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GUEST EDITORIAL

Climate change and adaptation in water sector in India

Consumption of fossil fuels has increased to satisfy the growing demand for rising industrial activities, expanding transportation, intensifying agriculture and burgeoning population since the 1850s. Burning fossil fuels has led to a significant rise in the emission of gases, such as CO_2, CH_4, NO_x, etc. (collectively known as greenhouse gases, GHGs) in the atmosphere. Consequently, more reflected radiation or heat is trapped in Earth's atmosphere, raising its temperature and causing climate changes. The recently released Sixth Assessment Report (AR6) by Intergovernmental Panel on Climate Change (IPCC) mentions that 'it is unequivocal that human influence has warmed the atmosphere, ocean and land'. IPCC also notes that 'the likely range of total human-caused global surface temperature increase from 1850–1900 to 2010–2019 is 0.8°C to 1.3°C, with the best estimate of 1.07°C'.

To tackle global warming, it is necessary to know how warming will progress in future. Global Climate Models (GCMs) simulate the behaviour of Earth's climate. GCMs are run with likely future scenarios of GHG emissions that will depend on many factors: population, energy consumption, use of fossil fuels and renewable energy sources, forestation, economic and industrial development, commitment of national governments to reduce emissions, investments to employ low emission technologies, conflicts, etc. Five scenarios of likely socioeconomic changes leading from very low to very high GHG emissions have been developed. The corresponding estimated average temperature rise could be between 1.1°C and 5.4°C in 2100 relative to the 1986–2005 levels. Of course, the estimates have uncertainties. Actual warming will depend on the decisions that the governments will take and enforce in future.

Global warming is likely to cause widespread changes in the climate, which will adversely impact different spheres of life. Most of the impacts will be felt through water. The hydrologic cycle describes the occurrence, distribution and movement of water through various phases in the atmosphere, earth and oceans. This cycle will intensify with increased warming, resulting in more intense rainfalls, more severe floods, more frequent and longer droughts, longer and warmer heat waves, more harmful hurricanes, etc. Flooding will become more severe as rainfall intensifies, resulting in deaths, infrastructure damage, health issues, environmental degradation, coastal land loss, economic losses and disruption of the ecosystem and social fabric. More frequent and intense droughts, coupled with warmer temperatures, will significantly impact food production and degrade ecosystems. In a warmer climate, snow and glaciers will see accelerated melting. Himalayan rivers derive considerable flow from snow/glacier melt, and as glaciers retreat, water and food security in the Indus, Ganga and Brahmaputra basins will suffer. With changes in rainfall patterns, some rain-fed agricultural areas will receive less rain, thereby facing production losses. In a warmer climate, the production of crops such as wheat, rice and horticulture, is likely to fall substantially.

Due to the warming of oceans and higher melting of glaciers and ice caps, sea levels are rising. Rising sea levels will inundate coastal lands, displace millions of people and damage infrastructure, including ports, disrupting trade and travel. Warming ocean waters will lead to more storms/cyclones with increasing devastating power. Retreating glaciers, early snowmelt and severe droughts will cause more dramatic water shortages and forest fires. In a warmer climate, croplands, forests and cities will be hit by new pests, endangering human and animal health, agriculture and fisheries. The outbreak of allergies, asthma and infectious diseases will be more common due to higher temperatures, higher air pollution, and conditions favourable to the growth of disease-causing bacteria. The World Health Organization (WHO) estimates that between 2030 and 2050, the world may face approximately 250,000 additional deaths per year from malnutrition, malaria, diarrhoea and heat stress in a warmer climate.

Scientists fear that if global warming exceeds 2°C by 2100, the earth may see catastrophic and irreversible changes. Under the Paris Agreement (2015), nearly 200 countries agreed to limit global warming to below 2°C by 2100. But this target, as of now, seems difficult to attain.

Actions that reduce emissions of GHGs or remove these from the atmosphere are 'mitigation' measures. Typical mitigation measures are less use of fossil fuels for energy generation, transport, heating/cooling, etc. Wider use of renewable energy sources (hydro, solar and wind) reduces dependence on fossil fuels. CO_2 can be removed from the atmosphere by afforestation, Carbon Capture and Storage (CCS), etc.

Adaptation refers to the adjustment to actual or anticipated climate so that harmful impacts are moderated. Earth's climate has been changing in the past also, but the current rate

of change is very high. Humans have been adapting to changing climate in the past with partial success. At times, migration helped overcome the threat.

