Report on Capturing Rainwater by Center for Science and Environment, June 2010) .

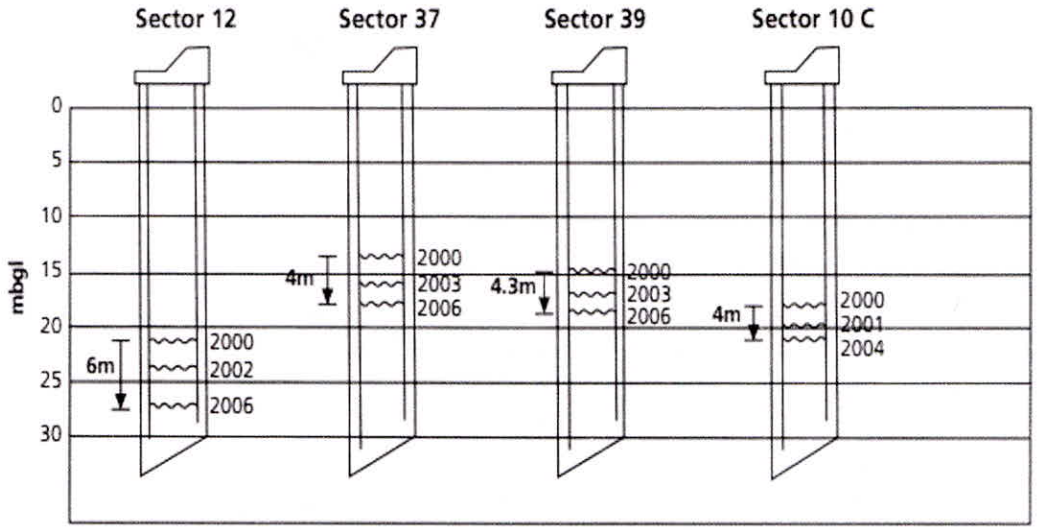
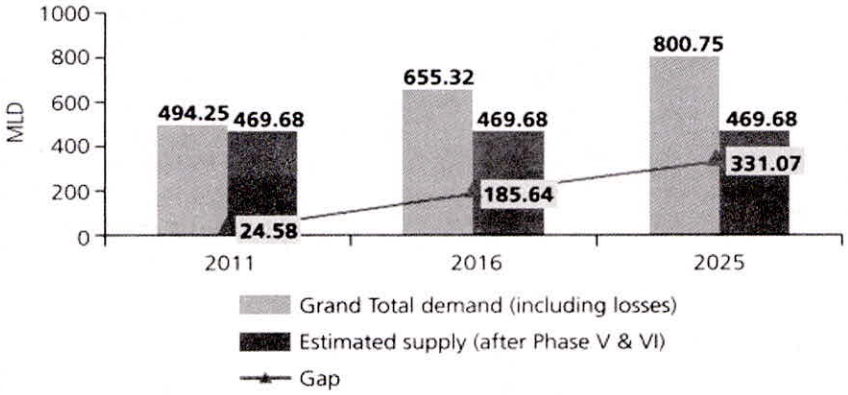


Fig. 2. Groundwater decline in deep aquifers

CLIMATE CHANGE AND WATER DEMAND

In Chandigarh, demand for water is estimated to grow in future. It is estimated that by 2025, the water demand will be 800 MLD, an increase of 58% over the 2011 demand of 494.25 MLD. (Figure 3)

The warming trend is seen in both daily maximum and minimum temperatures, with minimum temperatures increasing at a faster rate than maximum temperatures. Using statistical forecasting method the temperature range from 2010 to 2050 was predicted as shown in figure 4,5 and 6.



