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# Sustainable Water Management: Possible Solutions

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## Introduction

In India the stress of increasing population and water use are making the freshwater inadequate and polluted and posing a major threat to water resources. The disputes between the states are a threat to peace as well use of water. The adoption of new innovations is vital to preserve, harness, develop and manage water resources keeping in view both their quantity and quality. Sustainability involves meeting the existing water requirement without compromising the ability of future generations to meet their own demand.

Sustainable development in terms of economic, social, and environmental context water is a major factor. India has to initiate a series of measures to ensure that her people have access to clean water and sanitation, there is food security, and there is no water related conflicts.

Water must meet the needs of the present population and those of future generations. the demand for water has been ever-increasing and is expected to reach a whopping 5890 km3/year by the middle of the present century. While the per capita demand for water has been increasing, the availability of the same has been decreasing due to various anthropogenic activities. Presently, more than 50% of the world's population lives under the threat of water-stress conditions.

## Water Resources of India

The global freshwater consumption was 3800 km3/year in 2017 and is projected to increase upto 5890 km3/year by 2050, Half of the world's population lives under high-to-low-water stress conditions, with one-fourth lacking access to safe and treated drinking water. The current status on sustainable development goal 6 on water and sanitation (SDG-6) is as follows: 26% and 46% of the world's population lacks a safely managed drinking water source and sanitation facility, respectively, and 19% of the world's renewable water resources are being withdrawn.

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India accounts for more than 17% of the world's population. However, its share of fresh water sources is only 4%. Presently, India has 1137 BCM (billion cubic metres) of water in surface and groundwater sources put together. As per the recent report prepared by the National Institution for Transforming India (NITI Aayog), the per capita water availability in 12 river basins including Ganga River basin is around 1000 m3.

**Precipitation**

The average annual rainfall for the country is 1160 mm which is the highest in the world for a country of similar area. In terms of volume, India receives an average annual precipitation of about 4000 $km^3$. Rainfall is mostly dependent on the South-West and North-East monsoons, on shallow cyclonic depressions, on local storms and disturbances. In India, precipitation has very high spatial and temporal variations. Most of it (about 3000 $km^3$) falls under the influence of South-West monsoon and about 21 percent of the country's area receives less than 750 mm of rain annually while 15 percent receives rainfall in excess of 1500 mm.

**River-basins**

The river basins in India, except Godavari, Brahmani-Baitarani, Mahanadi and Narmada will be facing water scarcity. Climate change will further exacerbate the problem. It has been well recognized that climate change is going to pose a significant challenge to sustainable water management world. The Water from various sources, such as precipitation i.e. rainfall and snow, surface water in rivers, lakes, and reservoirs, and replenishable groundwater. Out of the total available water resources, approximately 690 BCM is surface water, while the remaining 436 BCM is groundwater. Out of the total available water resources, around 690 BCM is surface water, and the remaining 436 BCM is groundwater. According to the most recent estimate, India's annual groundwater recharge totals 437.60 BCM. When accounting for natural discharge, the yearly extractable groundwater resource is projected to be 398.08 BCM. In 2022, the annual groundwater removal is 239.16 BCM (CGWB 2022). Thus, with the extraction of 239 billion cubic meters groundwater per year, India stands as the largest groundwater extractor in the world.

**Annual Water Requirement ($km^3$) for different Uses**

| Uses | Year 1997-98 | Year 2025 | | | Year 2050 | | |
|---|---|---|---|---|---|---|---|
| | | **Low** | **High** | **%** | **Low** | **High** | **%** |
| Irrigation | 524 | 561 | 611 | 72 | 628 | 807 | **68** |
| Domestic | 30 | 55 | 62 | 7 | 90 | 111 | **9** |
| Industries | 30 | 67 | 67 | 8 | 81 | 81 | **7** |
| Power | 9 | 31 | 33 | 4 | 63 | 70 | **6** |
| Inland Navigation | 0 | 10 | 10 | 1 | 15 | 15 | **1** |
| Environment Ecology | 0 | 10 | 10 | 1 | 20 | 20 | **2** |
| Evaporation Losses | 36 | 50 | 50 | 6 | 76 | 76 | **7** |
| Total | 629 | 784 | 843 | 100 | 973 | 1180 | **100** |
| Population (million) | | 1286 | 1333 | | 1346 | 1581 | |

