Impact of Climate Change on Water Resources of India

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ABSTRACT

Climate change is not only a major global environmental problem but also an issue of great concern to a developing country like India. Studies have been carried out earlier to analyze the trends of temperature varieties over India/ Indian subcontinent and results have been compared with the global trend. An analysis done by NIH Roorkee of temperature data of 125 stations distributed all over India shows an increase of 0.42^0 C, 0.92^{0}C and 0.09^{0}Cin annual mean temperature, mean maximum temperature and mean minimum temperature respectively over the 100 years. However trends are varying on regional basis. It has been observed that the changes in temperature in India, Indian subcontinent over last century are broadly consistent with global trends of increase in temperature.

Temperature drives the hydrological cycle, influencing hydrological processes in a direct or indirect way. A warmer climate may lead to intensification of the hydrological cycle, resulting in higher rates of evaporation and increase of liquid precipitation. These processes in association with a shifting pattern of precipitation may affect the spatial and temporal distribution of runoff, soil moisture, ground water resources etc and may increase the frequency of drought and floods. Extreme conditions exist in India – these are flood followed by drought. It has been estimated that 40mha of area is flood prone which constitute 12% of total geographical area of the country and it has been found that 51mha area is drought prone which constitute 16% of total geographical area.

Keywords: global, hydrological, evaporation, precipitation, drought

1. INTRODUCTION

In order to minimize the adverse impacts of climate change on water resources and attaining its sustainable development and management, there is a need for developing rational adaptation strategies. Three prominent visible signals of climate change are: (i) increase in global average temperature, (ii) change in regional precipitation patterns, and (iii) rise in sea level.

In India the distribution of rainfall is highly non-uniform both in terms of time and space. As a result water is required to be stored and utilized for meeting the demands of different sectors throughout the year. Efficient water management requires sustainable development of the available surface and ground water resources and their optimal utilizations. To understand the regional implications of climate change on water policy and infrastructure, it is necessary to first obtain regional projections on temperature, precipitation, stream flow, and other relevant variables. Although specific regional effects in this regard are still uncertain, climate change is expected to lead to an intensification of the global hydrological cycle and can have major impacts on regional water resources, affecting both ground and surface water supply. Circulation patterns that affect precipitation in terms

Of impacts affecting normal human life, the biggest impact will be on water—with respect to both water availability and extremes of floods and droughts.

In its Fourth Assessment Report, the IPCC suggests that average temperatures will climb 1.56 to 5.44°C in south Asia by 2099. Dry season rainfall will drop by 6 to 16 per cent, while wet season rains will increase by 10 to 31 per cent. Such shifts in temperature and precipitation patterns could carry major repercussions for India\'s freshwater resources and food production. Rising surface temperatures appear to be contributing to melting of snow and ice pack in the Himalaya, thus threatening the water supplies on which hundreds of millions of people depend. As per IPCC analysis India could suffer from outright water stress – annual availability of less than 1,000 cubic meters per capita – by 2025, and gross water availability could fall as much as 37 percent by mid-century. In addition to the implications for drinking water and sanitation, this could considerably diminish crop yields in the region. Temperature increase of as little as 0.5 to 1.5°C might trim yield potentials for Indian wheat and maize by 2 to 5 per cent. For greater warming, above 2.5 degrees centigrade, the losses in non-irrigated wheat and rice yields in south Asia could cut net farm level revenues by 9 to 25 per cent.

Where some parts of India will face shrinking water supplies, others will face rising seas. Average global sea levels are projected to rise at a rate of 2 to 3 mm per year over the coming 100 years. Low end scenarios estimate sea levels in Asia will be a minimum, 40 cm higher by the end of the 21st century. The IPCC calculates that this would expose from 13 million to 94 million people to flooding, with about 60 per cent of this total in South Asia. In India, sea level rise of 100 cm would inundate 5,763 km3 of the country\'s landmass. Because of their high population density, susceptibility to coastal flooding and saltwater intrusion from sea level rise, and exposure to storm surges, the IPCC has specifically designated several of India\'s low-lying coastal river deltas-the Ganges (shared with Bangladesh), the Godavari, the Krishna, and the Mahanadi- as particular "hotspots" of climate change vulnerability.

2. CLIMATE CHANGE AND WATER RESOURCES

Temperature drives the hydrological cycle, influencing hydrological processes in a direct or indirect way. A warmer climate may lead to intensification of the hydrological cycle, resulting in higher rates of evaporation and increase of liquid precipitation. These processes, in association with a shifting pattern of precipitation, may affect the spatial and temporal Distribution of runoff, soil moisture, groundwater reserves etc. and may increase the frequency of droughts and floods. The future climatic change, though, will have its impact globally but likely to be felt severely in developing countries with agrarian economies, such as India. Surging population, increasing industrialization and associated demands for freshwater, food and energy would be areas of concern in the changing climate scenarios. Increase in extreme climatic events will be of great consequence owing to the high vulnerability of the region to these changes.

