Indian Journal of Traditional Knowledge
Vol 24(3), March 2025, pp 258-267
DOI: 10.56042/ijtk.v24i3.6100

Contextualizing traditional water knowledge with modern water challenges in India: A hydrological review

V C Goyal, M Furqan Ullah* & Charu Pandey
National Institute of Hydrology, Roorkee 247 667, Uttarakhand, India
*E-mail: ullahmfurqan@gmail.com

Received 30 April 2024; revised 17 January 2025; accepted 06 March 2025

During last few decades many new challenges in the field of water have emerged such as impacts of climate change, declining groundwater levels, decline in groundwater recharge, water logging, encroachment of water sources, decline in green cover, increasing menace of flood and silting due to encroachment of floodplain of rivers, increasing water pollution due to inappropriate and inadequate disposal of solid and liquid wastes, cloudburst, flash flood, cyclone and other disasters, etc. Due to increasing water demand and decreasing water availability, ensuring water security has emerged as a big challenge. India is a unique country where rivers are worshiped and respected since ancient times. Evidences are available in ancient scriptures about hydrological knowledge and importance of water management. Various traditional systems of water harvesting, conservation and management are still available and some are being used since ancient times. In spite of this traditional knowledge and cultural values, the water resources of India are in turmoil due to rapid industrialization, urbanization and materialistic approach towards over-exploitation of natural resources. This paper attempts to contextualize Indian traditional water knowledge with contemporary water challenges in India. Such traditional structures and knowledge, if adopted and practiced prudently, can provide sustainable solutions even today.

Keywords: Contemporary water challenges, Indigenous water systems, Modern water issues, Traditional water knowledge, Traditional water management, Water security

IPC Code: Int Cl.[25]: E03B 3/00

India is known for its rich traditional knowledge, which has been practiced and nurtured over centuries and transferred through generations in form of technical know-how, skills, practices, and beliefs. According to NITI Aayog, India is suffering from the worst water crisis in its history, and millions of lives and livelihoods are under threat. Currently, 600 million Indians face high to extreme water stress and about two lakh people die every year due to inadequate access to safe water[1]. The crisis of water was identified by the Indian Government about 35 years ago when the first national water policy was prepared in 1987. In 2012, the Government of India adopted a fresh National Water Policy, which provided for significant change in the approach and action. This policy draws principles of water resource management from globally recognized sustainable systems such as Integrated River Basin Management, conjunctive water use, and aquifer as unit of ground water management[2]. Due to continual increasing demand and developmental activities, the scenario of water resources of India is completely changed. The ground water is getting more and more depleted and surface water of the country is getting more and more polluted. United Nations World Water Development Report (UNWWDR) also suggests that growing water demands cannot be met by freshwater alone, whose availability is further constrained by the climate change and water-related disasters, and wastewater treatment and reuse is the only solution[3].

Materials and Methods

This research focuses on highlighting the traditional knowledge on water management systems in India, and contextualizing Indian Traditional Water Knowledge with contemporary water challenges to suggest sustainable solutions. The methodology of this study comprises information/data collection from published literature based on prior studies. The paper discusses the utility of traditional knowledge and practices in cases of different contemporary water challenges.

*Corresponding author

Results and Discussion

Modern water challenges and appropriate traditional knowledge

India is a country with rich moral values and cultural heritage. Many traditional methods and practices related with water conservation, purification, domestic and agricultural use, etc. have been used and are still in use in India since time immemorial[4-12]. Ignorance of the rich traditional knowledge and practices has added to the vagaries related to water (mis) use. These traditional methods can be a great boon for solving water related challenges of modern times.

The major water-related challenges of modern times include decreasing water availability, deteriorating water quality, decreasing water productivity, water-related disasters, etc. This paper explores the relevance of traditional knowledge towards solving water related challenges of modern times in India, as seems to be further compounded by the impacts of climate change.

Decreasing water availability

As mentioned in Ganga River Basin Management Plan, *Aviral Dhara* or 'continuous flow' is the quantity of water flow required to sustain the river ecosystems as well as the human life surrounding the rivers. Maintaining this flow in rivers is increasingly being recognized as critical for environmental as well as socio-political reasons. Flowing water is an important agent for removing pollutants from land and stagnant water bodies. Maintaining flow in rivers, springs, and groundwater is of prime importance for sustaining ecological balance[13].