**Ground water resources**

The total augmented groundwater resource of the country is assessed as 433%. After allotting15% of this quantity for drinking, and 6 $km^3$ for industrial purposes i.e. total 71 $km^3$, the remaining i.e. 433-71=362 $km^3$ can be utilized for irrigation. Out of this, the utilizable quantity i.e. 90% is 326 $km^3$. Total Utilizable Ground Water Resource = 326 + 71 = 397 $km^3$.

The overall stage of groundwater extraction in the country is 60.08%. The stage of groundwater extraction is very high in states like Haryana, Punjab, Rajasthan, Dadra & Nagar Haveli, and Daman & Diu, where it is more than 100%. In Delhi, Tamil Nadu, Uttar Pradesh, Karnataka, and UTs of Chandigarh, Lakshadweep, and Puducherry, the stage of groundwater extraction is between 60-100%. In other states, the stage of ground water extraction is below 60%. Out of the total 7089 assessment units (Blocks/Talukas/Mandals/Districts/Firkas/Valleys), 1006 have been categorized as 'Over-exploited', 260 as 'Critical', 885 as 'Semi-critical', and 4780 units as 'Safe'. There are 158 assessment units, which are completely saline. The percentage of over-exploited and critical administrative units more than 25% of the total units are in Delhi, Haryana, Karnataka, Punjab, Rajasthan, Tamil Nadu, Dadra & Nagar Haveli, and Daman & Diu.

**Per capita per year availability and utilizable surface water in India (in $m^3$)**

| Year | Population (in million) | Per-capita surface water availability | Per-capita utilizable surface water |
|---|---|---|---|
| 1951 | 361 | 5410 | 1911 |
| 2001 | 1027 | 1902 | 672 |
| 2011 | 1210 | 1614 | 570 |
| 2050 (Projected) | 1346 (Low growth)<br>1581 (High growth) | 1451<br>1235 | 421 |

**Futuristic Demand of Water in India in BCM**

| Year | Irrigation | Drinking | Industry | Energy | Others | Total |
|---|---|---|---|---|---|---|
| 2025 | 910 | 73 | 23 | 15 | 72 | 1093 |
| 2050 | 1072 | 102 | 63 | 130 | 80 | 1447 |

## Sustainable Water Management- Approaches

### Recycling of Water

The difference between water availability and water demand has been ample in most of the cities. This has forced many cities to source water either from faraway places or to go for costly desalination. The reuse of treated wastewater is an attractive option for bridging the gap between the demand and supply of water. In 2017, IIT Madras has

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implemented a water infrastructure system for 100% reuse of the treated wastewater for: (1) toilet flushing; (2) horticulture; (3) maintenance of sports facilities; (4) centralized air conditioning plants; (5) selling the treated water to external users, and (6) for storing in a lake for future use. The system costed 100 million INR for installation, and this investment was recovered within four years of installation. The efficient and safe operation of this 4 MLD capacity system has convinced Chennai city for scaling it to 260 MLD system to bridge the gap between the demand and the supply in the city. Wastewater is a source of energy, carbon, and nutrients. The new innovative technologies and management strategies need to be developed to make the wastewater/organic waste management.

**Hydrological Information System**

Hydrological Information System (HIS) is a inclusive, reliable, and easily accessible pre-requisite for optimally utilizing the water resources. The availability of meteorological data is very good, that of surface water satisfactory and data on groundwater good. But the data on water quality is limited. Although groundwater availability maps have been prepared for certain locations, extraction rates are often not available. To achieve these objectives, there is a need to strengthen the existing monitoring network; proper coordination amongst the different agencies is essential.

Many initiatives have been taken including the Hydrology Project phase 1 and 2 to improve the existing Hydrological Information System in India, the objective to develop and improve the existing HIS of various government agencies in peninsular states of India. Besides this, many other government organizations are putting in efforts towards collection and distribution of hydrologic and related data.

