1. EQUITABLE WATER RESOURCE MANAGEMENT

Overview

United Nations General Assembly (UNGA) resolution adopted in July 2010, explicitly recognizes the human right to water and sanitation and also calls upon international co-operation to help countries, particularly developing countries, to provide safe, clean, accessible, and affordable drinking water and sanitation for all. According to World Health Organization (WHO), a person requires a minimum of 50 litres of water per day to meet the most basic needs and the water source has to be within 1 km reach. Globally, 2.3 billion people live in water-stressed countries and about 2.0 billion people lack access to safe drinking water. Global consumption of water is doubling every 20 years. This consumption growth is more than twice the rate of human population growth.

Blessed by nature, every year on an average, India receives nearly 4000 billion cubic metres (BCM) of water through rainfall of which about 1999 BCM form available water in *rivers, lakes, reservoir, groundwater, and glaciers*. However, India is home to 18% of the world's population but just 4% of the fresh-water resources of the world. The Global Climate Risk Index 2021 ranks India as the 7th most-affected country from climate-related extreme weather events such as storms, floods, heatwaves, etc. Widespread drought in July 2019 followed by devastating floods in August 2019 in Chennai, Flash floods of Uttarakhand (2013) and Wayanad (2018) can be seen as a perfect example of extreme events due to changing climatic trends.

Considering Ecosystem Restoration significant, the United Nations has also called for 'UN Decade on Ecosystem Restoration 2021-2030'. Even the Sustainable Development Goal (SDG) target 6.1 aims universal and equitable access to safe and affordable drinking water for all by 2030.

Issues

- The distribution of this water and rainfall is not uniform across the country. E.g., Brahmaputra and Barak basins, the most flood prone basins, which have surplus water availability drain its major share into Bay of Bengal. At the same time, basins like Cauvery and East Flowing Rivers (EFR) between Pennar and Kanyakumari are facing water deficiency.
- In India, analysis done by Central Ground Water Board on groundwater availability and utilization reveals that annual extraction in 16% of the total assessed area is 'over-exploited', and 14% is at 'critical' or 'semi-critical' stage. Due to universal availability, easy access, and low cost of extraction, groundwater is the most preferred source of water for various uses in India. The overall stage of groundwater extraction(ratio of annual withdrawal to annual availability) in the country was at nearly 62% in 2020. This ratio stood very high (more than 100%) in the states of Punjab, Haryana. Rajasthan and Delhi.
- Taking up new and large storage projects often take long gestation period due to the time required to manage environmental aspects, resettlement and rehabilitation processes, investigation and other issues arising in the implementation stages. *The concept of inter-basin transfer was formalized in the year of 1980 under National Perspective Plan (NPP), but the first inter-linking project of Ken-Betwa is set to begin after 40 years since inception.* A significant quantity of the reservoir storage capacity is also lost in siltation which reduces the effective potential of the projects.
- Cropping Pattern - Only 68 million hectares out of the net sown area of about 140 million hectares are covered under irrigation and the rest is rainfed. Out of the total irrigated area around 46% is under rice and sugar cane, the top two water consuming crops, and 41% under wheat.
- Irrigation Practices –
  - ✓ Among domestic sectors about 91% of the water is consumed for irrigation purpose in India, while the figure is in between 30-70% in many other countries. (Consequent to partition of the country in 1947 food

problem for India worsened as large parts of the highly developed canal irrigated areas were included in Western Pakistan. India, therefore had to utilize its water resources to the fullest extent practicable and the five-year plans gave prominence to irrigation sector).

- ✓ Over consumption of water in agriculture sector is also due to the conveyance loss during distribution through canals, flood irrigation farm fields, cultivation of crops without regard to the agro-climatic conditions (E.g., dominance of high-water consumption crops even in arid zones), misconception among farmers that more water brings more yield, unplanned and untimed irrigation schedule, and poor quality of irrigation water. Indian farmers use 2 to 4 times more water to produce a unit major food crop than in China or Brazil.
- ✓ Operation of most of the major and medium irrigation projects involves significant number of human interventions and manual calculations based on static data, which often causes losses which are avoidable.
- ✓ Although the conjunctive use of surface water and groundwater was strongly advocated by the government since the inception of irrigation schemes in the country, it has not been practiced judiciously.

- During 1980s groundwater irrigation expanded at a much faster rate than canal irrigation. Consequently, area under canal irrigation not only stagnated but declined to 23.43% in 2014-15. There are some specific reasons for making canal irrigation out of favour : *low reliability and reduced flow of water at source; poor maintenance of canal and tributaries; poor utilisation of the irrigation potential created; and an increase in cultivation of water intensive crops; and adoption of water intensive practices*.
- Increased Groundwater Extraction - The gains in irrigated agricultural production have progressively led to a significant decline in groundwater levels particularly in north-western and Peninsular southern India. It may even lead to salt-water intrusion in coastal aquifer which is a permanent damage to the water quality. Further, as the depth of groundwater falls more energy is consumed to pump water resulting in higher cost of irrigation and cultivation.
- Urban/ Rural areas haven't increased efficient treatment of their used water.
- Impact of Climate Change - Data for period 1971-2020 shows that the long period average (LPA) of south-west monsoon declined by 1 cm and that of annual rainfall 1.7 cm, as compared to 1961-2010 average. Shortage of 1 cm rainfall across the country means an annual reduction of about 25 BCM to 30 BCM equal to the quantum of water required to meet annual domestic water demand of 600 million people with 135 litres per day.
- Socioeconomic Disparities - In most of the households due to not having water supply on the premises, women and girl children are often burdened with the responsibility of fetching water from far or collecting water from tankers. The associated hassles hampers quality education and independent income generation.
- Consumption Pattern – India's domestic water sector consumes about 7% of total water consumed annually. Drinking water is considered as wastewater/used water immediately after it leaks out from tap or distribution pipeline. This means, though the total quantity of drinking water is only about one tenth of irrigation water, the economic loss of leakage and theft from drinking water supply line is much more than that from irrigation canals. The per-capita availability estimated to be at 1,486 cubic meters in the year 2021 by Ministry of Jal Shakti is expected to fall to 1,140 cubic meters by the years 2050. (*The annual water availability of less than 1,700 cubic meters is considered as water-stressed condition, whereas below 1,000 cubic meters it is considered as water scarcity condition*.)