In Indian traditions and culture, rivers are considered as divine, sacred and are respected since ancient times. People of India believed that water in rivers purify them from sins. There are many traditional mythological scriptures which throw light on purifying power of water. Important hydrological concepts are available in various verses of Vedas, Puranas, Meghmala, Mahabharata, Mayurchitraka, Vrhat Sanhita and other ancient Indian works[14]. In spite of the deep rooted Indian traditions of water conservation, the survival of rivers, streams, ground water, springs, etc. has emerged as a major challenge in modern times.

Depleting ground water levels

Groundwater is the main source of domestic water supply (~80%) for rural and urban India making the country the largest user of groundwater in the world[15]. Groundwater is being depleted due to heavy extraction in many regions of India, which is more visible in Rajasthan, Gujarat, Punjab, Haryana, most of Western Uttar Pradesh and all the southern States. The Easement Act, 1882 freely entitles the owners of land to collect and dispose the water under their land. This leads to an unregulated proliferation of wells and bore wells. There is virtually no legal liability for them to cause any damage to water resources including over-extraction of ground water[16]. Heavy extraction of groundwater for drinking and non-potable uses makes this resource scarce. Even hand pumps installed to tap groundwater manually for domestic uses are attached with submersible pumps, which lead to huge wastage of water.

The beneficial use of groundwater was based on limited extraction through manual efforts. Wastage can be avoided if non-electric extraction of groundwater is restored, or when strict restraint is ensured against over-extraction. Various traditional water conservation systems like step wells, baolis, talabs, johads, tanka, khadin etc are in use in India since centuries. Traditional roof water harvesting system is also in use in India, especially in Rajasthan since ancient times. The concept behind these systems is that 'rain should be harvested whenever and wherever it falls'[17]. Traditional water harvesting systems were declined during British rule in India. Britishers introduced centralized water supply system in place of decentralized rainfall-based water harvesting systems[18]. The traditional structures and techniques of water harvesting and conservation also facilitate groundwater recharge. Some of these systems are listed in Table 1.

Table 1 — Traditional structures and practices related to water availability/conservation

Depleting groundwater	Depleting river discharge	Disappearing water bodies	Water security at village
Small heaps of sands (Kerala); Garanda (Karnataka); Paar system, Kuis/Beris and Baolis/Baoris/Bawaris/Bers/Nauns (Rajasthan); Baudi (HP); Jhalara (Raj); Dighi (Delhi); Kunds/Kundis (Raj, Gujarat)	Ramtek model (Mah.); Jarukuttu (Kar.); Bavi/Kunta/Revu/Cheruvu (AP and Telangana)	Chandela/Bundela tanks (Bundelkhand); Johads, Khadins (Raj.); Madakas (Kar.); Pemghara (Odisha); Talab/Bandhi/ Sagar/Samand/Pokhariyan (Bundelkhand); Nadi (Raj.); Chappris (HP)	Taanka (Raj.); Jack wells (A&N, Lakshadweep); Khatri (HP); Chaal/Naula/ Chuptyaulas/Dhara/ Mungurus (Uttarakhand); Virdas (Guj.); Surangam (Kar., Kerala)

Depleting river discharges

There are numerous rivers that are so heavily exploited that they have no river flow left during the summer season. The problems of river water started during British rule in India when the idea of tapping river water for irrigation purposes was introduced. Numerous small and large multipurpose dams have been built on various rivers for irrigation, power generation and recreational purposes. Gradually the people lost the spiritual connect with rivers and, as a result, rivers became dry and polluted.

Decentralized river and canal networks provide a solution without adverse impact on river flora. Various alternate irrigation and water supply systems were used in India without disturbing the river flow. These traditional systems are ecologically safe, feasible and cost effective for rejuvenating India's depleting water resources including depleting river discharges. One such example is of Ramtek Model, which are water harvesting structures constructed and maintained by malguzars of Ramtek town of district Nagpur, Maharashtra. In this system, a series of water tanks were made starting from foot hills to the plain areas and these tanks were connected by underground and surface canals. Once tanks located at height are filled to capacity, the water flows down to fill another tank at lower height and so on. This system is very effective for water conservation, which conserves about 60 to 70% of the total runoff in the region. Some other systems are listed in Table 1.

