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Impact of climate change on water resources

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ABSTRACT
In many developing countries, there is a problem of water crisis. Climate change is adversely affecting the water cycle and in turn affecting water management. Increasing population, urbanization and climate change will put much pressure on water resources in future. Therefore, integrated water management will be required for sustainable management of water resource. Water is a key parameter affected by climate change and its management is important and therefore this paper aims to raise the understanding of the links between climate change and freshwater resources, in a manner that would help in taking decisions on water resource management. As there is a link between water resources and other sectors, therefore it can be said that water resource will inevitable affect other sectors too.

Keywords: Drinking Water, Integrated water management, urbanization, water cycle

1. INTRODUCTION
At present, 2-3 billion people do not have access to safe drinking water, 884 million lack accesses to an improved water source, 2.6 billion do not have access to improved sanitation, and 1.1 billion still practice open defecation (WHO and UNICEF, 2010). There is

more than enough water in the world for domestic use, agriculture and for industry. It is primarily poor water management and lack of water entitlements, rather than physical water scarcity, that generate water-related tensions and poverty.

When it comes to clean water, the pattern in many countries is that the poor get less, pay more and bear the brunt of the human development costs associated with scarcity (Summary, Human Development Report 2006). It is primarily poor water management and lack of water entitlements, rather than physical water scarcity, that generate water-related tensions and poverty (Castillo et al. 2009; Dipayan Dey, 2015). The inadequacy of the data actually collected in the water and sanitation sectors at national level is also a matter of serious concern.

The overall availability of water will be seriously impacted by climate change mainly through drought, the decline in water supplies stored in glaciers and snow cover, and flooding. Increased water scarcity (commonly defined as the condition in which the annual availability of renewable fresh water is 1,000 cubic meters or less per person) will result in increased competition between sectors such as domestic, agricultural and industrial water use. Groundwater levels of many aquifers around the world are in decline due to groundwater pumping surpassing groundwater recharge rates. Drinking water availability will decrease due to a worsening of water quality in the course of water pollution and salinization. In turn, waterborne sanitation will be adversely affected by the increased scarcity of water (Sherbinin & Dompka eds. 1998; Dagar and Shakuntla Devi Dagar, 2015). Water is a key parameter affected by climate change and its management is important and this forms the basis of this paper.

Bates et al (2008) enumerated other policy areas influenced by water resource management, including energy, health, food security and nature conservation, and propose that the appraisal of adaptation and mitigation options should ideally be conducted across multiple water-dependent sectors. As there is a link between water resources and other sectors, therefore it can be said that water resource will inevitable affect other sectors too. Therefore, there is a need to find measures on water resource management. Current water management practices may not be robust enough to cope with the impacts of climate change on water supply reliability, flood risk, health, agriculture, energy and aquatic ecosystems (Bates et al. 2008).

2. LITERATURE REVIEW

This section includes a review and analysis of available information on links between climate change and freshwater resources, along with an assessment of potential impacts.

Few issues have received so much attention and have generated so much controversy as the effects of increasing concentrations of CO_2 and other greenhouse gases in the atmosphere on temperature and climate. Predictions range from serious effects on ecosystems and our health, increased flooding and desertification (Hulme and Kelly 1993).

The fact of anthropogenic (i.e. caused or produced by humans) climate change is no longer in dispute in the peer-reviewed scientific literature. It is also clear that the main impacts of climate change on human beings and the environment occur through water. While climate change will create important pressures on water, however, it is not considered to be the most influential driver of these pressures beyond the water sector. In the assessment of the U.N., the most important drivers – forces and processes generated by human activities – are demographic changes and the increasing consumption that come with rising per capita incomes. Therefore, for present purposes, the impacts of climate change need to be seen in light of its direct effects on water resources as well as its indirect influence on other external drivers of change (UNWWDR, 2009).

The Intergovernmental Panel on Climate Change (IPCC) has warned that in many regions of the globe, changes to the supply and quality of freshwater resources resulting from climate change may imperil sustainable development, poverty reduction and child mortality goals (Bates et al. 2008).