Solutions

- To address these spatial and temporal disparities, the available water should either be stored in reservoirs or be transferred from surplus basins to deficit ones. Both these options aren't easily implementable owing to certain inherent limitations.

- Good Agricultural Practices-
  - ✓ India needs a paradigm shift from its cultivation from rice and sugarcane to millets which are nutritious and water efficient. UNGA has adopted the idea proposed by Government of India (GoI) to declare 2023 as International Year of Millets.
  - ✓ A study conducted by the Department of Agriculture Cooperation and Farmers Welfare to assess the impact of micro-irrigation revealed that irrigation cost gets reduced on an average by 32.3%, energy consumption by 31%, average productivity of fruits and vegetables increased by at least 40%, saving of Fertilizers is increased by 7- 42% and average rise in farmers' income by 48.5%. As on today, only 14.5 million hectares are covered under micro-irrigation.
  - ✓ The traditional methods of irrigation, mainly flood irrigation, have low irrigation efficiency (38%) due to excessive seepage loss and inequitable and untimely supplies. Adoption of water saving technologies such as sprinkler and drip irrigation systems (90% efficiency) can be very effective.
  - ✓ Mulch is any covering material, either organic or inorganic, applied on soil surface to create a barricade which does not allow escape of soil moisture. Mulching improves soil structure, reduces soil salinity and also controls weeds. Various types of plastic mulches are available in market, but mulching can also be effectively done by using agri-wastes such as wheat straw, gross clippings, leaf debris, etc. Reducing seepage prevents soil erosion and improves water availability over a longer period of time for irrigation purposes.
- Technology Infusion –
  - ✓ This could be in the form of automation of canal operation, real-time assessment of irrigation requirement with the help of Artificial Intelligence (Al), modern and water saving irrigation methods, automated leak detection in drinking water pipelines, cost-effective wastewater treatment, on-the-spot water quality testing, and zero-liquid discharge power plants. A dynamic irrigation schedule that considers actual rainfall, soil moisture, stage-of the crop growth and seasonal change in cropping pattern is nearly impossible manually but can be easily achieved by an Al system.
  - ✓ *Direct Seeded Rice (DSR)* and *System of Rice Intensification (SRI)* can save 25-30% of water compared to traditional flood irrigation. In sugarcane, *trench farming* has been found very effective in saving water.
  - ✓ Moisture sensors and automated irrigation systems which can be controlled by a farmer using smart phone, can create an irrigation schedule.

AGNIi Mission (Accelerating Growth of New India's Innovations)

AGNIi is one of the nine missions under the Prime Minister's Science, Technology, and Innovation Advisory Council, working under the Principal Scientific Adviser (PSA)and executed at Invest India, the National Investment Promotion and Facilitation Agency. It focuses on the following:

- Bridging the Gap between Innovators and Adopters: AGNIi partners with agencies and organisations understanding their strategic, policy, and programmatic priorities at leadership tier, and their operations in the field. Around these pain-points, AGNIi formulates operational scenarios that these agencies themselves would recognise.
- Creating a Scalable Impact: AGNIi institutional partnerships establish channels that help to better understand community needs.
- Empowering the Bottom of the Pyramid: A primary AGNIi aim is to ensure that Government's guiding principle of Antyodaya - that the poor, marginalised, and those left behind-are engaged to the maximum possible extent.

- Supporting the Competitiveness and Capturing the Value of Indian Technology.

Water Availability

- **Atmospheric Water Generators (AWGS)** – AWGs essentially extract water from humid ambient air and convert the same into potable water. These are decentralised, economical and environment-friendly systems that generate clean water through a multi-stage filtration process and then mineralise the same before dispensing. Recently such solutions have gained traction and have been installed in public spaces such as the Secunderabad railway station in Telangana by the Indian Railways and schools in Uttarakhand to ensure availability of improved quality water.
- There are indigenous solutions for real time doorstep delivery of safe drinking water through remote supervision and control through GPRS connectivity in real time.

Water Quality

- **Filtration solutions:**
  - ✓ The Indian innovation ecosystem provides various sustainable water filtration and membrane-based cost-effective technologies for treating water.
  - ✓ Meanwhile, the Council of Scientific and Industrial Research (CSIR)- Central Salt and Marine Chemicals Research Institute, Bhavnagar has developed an indigenous hollow-fiber membrane technology that provides sustainable cost-effective process with nearly 100% water recovery to treat water containing suspended particles, pathogens, and other harmful micro-organisms.
  - ✓ Similarly, CSIR- Indian Institute of Toxicology Research, Lucknow has developed *Oneer* an innovative water technology that eliminates pathogens such as virus, bacteria, fungi, protozoa, and cyst to provide safe drinking water to communities as per national and international standards for potable water.
- **Monitoring solutions:** They essentially utilise sophisticated tools such as IoT that enables low-cost, low-power, and real time monitoring of water quantity (water levels, flow, soil moisture, and rainfall intensity) and quality (pH, conductivity, turbidity, dissolved oxygen, Trace metals, and micro-organisms).

