CLIMATE RISK ADAPTATION AND MITIGATION IN INDIA: ROLE OF RESERVOIRS AND HYDROPOWER

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1. INTRODUCTION

India is growing so is the dependence on natural resources. Water takes a center stage whether it is meeting domestic, agricultural, industrial, or environmental demands from natural systems. As per the National Commission for Integrated Water Resources Development estimates, overall water demand in India will increase to 1,180 billion cubic metres (BCM) by 2050 [1]. This is an increase of over 67 percent of the 2010 levels. Among sectors, water demand for power generation, inland navigation, and maintaining aquatic ecosystem will increase by three-fold, for industries and domestic uses it will be more than double. As per the Council on Energy, Environment, and Water (CEEW) estimates, water consumption will increase by 3.2-6.5 percent per annum for the inland thermal power plants under various scenarios, ranging from renewable energy dominant to the fossil-fuel dominant economy, and they will continue to play an important role in India's energy mix [2]. Nonetheless, with an estimated requirement of 807 BCM in 2050, irrigation will continue to be the major driver of the water demand.

At the National scale, the per capita water availability is already below the water stress threshold limit of 1700 cu m per annum. Even during normal rainfall years, significant parts of central and peninsular India experience water scarcity. This is mainly due to the large-scale spatial and temporal variability in climate and geo-hydrological settings. Most of peninsular India is underlain by hard rocks (consolidated formations) which have limited aquifer storage potential to receive recharge water [3]. As a result, well failures and water shortages during summers are common in such areas [4]. Considering that the present average freshwater availability (average annual utilizable is about 1,123 BCM) is further expected to be adversely influenced by climate variability and change, better planning of water resources development and management is required to provide water security during dry years and the period of seasonal water scarcity.

2. CLIMATE-INDUCED HYDROLOGICAL CHANGES AND THEIR IMPACTS

The whole of South Asia is experiencing long-term changes to climate resulting in increased occurrence of extreme weather events such as floods and droughts. As per a study by the Council on Energy, Environment, and Water (CEEW), India has witnessed more than 478 extreme weather events between 1970 and 2019, most of them occurring after 2005 [5].

As per the latest IPCC report findings, both the intensity of heavy precipitation (especially in coastal areas) and the length of the dry spell have increased in the Indian sub-continent. Also, the global terrestrial annual evapotranspiration (ET) has increased since the early 1980s, driven mainly by the climate-induced increasing atmospheric water demand, and vegetation greening. In parts of southern India, the ET has been increasing by up to 100 mm/year [6]. As a result of changes in rainfall and ET along with land-use changes in the catchment, the river flow has been altered and in fact, decreased in most of the river basins in India. The evidence is clear that along with climate variability, human influence on climate is leading to reduced water availability in many regions of India [6].

The observed hydrological changes pose a significant risk to water availability for agriculture, energy production, industrial, domestic, and environmental needs in India. It is projected that paddy production will decrease by 10 to 30 percent and maize production by 25 to 70 percent by 2080 due to increased water stress under a temperature increase of 1° to 4°C [6]. Similarly, Coal power plants' annual usable capacity factor is projected to decrease due to water constraints under a 2°C global warming scenario (Wang et al., 2019b). However, gross hydropower potential is expected to increase by 20% by the end of the 21st century due to increased rainfall in some parts. Urbanization and climate change driven urban heat island (UHI) effect will increase the domestic water demand substantially. Further, the urban extent in drylands is expected to increase from 2000 to 2030, exposing the population in Indian cities to drought risk [6].

3. ROLE OF DAMS IN CLIMATE ADAPTATION

Infrastructural measures are one of the important options for adaptation to climate variability and change. Some of the infrastructure-based adaptation options in the water sector include building water storage facilities, stormwater management systems, and wastewater treatment infrastructure.

Surface storages (reservoirs) created through dams are the most important source of water supply for irrigation, domestic uses, and industries (mainly the thermal power plants). Further, they ensure domestic water supply in many rural and urban areas during the summers. As the climate-induced changes are going to interfere with the rainfall pattern with a high probability of high-intensity rainfall falling only over a few days during the monsoon, the role of reservoirs in providing water security during the lean season (non-monsoon) becomes much more important. Also, dams play a crucial role in flood control.

As of 2018, there are 5,334 completed large dams[1] in India having a gross reservoir storage capacity of about 325 billion cubic metres (BCM). By the end of the 12th five-year plan, the irrigation potential utilised by developing reservoir-based major, medium, and minor irrigation projects was 46.5 million hectares [8]. Freshwater withdrawal for electricity generation in India was estimated to be 33.6 BCM in 2015 [2]. About 90% of this was for the thermal power plants requiring a huge amount of water, thus can be safely assumed to be from the reservoirs. Additionally, many metropolitan cities such as Delhi, Bengaluru, Hyderabad, depend on reservoirs to meet their growing water demand. Thus reservoirs are important for the food, energy, and livelihood security in India.