Year	Projected population (lakh)
2011	14.38
2016	17.8
2025	24.88

Fig. 3. Demand – Supply Scenario

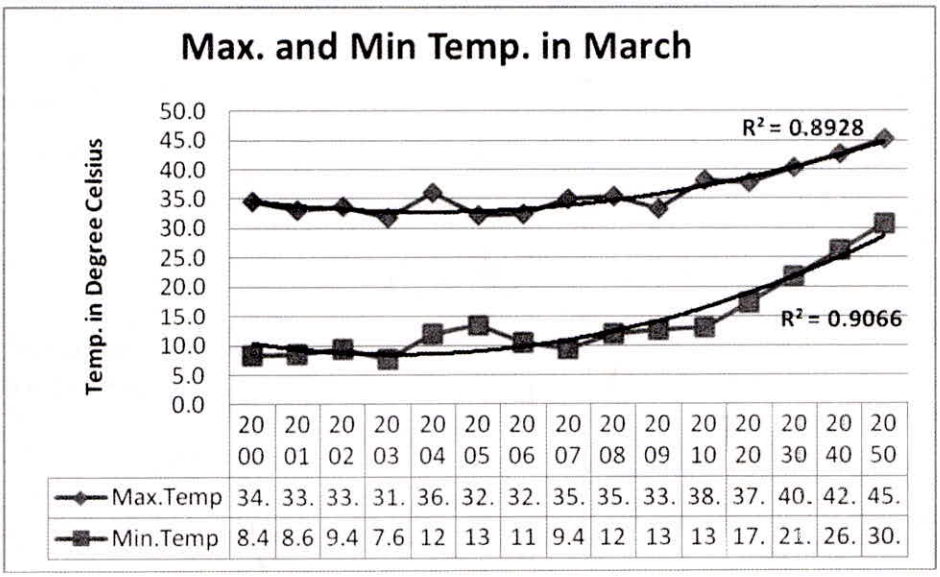
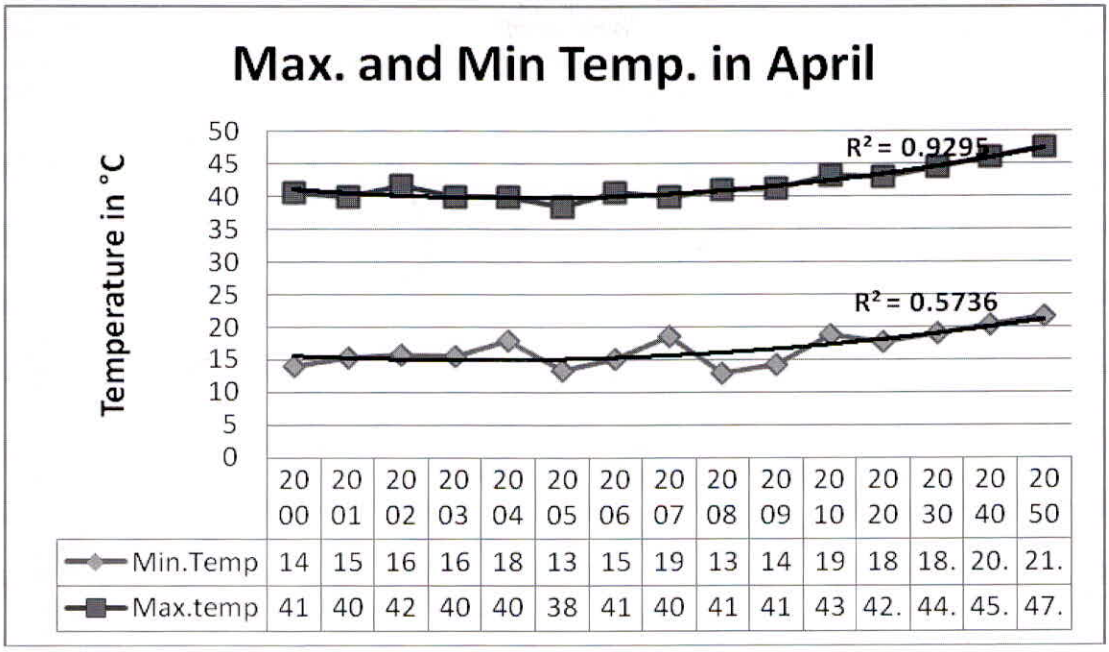
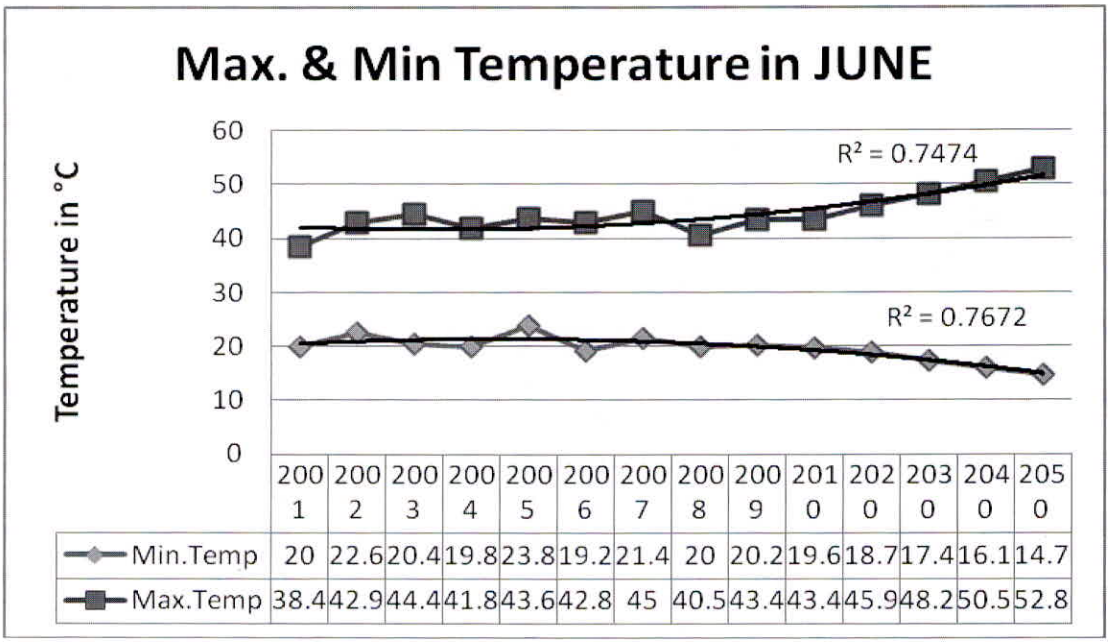