Collaborating for Clean Water

- **Quenching Eastern India's thirst** - AGNIi collaborated with Aga Khan Foundation in December 2018 for identification of affordable water filtration technologies to be deployed in selected sites in Eastern India.
- **Strengthening Grassroots Networks** - MeitY's CSC network with its strong on-ground presence can play a pivotal role in facilitating adoption of clean water technologies to rural remote areas of the country.
- **Partnering with Global Stakeholders** - WaterAid a multinational NGO works for empowering local communities and ensures delivery of innovations/technologies in pursuit of clean water and sanitation for all. It has partnered with AGNIi.

- Nature-based solutions to manage water sector involves enhancing and delivering natural ecosystem services such as mangroves protecting shorelines from storms, peatlands sequestering carbon, wetlands filtering contaminated water, lakes storing large water supplies, and floodplains absorbing excess water runoff. In urban set up, the idea is to integrate grey build up infrastructure to support and complement natural infrastructure such as promoting green roofs, open and green buildings, planting trees and terrace gardens, recycling, and reusing water and much more.
- Tapping rainwater is also required to rejuvenate urban lakes and ponds. For instance, the city of Indore in the state of Madhya Pradesh gets its water from Narmada River, whereas the city of Bengaluru in Karnataka gets

its water from Cauvery River located about 100 km from the city. This not only comes with huge economic costs but is also unsustainable.

- Watershed management - New York City watershed treatment has proved that managing watershed at different levels can also offer clean and safe drinking water supply saving millions of dollars of construction and maintenance cost of water filtration plant.
- Endorsing blue-green infrastructure in the cities, creation and maintenance of urban green spaces is also recommended.
- Sustainable Drainage System - Surface permeability in urban areas can also be increased by using permeable paving where appropriate (e.g. footpaths, car-parking areas, access roads), thus reducing surface run-off and increasing groundwater recharge. One of the practices to avoid storm water being practiced in China is 'Sponge Cities' whereby excessive rainfall is absorbed through soil infiltration while retaining it in underground turrets and storage tanks, only discharging it into the river once water levels are low enough.
- Skill Development -
  - ✓ Countries such as the Philippines have been actively experimenting with skilling programmes under the United Nation's International Center for Technical and Vocational Education and Training.
  - ✓ Our states we have traditionally seen various kind of 'water experts' at service of the society, including the sunghas in Rajasthan, chowkidars in Kumaon hills of Uttarakhand, Kollalus in Garhwal, jagliyas or patkaris in Maharashtra, etc.
  - ✓ More than 7 lakh Swachhagrahis in Swachh Bharat Mission, have been imparted skills around sanitation deeply linked with water issues as well.
  - ✓ Under the Atal Bhujal Yojana too, there are thousands of Bhujal Jankaars (people knowledgeable in ground water issues) and a sizable workforce is available under the Jal Jeevan Mission as well.

Steps Taken By The Government

- The National Water Policy 2012 recommends conservation of existing water bodies, rivers, river corridors, etc.
- Swachh Bharat Mission (SBM) ensured access to sanitation facilities to all.
- Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) is the most comprehensive protective irrigation scheme launched in 2015-16 with the following components -
  - ✓ Accelerated Irrigation Benefit Programme (AIBP) (covers major to medium irrigation projects that involve an area of more than 2,000 hectare),
  - ✓ Har Khet Ko Pani (HKKP), along with Command Area Development and Water Management (CADWM) programme aims to utilise created irrigation potential as soon as project is completed
  - ✓ Per Drop More Crop (PDMC), and
  - ✓ Integrated Watershed Management Programme.
- The Jal Jeevan Mission (JJM) aims to ensure Functional Household Tap Connections (FHTC) to all rural households by 2024 (about 51% coverage till now). Online Jal Jeevan Mission dashboard provides status on provision of tap water supply in rural areas. Water Quality Management Information System has been developed using the reports generated from water quality testing laboratories.
- Per Drop More Crop (PDMC) component under PMKSY with the motto of '*Har Khet Ko Paani*' focuses on water use efficiency at farm level through micro-irrigation and better on-farm water management practices. The scheme also focuses on creating protective irrigation by harnessing rainwater at micro-level through *Jal Sanchay and Jal Sinchan*. Micro-irrigation is also incentivised through subsidy to ensure water use efficiency

in the agriculture sector by promoting appropriate technological interventions like drip and sprinkler irrigation technologies.