Both mitigation and adaptation will be necessary to manage climate change problems comprehensively. In the water sector, mitigation has a limited role, and adaptation is necessary to overcome the current and likely future threats. Adaptation should be practiced so that society also harnesses the beneficial opportunities coming with climate change.

A purpose of adaptation is to make systems more resilient, i.e. increase their ability to bounce back after negotiating new stress. More broadly, adaptation describes not just the ability to maintain essential functions, identify and structure but also the capacity for transformation. Adaptation actions should be designed so that in future, the existing and likely concerns are optimally addressed. An overarching theme in adaptation should be to improve water use efficiency in all sectors.

India is a big country with large variations in topography, climate, water availability, demands, water quality, extremes and disasters. Since water problems are best managed at regional/local levels, it is helpful to look at the key issues at regional levels. In the North-East (NE) region, water supply is many times more than the demand, whereas in the Deccan Hard Rock (DHR) region, the situation is reversed. Floods occur almost every year in the NE region, and droughts are recurrent in DHR. Groundwater mining is a serious problem in Western India and the DHR. Many river basins, particularly in the Himalayas, are witnessing increasing intense rainfalls and flash floods. Increasing cyclonic activities, rising sea water levels and sea-water intrusions are seen in coastal areas. Deterioration in the environment and water quality is pervasive. Agricultural production will have to be increased substantially to ensure food security for the nation. However, increasing and at times indiscriminate use of chemical fertilizers to achieve the production targets are damaging soil health, quality of water resources and human health.

Most Indian River basins are witnessing increasing water quantity and quality stresses. Better adaptation requires estimates of water demand and supply at various future times and their uncertainties. Currently, we have such estimates for only limited river basins, but the information is needed for all regions and major river basins. Further, even after substantial efforts in R&D and capacity building, not much headway has been made in managing the disasters. Fragmented governance is hampering adaptation. Activities are often initiated to respond to specific catastrophic events, but long-term planning and implementation at regional scales are lacking.

Since agriculture is the largest consumer of water, it offers the largest opportunity to save water. Wider use of micro-irrigation, targeted delivery of fertilizers and pesticides, emphasis on organic agriculture and right pricing will substantially reduce demand and water pollution. To close the gap between demand and supply and to manage extremes, it is necessary to conserve (flood) water by combining structural measures, such as reservoirs, and nature-based solutions, such as wetlands and ponds. Natural water retention in the cities can be increased by creating no-build zones and in catchments by land-use management, constructing check-dams, water harvesting, artificial recharge, etc. These measures must be supplemented with non-structural measures like early warning systems for better flood and drought management.

Increasing instances and magnitude of floods, droughts, heatwaves, air pollution, and more exposure are also leading to increasing vector-borne and water-borne diseases, mental diseases and allergies. Therefore, comprehensive adaptation strategies should involve health workers, counsellors and social scientists. Since *in-situ* adaptation has limitations, managed retreat, i.e. the purposeful, coordinated movement of people and assets out of harm's way, is a powerful approach.

Finances are important in determining what can be achieved by adaptation. Although more money is being allocated globally for adaptation in the water sector, much higher budget allocation is needed in India to reduce risks meaningfully. Strong institutions to plan and implement adaptation as well as monitoring, evaluation and execution are required. Adaptation plans should also have provisions to apply course corrections as needed.

AR6 of IPCC has emphasized Climate Resilient Development (CRD), integrated adaptation measures and enabling conditions with mitigation to promote sustainable development for all. CRD suggests that human and ecosystem functions be protected and maintained at the planetary scale and this can be achieved only when all nations make concerted efforts.

Climate change is a threat to human well-being and environmental health. Although every living being will be affected by it, impacts will be non-uniform. The poor and weak are the first and worst victims when calamities strike. Climate change is a global issue, but impacts are felt on a local scale. Hence, mitigation and adaptation should be practiced at various scales. Societies need to live in harmony with nature. It is best to avoid living in disaster-prone areas. Adequate space should be left for rivers to flow. People should reduce the use of natural resources, including water, and avoid polluting them.

These days, governments are beginning to consider climate change in development plans. All countries need to work together to fight this global threat. Hopefully, humanity will have the foresight to unite to meet this challenge. IPCC highlights that any further delay in global action on adaptation and mitigation will miss a brief and rapidly closing window of opportunity to secure a livable and sustainable future for all.

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