Fig. 4. Temperatue range in March



	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2020	2030	2040	2050
Min.Temp	14	15	16	16	18	13	15	19	13	14	19	18	18.	20.	21.
Max.temp	41	40	42	40	40	38	41	40	41	41	43	42.	44.	45.	47.

Fig. 5. Temperatue range in April



	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2020	2030	2040	2050
Min.Temp	20	22.6	20.4	19.8	23.8	19.2	21.4	20	20.2	19.6	18.7	17.4	16.1	14.7
Max.Temp	38.4	42.9	44.4	41.8	43.6	42.8	45	40.5	43.4	43.4	45.9	48.2	50.5	52.8

Fig. 6. Temperatue range in June

In april 2010, max temp. reached 43 degre celsiusand min. temp. 19 degrees with a rise of 4 degrees as compared to the year 2010. Rainfall data also varied with the temperature.

Typically the hottest month is May, and then the monsoon arrives which brings down the temperature. In this month , in 2002, 2004 and 2010 max. temp. reached as high as 44 ^{0}C but their respective min. Temp. were 18 ^{0}C in 2002 , 14 ^{0}C in 2004 and 20 ^{0}C in 2010. The gap between minimum and maximum is decreasing indicating minimum temperatures warming at a faster rate. Similarly, in June as shown in figure 6, maximum temperature is rising over the years.

RESULTS AND DISCUSSION

Data for Chandigarh shows a rising trend in Temperature and precipitation pattern. Changes in precipitation is one of the expected impacts of climate change. Temperatures in Chandigarh have increased. Pronounced warming has occurred in summer, with the largest increase was observed in the period May- June. By analyzing long-term precipitation trends in the Chandigarh, it is determined that Precipitation over Chandigarh has been below its mean total rainfall. In past rainfall was used to be distributed over months March to September but now it is limited to four months June to September.