- To promote micro-irrigation, GoI created a special Micro-Irrigation Fund with a corpus of Rs. 5,000 crore during 2018-19 with NABARD as implementing agency.
- Crops Diversification Programme (CDP) is being implemented in the original green revolution states viz. Punjab, Haryana and Western UP since 2013-14, to shift towards less water requiring crops such as oilseeds, pulses, coarse cereals, nutri-cereals, cotton, etc. State governments have also launched initiatives aimed at optimising water demand for agriculture. E.g.
  - ✓ ban on early sowing of paddy by Haryana and Punjab;
  - ✓ Jal Hi Jeevan Hai' Scheme by Haryana to incentivise growing of less water intensive crops;
  - ✓ mandatory use of drip irrigation for sugarcane cultivation in Maharashtra.
  - ✓ 'Jal Jeevan Hariyali Abhiyan' in Bihar has increased the number of water structures (e.g. check dams), plantations and the use of micro-irrigation.
  - ✓ In Chattisgarh, construction of small dams, canals and dykes resulted in additional groundwater recharge.
  - ✓ 'Neelambar Pitambar Jal Samridhi Yojana',2020 in Jharkhand for creation of field bunding, rejuvenation of nalas and construction of soak pits.
  - ✓ 'Birsa Munda Krishi Kranti Yojana' in Maharashtra has increased micro-irrigation area and took up construction of new wells and ponds along with repair of unused wells.
- In December 2019, while launching the Atal Jal Yojana, the Prime Minister had urged farmers to opt for less water intensive crops and irrigation methods.
- The Government also conducts mass awareness and public outreach programmes. E.g., *Jal Pe Charcha*, where training was imparted to volunteers.
- The National Water Mission (NWM) was launched in the year 2009 as part of which, Ministry of Jal Shakti has launched 'Sahi Fasal' campaign in November 2019 to nudge farmers in the water-stressed areas to grow crops which are water-efficient, economically remunerative, healthy and nutritious, suited to the agro-climatic-hydro characteristics of the area and are environmentally friendly.
- Best practices for water conservation and enhancing water use efficiency are rewarded through institution of 'National Water Awards'.
- 15th Finance Commission has categorically stated in its report that States need to develop long-term drought mitigation plans that include measures for improvements in surface and groundwater management and promotion of efficiency of water use. The performance incentive for sustainable water use for the State will be reduced by the percentage equal to the share of wells which showed decline in water table in pre-monsoon compared to mean level of previous decade.
- Launching of **'LiFE Movement'** by Prime Minister in 2022 is a nature-based initiative to promote an environmentally conscious lifestyle that focuses on 'mindful and deliberate utilization' instead of 'mindless and destructive consumption'.
- GoI has declared river Ganga as the national river in 2008 and launched the *Namami Gange Mission* in 2014 for conservation of Gang and its tributaries.
- Central Ground Water Board (CGWB) is working towards aquifer rejuvenation, water conservation and artificial recharge by implementing innovative schemes. It has prepared a 'Master Plan for Artificial Recharge to Groundwater-2020'.

- The major works taken up under MGNREGS include construction of check dams, ponds, renovation of traditional water bodies, land development, embankment, fields bunds, field channels, plantations, contour trenches, etc.
- **Jal Abhyaranya Programme** - Also known as *dhara, prava,* or *Aola*, springs hold cultural significance in the Himalayan region and is used for drinking as well as agriculture purposes. 23.9% of surface flow irrigation systems are based out of springs in HR.

Under the National mission on Himalayan Studies Programme, Ministry of Environment, Forest and Climate Change, the G.B. Pant National Institute of Himalayan Environment is taking lead in maintaining the Geo Database of spring inventory and developing demonstrative models of Gram Jal Abhyaranya in at least one village of selected districts of 12 IHR States. It also promotes replication of field model for rejuvenation of drying springs in the Himalayan states through technology and community based approaches for providing water security to local communities by the year 2024 in collaboration with the state agencies.

The ice stupas are an innovative and easy water conservation techniques formed using glacial stream water carried down from higher ground through buried pipes, with the final section rising vertically. Due to the difference in height, pressure builds up and the water flows up and out of the pipe into sub-zero air temperatures. The water then freezes as it falls to gradually form an ice cone or stupa. In late spring the melt water is collected in large tanks and then fed onto planted land using a drip irrigation system.

Community Participation

- Tarun Bharat Sangh, headed by the 'Water Man' Mr. Rajendra Singh has been working for restoring and reviving water conservation structures across Rajasthan, Uttar Pradesh, Bihar, Jharkhand and Uttarakhand in the country for a few decades.
- Samerth is an organisation active in the Kutch district in Gujarat - it is a drought-prone area and known for the Rann (desert).

Other Steps

- Green Infrastructure-such as rain gardens, constructed wetlands or infiltration trenches can help filter out pollutants before they go into the river.
- Preserve natural features, such as floodplains with a natural vegetation buffer along streams that can slow, filter, and store polluted runoff.
- Street sweeping -picking up pollutants before they go down the catch basin and into the waterways.
- Separating sewer and stormwater lines – city municipality should upgrade old infrastructure and separate storm water pipe from rainwater pipes.

2. JAL SHAKTI ABHIYAN (JSA)

Overview

JSA was launched in 2019. This was a time-bound, mission mode water conservation campaign, implemented in the July – November 2019 period in 256 water-stressed districts of the country to make *water conservation an andolan through extensive communication and involvement of communities*.

- JSA focused on five aspects: *water conservation and rainwater harvesting, renovation of traditional and other water bodies, reuse of water and recharging of structures, watershed development, and intensive afforestation*.

- Besides, the special interventions included development of Block and District Water Conservation Plans, Krishi Vigyan Kendra Melas, Urban Wastewater Reuse, Scientists and ITs, and 3D Contour Mapping of all villages.

Jal Shakti Abhiyan: Catch the Rain 2021 - The "Jal Shakti Abhiyan: Catch The Rain" (JSA:CT) campaign with the theme *"Catch the Rain, where it falls, when it falls"* was launched by Hon'ble Prime Minister on 22 March 2021, World Water Day.

- It was taken up in all the districts of the country during the pre-monsoon and monsoon period, i.e. from March 2021 to 30 November 2021, to create and maintain appropriate Rainwater Conservation Structures, suitable to the soil strata and climatic conditions of the area, with people's participation, before the onset of monsoons so that they are ready to catch the rain, where it falls, when it falls'.
- Funds for all water conservation related schemes (MGNREGS, AMRUT, CAMPA Funds, etc.) of central and state governments, funds mobilised locally and from corporate sectors were merged and aimed to create and maintain RWHS with total participation of people.
- The campaign, implemented by National Water Mission (NWM), had the following five focused interventions.