**Water Conservation**

The conservation of water inferred improving the availability of water by storing it in soil, water tanks, surface reservoirs and groundwater zone. If one looks at utilizable water resources in major river basins, these resources in Indus, Ganga, Brahmaputra, and Godavari basins are 73.31, 525.02, 629.05 and 110.54 $km^3$ per year, respectively. The storages available in these basins, including projects under construction, are 16.28, 54, 3.5, and 30.16 $km^3$. So it requires only a small fraction of available water is being regulated at present. The agricultural practices accounts for about 82% of all water withdrawn, it has the greatest potential for conservation. Just a 10% improvement in irrigation efficiency could conserve enough water to double the availability for drinking.

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The Modern methods of irrigation like use of drip and sprinkler irrigation saves large quantity of water. So there is utmost need to promote for large-scale adoption of sprinkler and drip irrigation in various parts of the country. Rainwater harvesting is another process to capture and store rainfall for its efficient utilization. It helps in checking the decline of water table, and may also control soil erosion and flooding. People were familiar with this concept and it is being robustly promoted as a water conservation method for sustainability.

**Inter-basin Water Transfer**

The technique of transfer of water from surplus areas to deficit areas is an old concept. Inter-basin water transfer is an option to partly overcome the spatial and temporal imbalance of availability and demand. Many such schemes have been implemented all over the world and in India too. A National Perspective Plan (NPP) for water resources development was formulated by the Government of India in 1980s. NPP comprises of two components: (a) Himalayan Rivers Development, and (b) Peninsular Rivers Development. Most of the clearances for the Ken-Betwa Link project have been obtained and work on this project is likely to begin soon. The next projects in pipeline are the Damanganga-Pinjal link and Par-Tapi-Narmada projects. Work on many intra-state links is under progress. For providing water to South India, Manas-Sankosh-Teesta-Ganga link and the Mahanadi-Godavari links will be crucial.

**Desalination of Water**

In desalination technologies, including distillation, and reverse osmosis, desalination is suitable in areas where freshwater is scarce but saline water is available and cheap energy is available. In comparison to water recycling technologies, desalination presents fewer health risks. The desalination process mostly uses fossil fuels. As the cost of the process come down, desalinization will become commercially more feasible.

**Mitigating Climate Change**

It has been well familiarized that climate change is going to pose a significant challenge to sustainable water management world over. Climate change is likely to result in hydrologic conditions and extreme weather conditions of a nature that will be different from those for which the existing projects were designed. It will not be advisable to be complacent about climate change which may ultimately put the planners and managers in a condition for which they may not be ready. Somerecommendations to cope up with the problems in a systematic and a planned manner are: i)A nationwide climate monitoring and awareness program should be developed; ii) Formulations of such new projects that influence climate, it should be ensured that no action is taken which causes irreversible harmful climatic impact; iii) Precise methodology for accounting of climate related uncertainty should be developed and made part of decision making; iv) The existing systems should be examined and reviewed to determine how they will perform under the future adverse climatic conditions; v)The availability of water and demands in all regions should be reassessed in the future circumstances; vi) Operating rules should be reviewed and updated as per requirement.

**Water Governance**

The existence of water governance crisis which has arisen due to mis-management of water and unscientific policies. The Ministerial Declaration of the 2nd World Water Forum, held in 2000 defined the main goal of water governance "to provide water security in the 21st century". This requires that freshwater, coastal and related ecosystems are protected and improved and every person has access to enough safe water at an affordable cost. Further, the vulnerable people are to be protected from the risks of water-related hazards. The need of the hour is to have appropriate policies towards sustainable water management and generate awareness among the citizens about the need to protect, preserve, and enhance existing resources of water.

**Extensible Strategies**

The measures of recycling of treated wastewater, rainwater harvesting at household level and managed aquifer recharge for increasing the groundwater storage helpful to attain a sustainable water supply system. This essentially means one has to plan all the three infrastructures, that is, the supply system of water, the wastewater management system, and the storm water drainage system in an incorporated way, unlike the present practice of planning the three components separately. This requires the appropriate framing of water allocation studies based on changing land-use patterns, uncertainties in future demands, impact of climate change on water availability, spatial distribution of sources, and types of sources in the future.