Disappearing small water bodies

Small water bodies such as ponds, lakes, tanks and springs etc. are potential sources of drinking water for human and cattle. These water bodies are also source of recharging ground water table. In olden times, the 'God fearing' nature of people was responsible for creating a sense of moral responsibility among the general populace to protect the environment while using the natural resources. Due to various human activities, majority of these water bodies have either disappeared or degraded in India.

In modern times, spreading the sense of moral responsibility towards protecting water resources should be the matter of concern. Mass awareness programs and local governance can protect small water bodies. Rejuvenation and conservation of water bodies can be efficiently done with the help of NBS. Some traditional water conservation systems, as listed in Table 1, can be a major source of fresh water, if rejuvenated and maintained properly.

Endangered water security at village level

Water availability for human consumption throughout the year is very important to ensure water security of any village or block, or district. It is a well observed fact that due to various reasons, the gap between water demand and supply is increasing leading to water security challenges.

Enabling self-sufficiency at village level can solve the water vulnerability. With concepts such as *'Khet ka pani khet mein, gaon ka pani gaon mein'*, water security is achievable. With active community involvement, it is feasible to achieve water security in a Gram Panchayat (GP) setup. Some of the possible solutions for handling water security at village level are:

IWRM approach

For economic and social welfare of the society at village level, in an equitable manner without disturbing the sustainability of vital ecosystems, Integrated Water Resources Management (IWRM) is a best approach, which promotes the coordinated development and management of water, land and other related resources.

Rainwater harvesting (*RWH*)

Rainwater harvesting is very effective system for solving the problem of water scarcity up to some extent in urban and rural areas. In India, more than 70% of annual rainfall occurs during the three months of the monsoon and most of it floods out to sea[19]. This leaves little scope for recharging the groundwater, which results in water scarcity during non-monsoon months. Through RWH, this erratic rainfall can be conserved, stored & used as per convenience, either directly or for recharging groundwater. Many traditional rainwater harvesting structures are available and can be used for achieving water security (Table 1).

Issues with centralized irrigation systems

Irrigation canals and conflict over water sharing

After independence, large dams have been constructed in India to cater to the vast irrigation requirement in different regions, leading to serious problems of forced human displacement and forest submergence. As alternate sources for irrigation, traditional water harvesting structures may be promoted, which are already in use in several places in India (Table 2).

Centralized sources of water for irrigation such as river lift points and sluice gates, have become major source of conflict between users. Water conflicts are

Table 2 — Traditional structures and practices related to irrigation systems

Shortage in canal water	Water conflicts	Water logging
Bhandara phad; Pat system (MP); Ahar Pynes (Bihar); Kuls/Kuhls (HP, Jammu)	Promoting local irrigation systems	Proper design of irrigation systems; precision irrigation
Apatani (Arunachal Pr.); Cheo-ozihi (Nagaland); Zing (Ladakh); Zabo (Nagaland)	Khazana (Goa); Oorani,	
Khadin (Raj.); Anicuts (Kar., TN);	Eri system (TN); Keres/Talparges (Kar.);	
Arghat/waterwheels (J&K)	Dongs (Assam); Neerkattis (Kar., AP and TN)	

arising due to promotion of major irrigation projects and centralized irrigation systems. These conflicts can be minimized by promoting localized traditional irrigation systems as described above.

Water logging in canal command areas

Water logging is one of the major land degradation processes that restrict the economic and efficient utilization of soil and land resources in command areas. Application of excess irrigation and recharge from irrigation distribution network causes gradual rise of groundwater table and creates water logging. For preventing water logging in canal command areas, it is required that irrigation system should be adequate for surface drainage, having suitable depth for efficient draining, and water-efficient irrigation technologies are used.

Decreasing water productivity

Overuse of freshwater in domestic activities leads to reducing the quantity of water for agriculture and livestock, causing food scarcity. Increasing water productivity through appropriate water conservation measures is much needed now. The emphasis should shift from traditional supply side management to demand side management. Innovative and out-of-box strategically thinking is required to prepare for the uncertain and hostile future. Improving soil health, green cover, increasing rainwater harvesting, enhancing groundwater recharge, reducing evaporation losses, use of clean-energy (e.g. solar, wind, ethanol, hydrogen) are some of the measures for improving water productivity.