a) Rainwater harvesting and water conservation - Water conservation and rainwater harvesting included renovation of traditional and other water bodies/ tanks; recharge using old bore wells; watershed development. Activities taken up under this included roof-top RWHS on all buildings- with priority for government buildings, water harvesting pits in all compounds, de-silting of tanks to increase their storage capacity, repairs to traditional stepwells and other RWHS, revival of wetlands and protection of flood-banks. *These works are taken up in rural areas from funds under MGNREGS or Finance Commission grants or locally mobilised; in urban areas from AMRUT and its own funds and in forest areas with CAMPA funds*.

b) Enumerating, geo-tagging and making inventory of all water bodies/Water Harvesting Structures (WHS) in every district based on old revenue records and using remote sensing images from National Remote Sensing Agency (RSA) and GIS mapping technology and using the data to plan scientifically new WHS; preparation of GIS based scientific plans for water conservation as per NWM guidelines.

c) Setting up Jal Shakti Kendras in all districts - They are to act as resource or knowledge centers' for disseminating information related to water, techniques for water conservation and water saving and also provide technical guidance to local people as well as to the district administration.

d) Intensive afforestation

e) Awareness generation - NWM has collaborated with NYKS, Department of Youth Affairs Nehru Yuva Kendra Sangathan (NYKS) Affairs, NGOs, universities, and premier education institutions like IIM, lITs, etc.to spread awareness on JSA:CTR campaign.

- Development of portal - National Water Mission, with the help of NIC, developed a portal for monitoring the progress of the campaign which showcases the campaign's progress in interventions: *a) water conservation and rainwater harvesting; b) renovation of traditional and other water bodies/ tanks; c) reuse of borewell/recharge structures; d) watershed development e) intensive afforestation; f) enumeration of water bodies and scientific planning.*
- IEC Materials: NWM got information education and communication (IEC) materials developed in regional languages on water harvesting and conservation by professional agencies and uploaded in the official website of NWM. These included slogans for wall writings, social media posting, e-posters, scripts for Nukkad Nataks, topics for debates, essay writings, quiz questions, etc.

Jal Shakti Abhiyan: Catch the Rain 2022

It was launched by Hon'ble President of India on 29.03.2022 and is being taken up in all districts of the country with the main theme *Catch the Rain, where it falls, when it falls*. Under this campaign new interventions in the campaign in addition to the activities considered under interventions of JSA: CTR-2021:

a) Spring Shed Development and Management

b) Wetland Development and Management

c) Catchment area protection and development

Amrit Sarovars - India is celebrating the Azadi ka AmritMahotsav, marking 75 years of Independence. 75 water bodies will be created or rejuvenated in every district. These will be called Amrit Sarovars. The creation/rejuvenationof the Amrit Sarovars will be a special effort under JSA-CTR 2022. Rejuvenation may include cleaning/ de-silting, removal of encroachments, ensuring that the channels for water flow are clear and treatment of the catchment area, if required.

3. TRADITIONAL TECHNIQUES

History

Water harvesting may be defined as deliberate collection and storage of water that runs off on natural or manmade catchment areas. Catchment may include rooftops, compounds, rocky surface or hill slopes or artificially prepared impervious/semi-pervious land surface.

- The practice of harvesting rainwater dates to Vedic times when the need to create water sources that would remain both clean and provide plentifully was recognised.
- Dholavira in Kutch, Gujarat laid out on a slope between two storm water channels is an example of sophisticated water engineering. Sage Narada, in Mahabharata advises Yudhishthira to excavate large lakes to store water and make cultivation independent of rainwater.
- Dams built of stone rubble were found in Baluchistan and Kutch dating back to 2000 BC. A refined water harvesting system of 1st century BC was found at Sringaverapura near Prayagraj. It contained floodwaters of River Ganga in a fully brick-lined tank.
- In South india, great Karikala Chola built a Grand Anicut or kallonai across the river Cauvery to divert water for irrigation in 2nd century AD.
- In Central India, King Bhoja of Bhopal built one of the largest artificial lakes, measuring approximately 65,000 acres fed by streams and springs in IT century.
- In North India, poet, and historian Kalhana in his 120 century chronicle Rajatarangini describes a well-maintained irrigation system in Kashmir.

In arid and semi-arid regions, streams were more seasonal, and therefore the diversion channels first led the water to a storage structure like a tank. Deep wells were dug in the beds of tanks and rivers, both to serve as a source of good water when the water receded and also to recharge the groundwater when they were fully submerged.

North-East India Techniques

- **Bamboo Pipes** - Bamboo pipes are used to divert water of springs on the hilltops to the lower regions by gravity for irrigation. Bamboos of varying diameters are used for laying the channels. In Meghalaya they do it for black pepper cultivation.

- **Apatani** – It is named after the Apatani tribes of the lower Subansiri district in Arunachal Pradesh. Apatani is a wet rice cultivation cum fish farming system practiced in elevated hilly regions and gentle sloping valleys of Northeast India. Apatani can tap the water of small streams and springs in these high rainfall hilly regions through their temporary walls. These walls act as barriers and can divert the flow of water towards terraced and valley lands.
- **Zabo** - Zabo literally means 'impounding run-off'. It is a method of catching rainwater from running off the mountains practiced in Nagaland.
- **Cheo-ozihi -** Angami tribe of Nagaland practices this system where a long channel carries the river water splitting into many branches, and water is often diverted to the terraces through bamboo pipes. The channel is called Cheo-ozilhi. Ozilhi means water and Cheo was the person responsible for the laying of this long channel with its numerous branches maintained and cleared each year by the local community.
- **Dongs or Ponds -** Dongs are ponds constructed by the Bodo tribes of Assam in Brahmaputra valley to harvest water for irrigation. Water was lifted from the ponds and distributed into the fields by an instrument called *lahoni*. The ponds were individually owned and there was no community involvement.
- **Garh and Dara -** In Assam, a Garh is built to channelise river water to the agricultural field. A Garh is like a big nala, where both sides of the nala have big and long embankment and the middle side is left open to water flow. In the paddy field, the whole area is divided into small pieces in square size, creating small embankments, called Dara, where rainwater is stored for cultivation.