Climate change will negatively impact on the quality of water in many parts of the world. Increasing water temperatures, higher or lower groundwater levels, floods and droughts raise the threat of heightened micro-organisms, chemical substances and radiological hazards in drinking water (CESCR, General comment No. 15). Many deltas in the world currently face water shortages which may be accentuated due to climate change and pollution. In the Mekong River Delta and Nile River Delta, freshwater shortage is currently already a big problem, and likely to increase in the near future (Most and Deltares et al. 2008). In the Small Island Developing States, water sources will be seriously compromised due to rising sea levels, changes in rainfall and increased evapotranspiration.

The deterioration of water availability and quality, caused by climate change, may have the indirect effect of raising operating costs and escalating the price of domestic water and sanitation, making these services unaffordable for low-income and marginalized households and posing significant challenges for tariff systems. The affordability of water and sanitation will be likely to decrease as water system reliability declines and operating costs for services rise, primarily due to the deterioration of water quality and water and sanitation infrastructure (IPCC Technical Paper VI).

Therefore, it becomes important to understand the link between climate change and water resources so that proper planning and measures can be designed and implemented for integrated water resource management. Also, urbanization and land use has to be considered with same importance as sometimes it may cause greater impacts and changes than the climate change.

3. MANAGING WATER RESOURCES

3.1. Water and wastewater efficiency

There are few case studies that show that various manufacturing sites have reduced the water usage. For example, in the last 5 years, PepsiCo’s water initiatives have enabled PepsiCo India to reduce water use in manufacturing plants by over 60%, and in the last two years alone, it has saved over 2 billion liters of water. Over the last 3 years, PepsiCo India has conducted trials of various rice varieties in farmers’ fields and used a seeding machine, which together have demonstrated water savings of 30% (WBCSD, March 2009).

BP has chosen to develop biofuels that are particularly water efficient – using rain-fed sugar cane and temperate sourced crops including non-food energy grasses. BP is further investigating biodiesel from jatropha curcas, a shrub that tolerates periods of low rainfall. Investment planning requires environmental and social impact assessments and stimulates mapping of water basin management which otherwise not take may place (WBCSD, March 2009; Hon'ble Chief Justice of India, 2015).

Veolia Water has implemented a 100% energy selfsufficient wastewater treatment plant in Germany. The quality of the incoming wastewater is monitored, which guarantees the quality of the sludge produced. The quantity of sludge is then reduced through thermophilic digestion and provides 60% of the plant’s electricity (other energy sources include biogas from landfill). The digested sludge and treated wastewater are used as irrigation and fertilizer in nearby fields (WBCSD, March 2009).

3.2. Carbon dioxide reduction

Since temperatures are projected to rise globally, average evaporation from oceans and other bodies of water will also increase, and therefore, globally averaged precipitation will also increase. However, the precipitation patterns may change (Albritton et al. 2001).

Some countries, especially small ones with little geographic and hydrologic diversity, are concerned about future water resources management and have tried to make some predictions as to what may happen to them in the long term. Such countries include The Netherlands which is concerned about increased flooding caused by the Rhine due to larger peak flows and rising sea water levels, and Israel which is concerned about water resources. The Dutch predictions (de Jong et al. 2001) are based on estimated average temperature increases by 4°C by 2100, from which they estimate precipitation increases by 4% in summer and 25% in winter which then go in their hydrological model to predict flood flows. These predictions are useful for long-range planning and they indicate that for the next 20 years, flood control dikes will still be feasible. As time proceeds, climate and climate science will develop further so that more detailed and reliable climate scenarios can be formulated. Sea level rises by the year 2100 are predicted to be in the range of 20–110 cm. Analyses such as these are useful for long-range planning for other river basins. If, indeed, increasing flood flows are expected, raising levees ultimately may no longer be feasible and construction of parallel flood ways may be the best approach. Normally, these flood ways would be farmed and there would be no expensive structures, so that when they are used for flood control and the ‘‘green’’ rivers become real rivers, there is minimum damage (Bouwer, 2002).