Most of the rainfall is received during the months of July and August. The annual average rainfall of Chandigarh, based on long- term average between 1951-1980 is 1059.3 mm and the total number of rainy days is 49.8. There is wide variation in rainfall as can be seen by the data given for the last 10 years. Rainfall has been below the annual average during two out of ten years. This study suggests the changes are already observable – and are likely

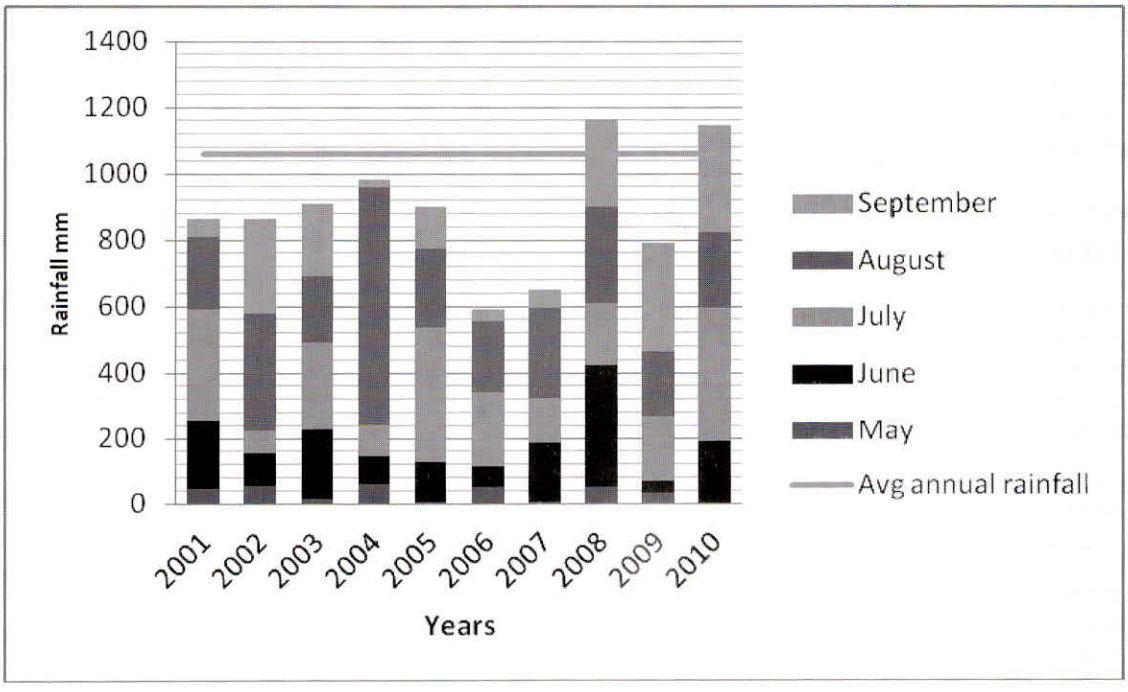


Fig. 7. Monthly rainfalls from over the decade.

to intensify with additional warming. In addition, there would be changes in the variability of climate, and changes in the frequency and intensity of some extreme climatic phenomenon.

CONCLUSION

The water needs of Chandigarh will grow at an explosive rate in near future. There is a need to put in place a number of measures to create awareness among the people about the importance of water and incentivize them to use water carefully and wisely. Water conservation measures which need to be looked upon to save city's water resources include rain water harvesting and reduce & recycle of water. Decisions about long-term water planning depend on climatic conditions and adaptation to those conditions. In the past, these decisions relied on the assumption that future climatic conditions would have the same characteristics and variability as past conditions. A focussed programme to encourage research on such issues as hydrogeological and rainfall mapping, technological tools must be instituted. Detailed studies can be carried out using GIS, satellite data. In order to reduce vulnerabilities, a timely adaptation to probable new environmental conditions under climate change becomes imperative.

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