The utilizable water potential of the country has been variously estimated in the past. The Central Water Commission estimated the utilizable surface water in each river basin considering the suitable sites/locations of diversion and storage, as 690 BCM. The National Commission for Integrated Water Resources Development Plan (NCIWARDP 1999) as well as the Standing Sub-Committee for \'Assessment of Availability and Requirement of Water for Diverse Uses in the Country\' constituted by the Ministry of Water Resources (August, 2000) have adopted this value.

The annual replenish able ground water resource for the country was estimated at 433 billion cubic maters (bcm) as on March 2004. The sources of replenishment include rainfall (67%) and other sources like canal seepage, return flow from irrigation, seepage from water bodies and artificial recharge due to water conservation structures (33%).

3. STUDY OF ASSESSMENT AND MAJOR THREATS DUE TO CLIMATE CHANGE

- With unmitigated emissions, by the 2080s, large changes are predicted in the availability of water from rivers, with substantial decreases in Australia, India, Southern Africa, most of South America and Europe, and the Middle East and increases across North America, central Asia and central eastern Africa.
- Any climate change impact assessment on water resources study requires the down-scaling of the precipitation and other variables such as temperature, relative humidity, solar radiation, wind direction and wind speed from the global scale to the regional scale.
- 3 -5 degrees annual rise in mean surface temperature by the end of century, and 2.5 to 4° C, with warming more pronounced in the northern part of India.
- A 20% rise in all India summer monsoon rainfall over all states, except Punjab, Rajasthan and Tamil Nadu, which show a slight decrease. Increase in extremes in maximum and minimum temperatures and precipitation, particularly over the western coast and west central India.

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However, studies by the Central Water Commission have predicted that per capita availability of water will go down drastically by 2050, even without considering climate change, due to population growth.(Raje and Majumdar 2010)

4. IMPACT OF CLIMATE CHANGE

The projections indicate that the warming would vary from region to region, accompanied by increases and decreases in precipitation. In addition, there would be changes in the variability of climate, and changes in the frequency and intensity of some extreme climatic phenomenon. Flood magnitude and frequency are likely to increase in most regions, and low flows are likely to decrease in many regions. However, there have been very few studies addressing the issue directly, largely due to difficulties in defining credible scenarios for changes in flood producing climatic events.

Water resources will come under increasing pressure in the Indian subcontinent due to the changing climate. An attempt has been made here to give a brief account of the possible impacts of climate change on India’s water resources, change in India’s water needs, climate of India, river basins of the country, present water resources and future demand and supply, impacts of projected climate change and variability, and associated hydrological events and vulnerability of regional water resources to climate change.

Extreme conditions exist in the country – there are floods followed by droughts. Due to excess rainwater, floods occur in certain parts. It has been estimated by RBA that 40 mha of area is flood-prone which constitute 12% of total geographical area of the country. Droughts are also experienced due to deficient rainfall. It has been found that 51 mha area is drought prone which constitute 16% of total geographical area.

Climate change presents a significant challenge to the urban water management agencies. The urban water infrastructure, consisting of water supply systems and sewage networks ,storm water drainage systems, pumping systems, detention tanks, groundwater pumping, and recycling of wastewater, is vulnerable to stresses caused by climate change. Most cities in India depend on surface water sources for municipal water supply.

The first level of impact of climate change on urban water supply is through the depletion of surface and groundwater sources, because of reduction in stream flows and reduction in recharge due to rainfall. An indirect effect of climate change is an increase in water demand, because of rise in temperatures, for the same given population. Increasing intensities of rainfall along with unplanned development of cities exacerbate the already critical problem of urban flooding .It is essential that the water administrators as well as companies in charge of municipal and industrial water supply and storm water drainage account for climate change impacts in planning for infrastructure investments.

