# Climate Change and Water

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## It is now well accepted in the scientific circles that, at the global scale, the atmospheric temperatures will continue to increase over the coming decades, and as a result, the precipitation patterns are likely to change and sea levels will rise.

These three prominent signals of global climate change result in regional modifications in water availability, evapotranspirative water demands of crops and vegetation, extremes of floods and droughts, water quality, salt water intrusion in coastal regions, groundwater recharge and other related processes. Visible impacts of global climate change will be felt mainly through the medium of water in the coming years.

Even without the likely adverse impacts of climate change, we are already living on the edge as water crisis gets more pronounced every year. Consider these facts: several of our rivers are polluted beyond acceptable levels; groundwater is contaminated in many regions of the country because of both natural and anthropogenic causes; safe drinking water is fast becoming an economic commodity rather than a resource to fulfil the basic human need; indiscriminate exploitation of ground water has put that resource in stress in many regions of the country; water is often transported over large distances with huge pumping involving enormous energy, for supply to cities; unplanned urban growth encroaching upon natural water bodies and drainage pathways has resulted in frequent and intense flooding of cities; we face severe water shortages in the summer months almost every year, and immediately after, intense floods during monsoon months causing huge loss of property and life. Climate change is likely to only exacerbate this situation.

We must accept that urbanisation and development in the country are an irreversible reality and are essential to improve the overall quality of life. An unprecedented growth of urbanisation in the country in a short time, however, has posed the biggest challenge for the urban water managers. An immediate impact of climate change on urban water systems is through altered surface and ground water resources, because of possible reduction in streamflow and rainfall. Additionally, increasing intensities of rainfall along with unplanned development of cities aggravate the already critical urban flooding problem and stress the urban water infrastructure. Urban floods are caused by short duration high intensity rainfall, which are projected to increase in many regions – but the overall water availability is governed by the seasonal rainfall, which may decrease. A challenging problem is to convert the urban floods into a resource, by innovative technologies to recharge ground water or otherwise store the floodwaters for subsequent use.

An accurate assessment of how the water scenario is likely to evolve in a region is not possible with the current available knowledge. Additionally, there are serious disagreements among the policy makers and even among the scientists on the authenticity of climate change itself and on the possible impacts it may have on regional water scenarios. The water managers are thus faced with the challenge of evolving adaptive responses and action plans in the face of not only a large uncertainty associated with the projected impacts but also a sense of perplexity and confusion that the issue of climate change seems to have created because of conflicting views, opinions and even scientific projections on the impending regional water scenarios. Such a sense of confusion is particularly pronounced in India, where the capacity to understand the different aspects of climate change as it affects the water systems is extremely limited among water managers.

How can science help the policy makers in resolving the many critical issues related to water, in the face of climate change? A major science question that we need to address in this context is on how river flows are likely to change in future because of climate change. Other important questions to resolve are: whether the frequencies and magnitudes of floods and droughts are likely to increase, and how do the agricultural and other water demands respond to climate change. We use hydrologic models along with global climate models (GCMs) in our attempt to answer these questions. Both

GCMs and hydrologic models are computer models of natural processes. The GCMs tell us, with some confidence, how the climate is likely to evolve in future while the hydrologic models help us capture natural processes related to water such as flow of water in a stream, evaporation from land surface, evapotranspiration from crops and vegetation, ground water movement and recharge, soil moisture and sediment and pollutant transport in streams. We use projections of future climate provided by the GCMs in the hydrologic models to assess the water situation in a region. With this knowledge, inexact though it may be, action plans for future may be examined. It is the responsibility of the scientific community to reduce uncertainties in the projections and to communicate the results in a manner useful for the policy makers.