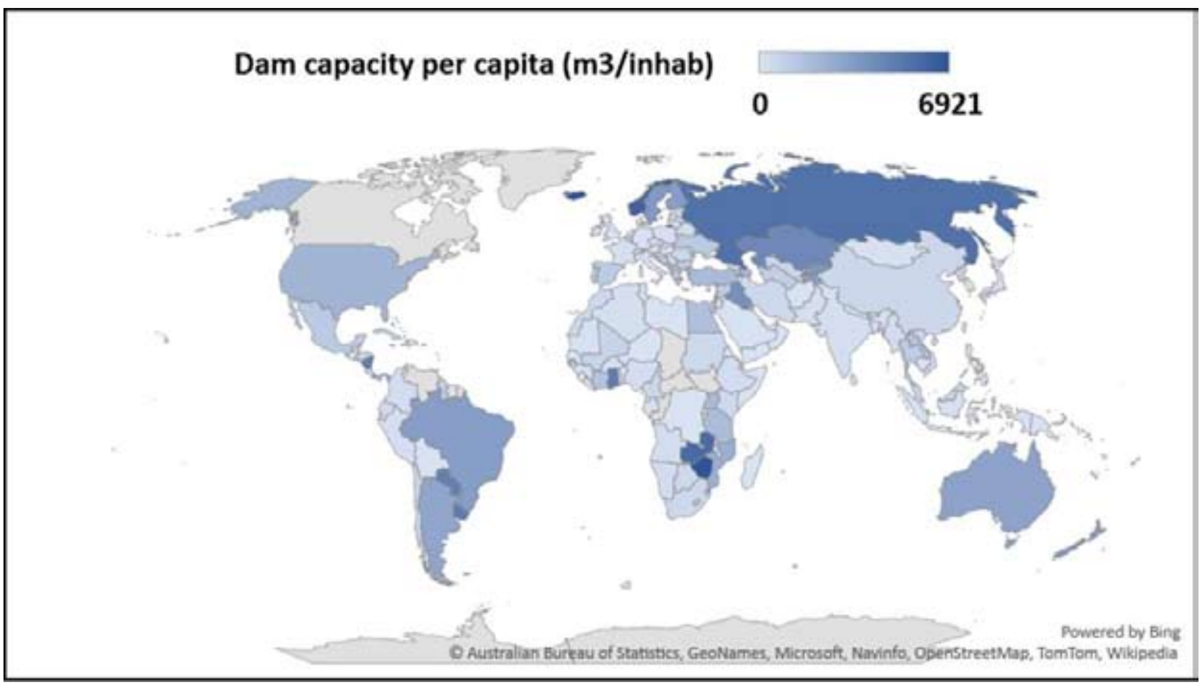

Fig. 1 : Per capita dam storage in different countries of the World, 2018
(Source: Prepared by the author using data from the FAO Aquastat)

1. A large dam is classified as one with a maximum height of more than 15 metres from its deepest foundation to the crest. A dam between 10 and 15 metres in height from its deepest foundation is also included in the classification of a large dam provided it complies with one of the following conditions: [a] length of crest of the dam is not less than 500 metres; [b] capacity of the reservoir formed by the dam is not less than one million cubic metres; [c] the maximum flood discharge dealt with by the dam is not less than 2000 cubic metres per second; [d] the dam has specially difficult foundation problems; or [5] the dam is of unusual design [9].

However, India has one of the lowest per capita surface water storage in the World (Figure 1). As of 2018, it was about 183 cubic metres (cu m) per person. In comparison, the per capita dam storage is much higher in other major economies. It is 537 cu m in South Africa, 569 cu m in China, 1153 cu m in Spain, 2250 cu m in the United States, 3124 cu m in Australia, 3344 cu m in Brazil, and 5500 cu m in Russia. There is no doubt that India needs more storage to better adapt to the challenges imposed by climate variability and change in the future. However, given the tradeoff between the social and economic benefits and social and environmental impacts of the large dams, the approach can be to a] develop run-of-the-river projects which need limited storage and hence have no major social (loss of productive land due to inundation, displacement issues, etc.) or environmental (loss of forest) impact; and b] build off-stream reservoirs or constructed wetlands which can be used to store floodwater or water diverted from the river during high flow events. The former will ensure a continuous shift towards clean energy production and the latter will contribute to flood control and assuring water security.

4. DAMS AND CLIMATE MITIGATION

Dams play an important role in climate mitigation as they contribute towards producing the cleanest form of electricity (Hydro-power). The hydroelectric potential in India is 148.7 gigawatt (GW), almost 81 percent is in the Brahmaputra, Indus, and Ganga river basins [8]. As of January 2022, only 45 GW capacity has been installed. Hydroelectric plants are the cleanest low-carbon technology in terms of their carbon footprint over the full life cycle [10], it is about 2–13 g CO_2-eq/kWh of electricity production. The carbon emission over a full life cycle for other renewable sources is 10–39 g CO_2-eq/kWh for marine technologies, 15–53 g CO_2-eq/kWh for geothermal power plants, less than 26 g CO2-eq/kWh for nuclear power plants, 20–38 g CO_2-eq/kWh for wind turbines, and 35-88 g CO_2-eq/kWh for solar PV panels [11].

5. CONCLUSION

Since independence, dams have played an important role in the economic growth of the country. They have been proclaimed as 'temples of modern India'. Considering the increasing climate variability and the hydrological changes projected to be induced by climate change, India needs to increase its per capita storage for water security. Further, in line with its commitment to carbon-neutral growth, India needs to fully exploit the hydropower potential. However, large dams do present a challenge of managing the economic, social, and environmental trade-offs. To address such concerns, it is suggested that in the future focus should be on developing run-of-the-river hydro-power projects that require very limited storage and constructing off-stream reservoirs to not interfere with the river's natural flow.

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