The population of the country has increased from 361 million in 1951 to 1201 million in March 2011. Accordingly, the per capita availability of water for the country as a whole has decreased from 5177 m3/year in 1951 to 1519 m3/year in 2011. Due to spatial variation rainfall, the per capita water availability also varies from basin to basin. The stage of groundwater development in the country is 58%. The status of groundwater development is comparatively high in the states of Delhi, Haryana, Punjab and Rajasthan and UTs of Daman & Diu and Pondicherry, where the Stage of Groundwater Development is more than 100%, which implies that in the these states, the average annual groundwater consumption is more than average annual groundwater recharge. In the states of Gujarat Karnataka, Tamil Nadu and Uttar Pradesh, the average stage of ground development is 70% and above. In rest of the states/UTs the stage of groundwater development is below 70%.Growing demand of water in agriculture, industrial and domestic sectors, has brought problems of over-exploitation of the groundwater resource, continuously declining groundwater levels, sea water ingress in coastal areas, and groundwater pollution in different parts of the country. The falling groundwater levels in various parts of the country have threatened the sustainability of the ground-water resource, as water levels have gone deep beyond the economic lifts of pumping. With rapid expansion in groundwater extraction, development-related problems have started emerging. Substantial decline of groundwater levels occurs even in blocks with sufficient groundwater resources due to climatic vicissitudes and localized development. (NDMA 2010)

The following specific adaptation options are relevant in the water sector, to combat the adverse effects of climate change: (i) demand management to suit the supply, by choosing appropriate cropping patterns and technologies to reduce water consumption in industry;(ii) increasing efficiency of water usage, particularly in the irrigation sector where the current efficiencies are very low; (iii) structural measures of increasing reservoir storage; (iv) non-structural measures of developing and operational izing adaptive reservoir operating rule curves, taking into account the likely mismatch between supply and demand; (v) out-of-the-box solutions to use the flood waters as a resource, say through diverting flood waters to potential groundwater recharge zones;(vi) large scale recycling of wastewater; and (vii)desalination of sea water to meet the municipal needs.

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India, China and Bangladesh are especially susceptible to increasing salinity of their groundwater as well as surface water resources, especially along the coast, due to increases in sea level as a direct impact of global warming For two small, flat coral islands off the coast of India, the thickness of the freshwater lens was computed to decrease from 25 m to 10 m and from 36 m to 28 m for a sea-level rise of only 0.1 m (Kelkar etal 2008). It is expected that climate change will alter the frequency of occurrence of extreme rainfall events and we are likely to experience more frequent high intensity rainfall in cities.

5. FUTURE ISSUES AND ACTIONS

Rapid urbanization will continue for the next three to four decades. Many towns and cities will Struggle to meet water demands even for domestic purposes unless specific c policy and administrative mechanisms are put in place. Climate change is only likely to increase such stresses. In this context, wastewater recycling and desalination technologies gain importance. Diversion of flood waters for groundwater recharge must also be practiced by the municipal corporations. Legal regulation of groundwater use will soon be a necessity.

Unlike in most developed countries, agriculture in India (and other similar countries) is characterized by small farmers (farmers with small land holdings, typically less than 2 hectares) .Most of whom depends on rainfall for agriculture. For food security and long-term sustainability of Agriculture—and ensuring enhanced quality of rural life—irrigated agriculture needs to be given Importance, with technologies and non-structural measures put in place to increase efficiency of water use. Alternatively, decentralized irrigation systems including watershed development, rainwater harvesting, development of village tanks and water bodies, need to be encouraged as an insurance against the uncertainties due to climate change.

For each degree Celsius warming, global average precipitation is projected to increase by 2- 4%, but at the regional scale both increases and decreases are projected. Global climate modeling studies suggest that the precipitation may increase or decrease by as much as 15% under the assumption of a doubling of atmospheric CO2. Increases in the amount of precipitation are very likely in high latitudes, while decreases are likely in most subtropical land regions. It is predicted that increasing atmospheric concentrations of GHG would result in changes in frequency, intensity, and duration of the extreme events, such as more hot days, heat waves, heavy precipitation events, and fewer cold days. The impact of climate change is projected to have different effects within and between countries. Clearly, variations in key climatic parameters such as precipitation and temperature will produce significant changes in the hydrological regime (rainfall-runoff, snow and glacier melt runoff, evaporation, stream flow etc.) of a basin/country. The resulting changes in regional weather patterns will vary widely but there is widespread agreement that in many parts of the world the frequency and severity of both floods and droughts will increase.

It is quite clear that even if countries do undertake immediate and rapid action to reduce their emissions, some degree of climate change is inevitable. Abilities to deal with weather extremes in the present day are considered to be very limited, the situation may get worse in the future. Therefore, the need is to significantly improve ability to plan and adapt to extreme events such as floods, droughts, cyclones and other meteorological hazards. Any robustness that we build into the system in this regard will always stand us in good stead, no matter what climate change actually transpires. In spite of the uncertainties about the precise magnitude of climate change and its possible impacts particularly on water resources at regional or basins scales, measures must be taken to anticipate, prevent or minimize the causes of climate change to mitigate its adverse effects.

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