Whether science is, at this stage, geared up to provide an accurate assessment of impacts of climate change at regional scales or not, it is important to acknowledge that water crisis is likely to be accentuated by climate change, and we must prepare ourselves to face abnormal conditions more frequently than we are used to. The water systems must be rendered shock-proof and resilient to a great extent. Current emphasis on creation of large scale water infrastructure in the country must be augmented with well-formulated adaptive policy options. Indeed, the issue of climate change offers an enormous opportunity to apply corrections to the poorly managed water systems in the country. In building resilient, adaptive responses, out-of-the-box solutions synthesising the Gandhian and the Schumaker 'small is beautiful' perspective with that of large scale engineering interventions will be necessary. Measures such as reviving village tanks, rejuvenating lakes and water bodies in urban areas, adopting small-scale, local rainwater harvesting and recycling of waste water should be integrated into the large scale engineering and management solutions of improving water use efficiencies - particularly in irrigated agriculture -, increasing reservoir storage and allied physical infrastructure, harnessing flood waters as a resource, changing the cropping patterns and desalination of seawater, to build resilience into water management systems. The response of groundwater to climate change is likely to be much slower and less critical compared to that of surface water. The ground water reservoir should therefore be recognised as an insurance against climate change. Emphasis should be placed on evolving conjunctive use policies of surface and ground water as an option for resilient response to climate change.

As young, brilliant students of science interested in water issues, the participants of this seminar are urged to see the impending water crisis as an opportunity for them to evolve creative solutions. Equity in supply of safe drinking water to all – from hamlets far removed from the rest of the world to the urban poor – must take priority over everything else in water use policies. A challenge for the young generation is to create new paradigms of development with an intensely human face.

This year is marked as the International Year for Water Cooperation by the United Nations (UN). The UN brochure declaring this says, “The objective of this International Year is to raise awareness, both on the potential for increased cooperation, and on the challenges facing water management in light of the increase in demand for water access, allocation and services”. An excellent example of international cooperation on water sharing is the famous India-Pakistan Indus Water Treaty, where the two countries agreed on some well laid principles of water sharing and have adhered to them in spite of frequent political and military tensions between the two countries. It is a great credit to both India and Pakistan that even during the three wars between the two countries (in the years 1965, 1971 and 1999), the water treaty was never broken. The water treaty has benefitted both the countries immensely in building drought resistance. India and Bangladesh, on the other hand, share more than 50 rivers between them and long standing conflicts on water sharing are yet to be fully resolved, although a few temporary agreements have been put in place between the two countries. Recently, an agreement on sharing of the Teesta river waters between India and Bangladesh was nearly arrived at but unfortunately could not be effected finally. The Colorado Compact, which governs sharing of the Colorado river water among seven states in the United States of America, has functioned extremely successfully for nearly 90 years now, and is treated as an ideal agreement to emulate in a federal structure of governance. In India, too, there are a number of water agreements among states, which despite political differences among the states, have worked very well. These agreements are effected through water tribunals, with legal authority, in most cases. The Narmada Water Disputes Tribunal (NWDT), for example, awarded a decision on the sharing of the Narmada river water among Madhya Pradesh, Gujarath, Rajasthan and Maharashtra. Similarly, the Cauvery Tribunal and the Krishna Water Disputes Tribunal awarded decisions on sharing of water between Karnataka and Tamilnadu in the case of Cauvery river and between Maharashtra, Karnataka and Andhra Pradesh, in the case of Krishna river.

A basic governing factor in arriving at water sharing agreement for a river among countries (or states) is the water available in that river at one or more specified locations. Often, the agreements are based on an estimated amount of water available with a certain degree of confidence. A deficit year or an excess year is defined depending on whether the actual flow in the river is less or more than this estimated amount of water. The water sharing principles are generally worked out for all the three situations: normal, excess and deficit years, with due accounting of water demands in the regions concerned. It is in this context that the issue of climate change becomes critically important, as both water available in a river and water demand are likely to be affected by climate change. Building clauses on climate change impacts - considering explicitly the uncertainty associated with the impacts - into water sharing agreements is indeed a challenge but will soon become inevitable.

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