Indo-Gangetic Plains

- **Ahar-pyne -** It is a traditional floodwater harvesting system prevalent in Bihar. Ideal terrain for Ahar-pyne should have an evident slope, sandy soil, low groundwater level and flood during monsoon. The Ahar-pyne system received a deathblow under the 19th century British colonial regime. In 1949, a Flood Advisory Committee investigating continuous floods in Bihar's Gaya district concluded that "the fundamental reason for recurrence of floods was the destruction of the old irrigational system in the district.
- **Bengal's Inundation Channel** – Floodwater entered the fields through the inundation canals, carrying not only rich silt but also fish, which swam through these canals into the lakes and tanks to feed on the larva of mosquitoes. This helped to check malaria in this region. Unfortunately, during the Afghan-Maratha war in the 18th century and the subsequent British conquest of India, this irrigation system was neglected, and was never revived.
- **Jampois or Dungs -** Dungs or Jampois are small irrigation channels linking rice fields to streams in the Jalpaiguri district of West Bengal.

Rajasthan, Gujarat, and the Western Deserts

- The natural undulations provide for creation of wells and lakes which are innumerable in Jodhpur and Udaipur. There are small (talai), medium (talab) and large (sagar) lakes. Pichola, Fatehsagar and Udaisagar are Udaipur's main lakes.
- The Chandela kings (between 9th to 13th centuries) in Central India established a network of several hundred tankas that ensured a satisfactory level of groundwater. Tankas were constructed by stopping the flow of a nullah or a rivulet running between two hills with a massive earthen embankment. The Bundela kings who came later used lime and mortar masonry.
- Great Thar Desert receives very little rainfall. Traditionally, the rainwater was captured and stored in ponds and underground tanks. For example, tarais (reservoirs) were built in the valley between sand dunes by constructing bunds at the two ends. When it rained, the rainwater was collected in the reservoir. The tarais

dried up in a few months owing to the highly porous soil. But the region around it remained wet and moist. Wells were usually dug close to a tarai.

- **Tankas/Tanks** - Popular in Bikaner, *Tanka* is a round or rectangular underground room in a house that functions as a water tank. Rainwater from the roof or terrace is directed towards an opening in the floor that leads to the Tanka. Rainwater is collected in these circular holes, lined with fine polished lime, made in the ground. Tankas are often beautifully decorated with tiles to keep the water cool. The water was used only for drinking purpose.

  In contrast, *tanks* (sagar/heel) are generally constructed with large walls on four sides and an almost impermeable floor, with enormous water holding capacity. These are the oldest source of water for irrigation. Most of them are small reservoirs with earthen walls, used for storing water diverted from a stream or run off.

- **Kunds or Kundis** - In western arid areas of Rajasthan, kunds are water-harvesting structures with a saucer-shaped catchment area that gently slopes towards the centre where the well is situated. A wire mesh across water-inlets prevents debris from falling into the well pit whose sides are generally covered with lime and ash. Most pits have a dome-shaped cover or a lid to protect the water. *Kunds are constructed where the groundwater availability is limited and salinity is moderate to high*. Locally available material like pond silt, charcoal ash and small gravels are used to make catchment areas of the Kunds.

- **Kuis or Beris -** Dug mostly in western Rajasthan, the Kuis are 10-12 metre deep pits in the vicinity of tankas to collect leaking or oozing water. When 6 to 10 Kuis are constructed together, the entire system is then called Par system. Rainwater harvested through such system is called *Patali Paani*. The mouth of the pit is usually made very narrow which reduces the evaporation of the stored water. The pit gets wider as it gets deeper, so that water can seep into a large surface area. This water is used sparingly, as a last resource in crisis situations.

- **Khadins -** The Khadin system is a runoff agricultural system, in which, the runoff water from the high catchment area is stored with the help of a Khadin bund where it is impounded during the monsoon season. This water is then used for irrigation. The Khadin soil remain moist for a long period because of water storage and chemical weathering, decomposition along with the activities of the microbes, which eventually raise the organic matter and other nutrient content of the soil. Khadin have functioned efficiently for centuries maintaining the soil fertility. The Paliwal Brahmins of Jaisalmer are said to be the pioneers of this technique in the 15th century. *This system has great similarity with the irrigation methods of the people of Mesopotamia around 4500 BC*.

- **Nadis -** A nadi is the local name of a village pond used for storing rainwater from the adjoining natural catchment areas. These were very common in Jodhpur. Because of poor maintenance and negligence, destruction of catchment areas and unplanned urbanisation, most of the nadis have been severely polluted.

- **Talabs -** It is a water harvesting structure constructed in valleys and natural depressions. Some talabs have wells in their beds. Such well-decked talabs are called *beris*. The existing oldest talab in Rajasthan is Ranisar(1490 AD).

- **Virda -** Virdas are shallow holes made in the sands of dry riverbeds and lakes for collecting drinking water. They are found all over the Banni grasslands, a part of the great Rann of Kutch in Gujarat. First a depression or heel is excavated up to depth of 2 to 5 meter depending on the type of soil and level of salinity. This helps in removing the salinity embedded in the topsoil and non-permeable clay. Such a dug area looks like a small pond.

The most important structure in this whole water system is Virda or dug well. Within a jheel, 10 to 20 wells of approximately 1 to 1.5 meter of diameter and 3 to 5 meters of depth are dug. These dug wells are

framed from inside in square form with wooden trunks to support them. Further on the inner side of these trunks, the locally available grasses mixed with local soil are filled very thickly and they work as a filter as well as fill the macro pores. The upper portion of these dug wells is plastered with the clay.