Strategies for domestic water use have to be different for rural, urban and peri-urban settings. In rural areas the major concern is to enhance water availability in the non-monsoon season. In urban areas, the main concern is to reduce the demand and curtail losses. In coastal areas, desalination and harvesting of dew may provide additional water. Peri-urban areas have their own set of challenges.

Domestic uses

Huge amount of water wasted daily during washing and cleaning floors, vehicles, clothes and for other similar activities. Wasting of water due to leaking tapes is common problem in Indian cities and towns. Wastage of water can be minimized by adopting responsible behavior towards this scare resource. By making minor changes in lifestyle, like immediate replacement of leaking taps, shutting off the tapes while brushing, shaving and washing utensils, people can make huge difference in water usage. Traditionally, metal pots (*Lota*) were used in India for washing hands and face, cleaning teeth, taking shower and washing utensils.

Agricultural uses

Inefficient irrigation methods

Inefficient use of irrigation water impacts on- and off-site water quantity and quality. Irrigation systems and water management practices can waste water and negatively affect farm profitability[20]. For getting agricultural productivity, Indian farmers have developed several efficient traditional irrigation systems based on harnessing and collecting rainwater and utilizing surface and groundwater. Irrespective of erratic rainfall patterns and uneven land topography, since ages Indian farmers have learned to irrigate their agricultural fields using community water harvesting methods. Contour bunding, for example, is a traditional land management technique for retaining water in marginal, sloping and hilly areas where soil productivity is very low. Some of the traditional yet efficient ways of irrigating crops are listed in Table 3.

Commercial cropping without consideration of high-water consumption

Agriculture is one of the major contributors to India's GDP, which plays an important role in Indian economy. For sustaining growth of agriculture, conservation of natural resources is very important. Due to commercialization of agriculture, many high-water consuming crops, which include cash-crops, are cultivated in various parts of India.

Keeping in view the high-water footprint of agriculture sector in India, cropping pattern should be sustainable and less water consuming. Various

Table 3 — Traditional structures and practices related to water productivity

Domestic uses	Agricultural uses	Industrial uses
Judicious use of water; reuse of wastewater	Contour-bunding (Mah., Gujarat, TN, Kar., AP)	Use of energy-efficient and environment-friendly technologies
	Diversion channels; Guhl (Uttarakhand); Dungs/Jampois (WB); tank systems (South Indian States); Naada/Bandhaa, Saza Kuva (Raj.)	Treatment of wastewater using NBS; use of recycled water
	Bamboo drip irrigation (Meghalaya);	
	Katas/Mundas/Bandhas (Gond tribals); Korambus (Kerala)	
	Rahat/Persian wheel for water lifting; Ascending chain of water lifting devices	
	Crop diversification; use of indigenous seeds; water-efficient crops	
	Soil mulching; organic/natural farming	

methods like drip irrigation, capturing and storing water, irrigation scheduling, cultivation of drought-tolerant crops, dry farming, rotational grazing, use of compost and mulch, crops covering, conservation of tillage and organic farming etc. are some of the methods useful to reduce water consumption[21].

Promoting crop diversification and less water demanding crops (e.g. millets)

In drought prone regions, water scarcity is a perennial problem. Neglect of less water demanding crops in these areas leads to loss of agricultural economy. In these regions, farmers can plan for growing less water intensive crops, like millets, sorghum, maize, pulses, groundnut, soya bean, black pepper etc.

Low moisture storage in soil profile

As moisture availability declines in soil, the normal function and growth of plants are disrupted, and crop yields are reduced. Sprinkler and drip irrigation systems are used for irrigating crops grown in the low soil water storage capacity. Sprinkler irrigation system operation allows the soil moisture to deplete up to the maximum allowable depletion and then refills the soil profile up to field capacity. Drip irrigation systems are designed and operated to keep the soil moisture content at a level above the maximum allowable depletion by applying water frequently[22]. Traditionally, soil mulching was practiced to control the loss of soil moisture leading to improved crop yields. Mulching not only controls soil erosion but also reduces evaporation. An indigenous bamboo drip irrigation system is very common for irrigating plantations in Northeastern hills of India. This system is being practiced by farmers of Khasi and Jaintia hills since about 200 years.