Dow Chemical’s site in the Netherlands uses household wastewater that is converted into industrial water to be used as feed water for several plants. In turn, wastewater from these processes is treated and used as feed water for the cooling tower. Three million tons of water per year that were previously discharged into the North Sea are now used two more times, resulting in 90% less energy use and a reduction in CO2 emissions of 1,850 tons/year. From 1994-2005, Dow reduced wastewater by 38% (per pound of production) globally (WBCSD, March 2009).

TEPCO's high-efficiency heating and cooling system for Sony Corporation's new headquarters in Tokyo uses waste heat from a public sewage treatment plant. The result is a reduction of approximately 3,500 tons of CO_2/year and 92% less water used compared to a common office building (WBCSD, March 2009).

3.3. Providing the right technology

One of the biggest US wastewater treatment plants, the metro plant for the twin cities of Minneapolis/ St. Paul, gathers and treats, on average, 250 million gallons per day (about 950 million liters) of the municipality's wastewater. To lower energy costs and improve treatment efficiencies, the municipality replaced the existing inefficient, coarse bubble aeration system with over 320,000 ceramic and membrane fine bubble diffusers from ITT.

GHD, working with Foster's Brewing, developed a water recycling scheme for the brewery that allowed them to augment the size of their Yatala brewery while reducing its water and energy footprint. The upgraded brewery reduced water use from 3.9 liters to 2.1 liters of water per liter of beer produced. Significant energy savings were achieved by not having to treat and transport water to the site and then treat and remove waste from the site (WBCSD, March 2009).

At an Abbott Laboratories pharmaceutical plant in Ireland, one particular water pump was causing maintenance difficulties. A life cycle cost assessment found that the pump was "over-specified" and was running at a greater speed than was required, causing poor performance and large energy bills.

3.4. Water-use planning

Water use planning is a decision making process that engages stakeholders in developing options for achieving a sustainable balance among social, financial and environmental interests.

3.5. Innovative technologies for water savings

Technologies like treatment and recycling own water and wastewater (with associated energy costs), recover and reuse water and energy (e.g., using steam or heat, recycle other industrial and municipal wastewater) are important.

3.6. Participatory activities to manage water locally

This can be achieved by conserving each drop of rainwater in the region by raising awareness and collaboration.

3.7. Forecasting the effects of climate change

In the UK, Veolia Water studied the impact of climate change in the long-run on the two main aquifers supplying water to the South-East of England, in particular the greater London area, providing 70% of the raw water treated by the company. Specialists implemented new tools allowing the Three Valleys Water Company to apply the results of the Inter-governmental Panel on Climate Change's Global Climate Models, to adapt them to the regional scale, and to generate the forecasted impacts on the evolution of the groundwater resource in 25 years time.

4. CONCLUSION

The goal of water management can be achieved through a range of policy instruments including appropriate low-cost techniques and technologies, appropriate pricing policies such as free or low-cost water services, targeted subsidies, and/or income supplements. Integrated water management will be achieved if the solutions to the problems of availability, accessibility, affordability and quality of water and sanitation in the context of climate change have been designed with the participation of the concerned communities. The purpose of mitigation actions is to prevent global average temperatures rising above the dangerous threshold of 2°C above pre-industrial levels. The Bali Action Plan encourages the adoption of measurable, reportable, and verifiable mitigation actions, as does the Copenhagen Accord of 18 December 2009 (Bodansky, 2010). On the most authoritative projections available at present, in order to avoid dangerous levels of GHG emissions the total amount of global emissions needs to fall by at least 50 to 85 per cent from 2000 levels by 2050. This means that heavily polluting OECD countries will need to have cut their emissions by 80 to 90 per cent, and developing countries will probably need to cut their collective emissions by 30 to 60 per cent, having peaked by the year 2025 (Humphreys, 2010). Integrated Water Resources Management (IWRM) provides a potentially valuable framework by which to adapt to climate impacts on water resources. IWRM is an approach to water management that explicitly recognizes the need to structure and manage trade-offs between competing water uses and promote the coordinated development and management of water, land and related resources, while preserving the integrity of the resource base and the sustainability of vital ecosystems. As water demands and environmental needs grow, water recycling will play a greater role in overall water supply. By working together to overcome obstacles, water recycling, along with water conservation can help us to con serve and sustainably manage our vital water resources.

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