In Virdas, the sweet freshwater remains in the upper layer from which the water is collected, and the saline water remains below the freshwater zone because of its higher density. The Maldharis (local nomadic people) first established these unique structures in the Rann of Kutch.

- **Naada / Bandha** - Nada/bandhas are found in the Mewar region of Rajasthan. It is a stone check dam that is constructed across a stream to capture monsoon runoff on a stretch of land. Because of submergence in water, the land becomes fertile as silt deposits on it and the soil retains substantial amount of nutrients.
- **Johads** - Johads are small earthen check dams that store rainwater. They constitute high elevation in three sides: a storage pit, and excavated soil on fourth side. Some johads are interconnected through deep channels, with a single outlet in a river or stream to prevent structural damage. This cost-efficient and simple structure requires annual maintenance of de-silting and cleaning the storage area of weed growth. A johad prevents rainwater from running off, allowing it to percolate into the ground, recharging water aquifers and improve the water balance of the earth. Recently, johads have seen a revival in Rajasthan, especially in Alwar district.
- **Stepwells or Baoli** - They are called *vav* or *vavadi* in Gujarat, and *baolis* or *bawdis* in northern India. The stepwells of Gujarat consist of a vertical shaft in the middle from which water is drawn. Important stepwells are profusely carved and designed in such a way to serve as a cool resting place in summer. 11th century Mata Bhavani's vavat in Ahmedabad is one of the earliest stepwells. *Rani ki vav* (Queen's well) at Patan was built few decades after that is the grandest among all ways. Some other fine examples in Gujarat are Dada Hair's vav in Ahmedabad, and the octagonal vav at Adalaj, Gandhinagar. Stepwells used exclusively for agriculture had drainage systems that channeled water into the fields.
- **Bawaris -** Bawaris were unique stepwells used for water storage in the cities of Rajasthan in medieval times. Scant rain received would be diverted to these man-made tanks through canals built on the hilly outskirts of cities. To minimize water loss through evaporation, a series of layered steps were built around the reservoirs to narrow and deepen the wells.
- **Jhalara** - Jhalara is also a local name given to manmade stepwells used for community water needs and for religious rites purposes. Often rectangular in design, jhalaras have steps on three or four sides. These stepwells collect the subterranean seepage of an upstream reservoir or a lake. The oldest Jhalara in Jodhpur is Mahamandir Jhalara, which dates back to 1660 AD.
- **Chauka System** - In Jaipur, degraded pastures have been dyked to form Chaukas to harvest rain. The Chaukas are rectangular plots arranged in a zigzag pattern and lie along a small gradient. Dykes with height of 1.5m are built along the three sides that lie towards the lower part of the gradient. Trees are also planted on the dykes to withstand rain. As the water level rises in one Chauka, it spills into the next and so on. Thus, the entire pasture receives water. The Chaukas do not get flooded. The excess water from the last Chauka flows into a drain. The Chauka system also promotes recharge of groundwater.

South India

- **Temple tanks** - The temple tanks are known as Kovil Kulam in Tamil Nadu, Kulam in Kerala, Kalyani in Karnataka and Cheruvu or Pushkarini in Andhra Pradesh/Telangana. It is the focal point of meditation and several religious activities like the Theppam or float festival. In addition to it there were several hundred *Yers* (artificial

tanks) to hold rainwater. It is also said that the founder of modern Bangalore, Kempegowda built several tanks in and around the city.

Tanks are of two types: *system* and *non-system tanks*. System tanks get their water from the overflow of a reservoir, nearby stream, and the runoff from around their catchment. These tanks, being water sufficient, help farmers to grow more than one crop a year. Non-system tanks depend entirely on rainfall and therefore can support only one crop. The tanks are connected through a system of canals to control and transport the water.

- **Eri** - One-third of the irrigated area of Tamil Nadu is watered by the Eris (tanks). A large number of broad irrigation tanks were built between 6th and 10th century A.D. during Pallava rule. From the beginning of the 16th century, rivers were partially diverted to fill these tanks quickly, which in turn, ensured food production. Before the East India Company's rule, local communities maintained these Eris.
- **Kulam** - Kulam was the small pond close to a temple constructed by the local masons. A Kulam was built with bricks (and occasionally by granite) and was attached to a temple, giving it the name Kovil Kulam or temple tank.
- **Lakes or Veris** and **ponds or Kuttais** were two other important water conservation structures in Tamil Nadu. A Yeri was a large earthenware tank dug out of the ground with the dugout mud making the side walls or bunds. A Kuttai was a small pond.
- **Anicuts (check dams)** were small or medium dams built across rivers to divert water into irrigation channels. The Grand Anicut or Kallanai was built by Karikala Chola in the 2nd century A.D. It was made of stone and situated on the river Cauvery where River Kollidam branches off.
- **Surangam** (tunnel) is a horizontal cave excavated in the mountains with super-condensed soil or rocks. This is a special water harvesting structure popular in Kasaragod district in northern Kerala. Water drips out from the rock crevice and runs through the horizontal cave/ tunnel (Surangam) and is collected in an open pit.
- **Kudimaramathu** is one of the old traditional practices of stakeholders participating in the maintenance and management of irrigation systems. In this, citizens of a village participate in maintaining the water bodies of their village by deepening and widening the lakes and ponds and restoring them back to their original form. The silt, rich in nutrients, collected in the process is used by the farmers themselves in their field.

  A study done by the Indian Institute of Science in Bangalore in 2016 suggested that if Bangalore were to harvest its rainwater and to recycle and reuse its water, it could meet its entire domestic water requirements.