Poor soil health leading to high water demands

Soil has the capacity to absorb rainwater, store it temporarily, and release it to plants and soil organisms. A low fertility soil, however, demands high doses of fertilizers, which in turn require more water for crop production[23]. A healthy soil is the basis of sound agriculture.

Methods for improving soil health include using compost, manure, crop residues, intercropping legumes with cereals and including the principles of conservation agriculture. Soils have to be nourished and cared for, and allowed to rest from time to time. For nourishing soil, earthworms are particularly important as they feed on dead and decaying materials. Organic/natural farming improve soil health and provide good soil moisture.

Heavy soil erosion

Soil erosion is a naturally occurring process that affects all landforms. The flowing water tends to take away the soils along its path. It leads to increased pollution and sedimentation in streams and rivers, clogging the waterways and causing declines in fish and other species[24].

Some traditional methods for conservation and management of soil in India, include construction of check dams, crop rotation, mixed cropping, controlled grazing, residue management, planting forestry species, applying farmyard manure, and making land boundary, are applied for controlling soil erosion[25].

Industrial uses

Compared to the agricultural water demand, the water requirement for industrial uses is quite low in India. Many industries, such as fertilizers, petro-chemicals, paper, internet data centres, are high water demanding. Concentrated in clusters, however, industries create heavy point loads on the available water resources. Besides consuming large quantities of water, many industries, such as leather, pharmaceuticals, semiconductor manufacturing, are highly water polluting and generate huge waste. Although BIS and other regulating bodies have

prescribed limits of water consumption in hospitals and other health care facilities (HCF), highly inefficient use of water is seen at these sites. Also, water demand is growing at hotels and other recreational facilities.

Water demand of industries is dealt with in ad hock manner, and many times realistic estimates are not available. Wherever available, freshwater is utilized even for those uses where recycled water can be used. All industries should be mandated, and strictly enforced, to utilize only limited quantity of freshwater, and all other requirements should be met by recycled water. With use of energy-efficient and environment-friendly technologies, water consumption in industries may be substantially brought down.

Deteriorating water quality

Wastewater generation

Generation of huge quantity of wastewater is a big challenge of modern times. When added to the freshwater sources, this degrades water quality and contaminates water resources. According to a report by United Nations, "globally, 80% of wastewater flows back into the ecosystem without being treated or reused, contributing to a situation where around 1.8 billion people use a source of drinking water contaminated with faeces, putting them at risk of contracting cholera, dysentery, typhoid and polio"[26].

Modern toilet practices and sanitary fittings generate excessive wastewater. Inefficient and careless use of freshwater at household level also generates huge quantity of grey water. There should be control over wastewater generation through community awareness and government legislation. Many traditional practices teach us the judicious use of freshwater, which leads to reduction in the amount of wastewater generated. There are several methods of cleaning and purifying wastewater. Traditional water treatment method is biological treatment, in which natural factors such as sunlight, temperature, filtration, adsorption, sedimentation, biodegradation, etc., are used to treat wastewater. Many Nature Based Solutions (NBS) are helpful in treating wastewater in an environment-friendly manner.

Pollution in water bodies

Pollution in water bodies is a major challenge for water resources of India. Indiscriminate use of fertilizers and pesticides for enhancing agricultural and horticultural production is one of the major contributor of water contamination. Industries are major source of water pollution, which release huge amount of wastewater. Urban drainage is another major cause of pollution in water bodies. As a result, soil and water bodies become contaminated and harmful for the human and animal health, and for the surrounding ecology and environment.

Organic/natural farming is the traditional method of agricultural production, which mitigates soil and water pollution. Use of organic manures should be promoted in place of chemical fertilizers and other chemical-free methods (e.g. bio-enzymes) used for pest control, soil preparation, crop protection, etc. Release of untreated wastewater by industries and production units may be controlled through strict compliance of environmental laws. Community awareness and behavior change can play a significant role in preventing pollution in water bodies.