The Islands

Jackwells - In lower parts of the undulating terrain, they make bunds using logs of hard bullet wood. Split bamboos are extensively used. These split bamboos serve as channels for rainwater that is collected drop by drop in pits called Jackwells.

Deccan and Maharashtra

- **Kohli Tanks -** Kohli Tanks are called so because of the name of group of cultivators who built these tanks three centuries back. The tanks were built on the slopes of the Gaikhuri range. The larger tanks were on the higher slopes, while the smaller ones were placed in the foothills. These tanks constituted the backbone of irrigation in the area until the government took them over in the 1950s. These are considered crucial for sugar and rice irrigation even today.

- **Bandharas** - These check dams also impound water and form a large reservoir called Bandhara. They raise the water level of the rivers so that the water flows into the channels. The water supply would usually last for a few months after the rains.
- **Phad** - More than 4 centuries old and managed by the community, this irrigation system is prevalent in north-western Maharashtra. The system operated on three rivers in the Tapi basin - Panihra, Mosam and Aram - in Dhule and Nasik districts.
- **Kere Tanks**, called *Kere* in Kannada, were the predominant traditional method of irrigation in the central Karnataka plateau, and were fed either by channels branching off from Anicuts (check dams) built across streams, or by streams in valleys. The tanks were built in a series, usually situated a few kilometres apart so that outflow/seepage of one tank higher up supplied the next all the way down the course of the stream.
- **Ramtek model** has been named after water harvesting structures in the town of Ramtek, Maharashtra. Ramtek model is an intricate network of groundwater and surface water bodies. These water bodies are intrinsically connected through surface and underground canals. This model harvests runoff through tanks, supported by high yielding wells and structures like Bawries, Kundis and waterholes.

  Tanks in Ramtek model form a chain, extending from the foothills to the plains, conserving about 60-70% of the total runoff. Once tanks located in the upper reaches close to the hills were filled to capacity, the water flowed down to fill successive tanks, generally through interconnecting channels.

Higher Himalayas

- **Zings -** Zings are water-harvesting structures in Ladakh. These are small tanks, in which melted glacier water is stored. A network of guiding channels brings water from the glacier to these tanks. As glaciers melt during the day, the channels fill up with a trickle, that in the afternoon turns into flowing water. The water is collected by the evening and is used the next day. A local water official called the *Churpun* ensures that water is equitably distributed.
- **Ghul** - In the high altitude of Himalayan region, water is tapped from hill slops known as Ghuls. Ghuls may be as long as 15 km carrying a discharge of 15 tó 100 litres of water per second. In the entire region of Western Himalaya comprising Jammu, Himachal Pradesh, and Northern Uttarakhand, Ghul is a standard harvesting technique.

4. PARTICIPATORY IRRIGATION MANAGEMENT (PIM)

Participatory Irrigation Management (PIM) broadly refers to the formation of groups of water users, mainly farmers, in a formal body for the purpose of managing ports or whole of an irrigation system. Such bodies are generally called Water Users' Associations (WUA), also known by the names such as *Pani Panchayat*, *Pani Samiti* or irigation cooperatives. In this approach, water users/tamers are involved as active stakeholders in management of irrigation systems right from planning and design to construction, design, maintenance, distribution and even financing. The Ministry of Water Resources brought out a Model Act to be adopted by State Legislatures for enacting new irrigation acts or amending the existing ones to facilitate PIM.

Many States have enacted new irrigation acts which now govern/regulate the constitution and functioning of Water Users Associations. Farmer Organisations are 3-tier for minor and medium irrigation projects, four-tier for major irrigation projects are mentioned below:

- Water User' Association (WUA): In a WUA, all water users are its members and it has a Managing Committee (President and 4-10 members). Each WUA has a delineated command area, generally a group of outlets or a minor irrigation system. WUA, Tarapur, Amethi, Uttar Pradesh and WUA Nashik, Maharashtra are its successful examples.
- Distributary committee (DC): It comprises five or more WAs. All the presidents of WAs will comprise general body of the Distributary Committee.
- Project Committee (PC): This is the apex committee of an irrigation system and presidents of the DCs in the project area shall constitute general body of the PC.

Even JJM envisions sub-committees of the Gram Panchayats to take up the role of planning, operations, implementation, management, and maintenance of the infrastructure provided under the Jal Jeevan Mission. These sub-committees usually have a 50% representation of women as well as a proportional representation of the weaker sections of the concerned area.

Robust and efficient functioning of these WUAs is challenged by several constraints; such as, lack of legal back up, uncertainty of water availability, lack of financial viability, technical knowledge and leadership, inadequate training and capacity development.

5. REJUVENATION OF RIVERS

Overview

The government has launched a mission to rejuvenate 13 rivers including Yamuna, Krishna, Cauvery Mahanadi & Brahmaputra on a war footing. This effort will play an important role achieving the international commitments-

- NDC forestry sector goal of creation of additional carbon sink of 2.5 -3 billion tons of CO2 equivalent through additional forest and tree cover by 2030 under the Paris Agreement of UNFCCC,
- restoration of 26 million hectare of degraded lands by 2030 as a land degradation neutrality target under United Nations Convention to Combat Desertification (UNCCD)
- halt the biodiversity loss by 2030 under Convention on Biological Diversity and Sustainable Development Goals.

It will strengthen the country's progress towards *Panchamrit* commitment at COP26 during November 2021 in Glasgow whereby India promised to reduce its projected carbon emission by one billion tonnes by 2030, meet 50% of energy requirements with renewable energy by 2030, enhance non-fossil energy capacity to 500 GW by 2030, reduce the carbon intensity of its economy by 45% by 2030 and achieve net zero emission by 2070.

The programme will be executed through the state forest departments as nodal departments.