Safe drinking water

Providing safe and quality drinking water has been a challenge with a growing water demand due to increasing urbanization, economic development and improvement in living standards. The situation is more alarming in rural areas with limited access to proper sanitation and water supply services. Barring situations where toxic contaminants are added to the drinking water supply sources, in other cases TK can provide reasonably safe drinking water for human consumption. Some of the traditional methods of water purification used in India since long time are discussed below.

For purifying water, Alum is used since ancient times. Use of Alum together with filtration is a standard practice in conventional water treatment processes around the world. Surface waters have been treated traditionally using herbs as natural coagulants in India for centuries. *Moringa seed* powder is used as a natural coagulant and flocculent to clarify turbid water and copper as an antibacterial agent to destroy pathogens like *E. coli* to produce clean drinking water[27]. Also, a combination of local plant materials including *Moringa oleifera* and *Phyllanthus emblica*, coarse sand, charcoal, and gravel is used for filtering raw water, for reducing total aerobic mesophilic bacterial, *Escherichia coli*, coliform, pseudomonas, and yeast counts, and turbidity.

Sometimes simple filtration methods such as using cloth pieces are used with rainwater harvesting for drinking and other domestic uses. It has been a traditional practice in India to keep tortoises in open

water wells so that they feed on organisms harmful to humans while keeping water safe for drinking. Water storing in brass vessels is in practice since ancient time for its health benefits.

Water-related disasters and impairments

As climate change increases the frequency and intensity of extreme weather events, water-related disasters such as floods, droughts, cyclones, storms, and landslides also increase. Due to different climatic and rainfall patterns in different regions, while some parts suffer devastating floods, other parts are suffering drought at the same time[28].

Adverse impacts of climate change

Adverse impacts of climate change related extreme events, and related manifestations in terms of degradation of ecosystem services, vulnerable livelihoods, etc. are inevitable. The challenge is to identify appropriate and timely adaptation measures in a continuously changing environment[29]. Climate change impacts the contaminant risk assessment and remediation processes[30]. For addressing the challenge of climate crisis, alternative approaches need to be adopted in place of energy- and water-intensive technologies, and nature-based solutions may be one of the green alternatives.

Cloud bursts & flash floods, GLOF

The Himalayan region of India is increasingly facing extreme weather events such as cloudbursts, flash floods, and avalanches. Heavy damage of property and lives occurs due to these extreme events, which may be averted if natural channels of rivers, streams and springs are not obstructed and their catchments remain healthy. Effective early warning systems about these extreme events can provide emergency relief for saving lives.

Covid-19 type pandemics and their impact on water resources

Water is considered as one of the most important resources during the occurrence of contagious diseases and pandemic situations, for maintaining proper hygienic conditions. According to the reports of various socio-anthropological surveys, pandemic Covid-19 influenced the hygienic habits of the society, including washing hands with soap and water, cleaning floors, food hygiene, and cleaning and sanitizing hospitals, etc. These habits influenced consumption of domestic water use and release of untreated wastewater. Traditional methods of water and wastewater treatment, and of maintaining hygiene, could be used to avoid contamination of wastewater.

Inefficient and insufficient storm water drainage designs

Urban wastewaters pollute rivers and aquifers. As natural drainage channels get clogged up and the urban catchment degrade, downpours leave the city waterlogged. With heavy concretization of urban areas, urban floods become common. Urban water and stormwater management is in a total mess in India. Also, roads and highways are waterlogged in towns/cities due to inefficient and insufficient drainage designs.

Well designed and well-maintained road drainage is important in order to minimize the environmental impact of road runoff on the receiving water environment, to ensure the speedy removal of stormwater to minimize disruption to road users and to maximize the longevity of the road surface and associated infrastructures[31]. To avoid the risk of water logging and flooding on roads, efficient (and sufficient) drainage system should be provided on both sides of roads and highways.

Anthropogenic activities

Blockage of natural drainage in watershed area of water bodies

Water passage into water bodies through their natural drainage is often disrupted, due to urbanization, encroachment, construction, etc. As a result, flooding occurs in the area lead, resulting in water logging. For the health of water bodies, it is essential that natural drainages in watershed areas should be kept clear from any type of blockages.

Encroachment on floodplains of rivers

Floodplains provide the space for rivers to spread their waters during floods, and are called ‘lungs’ of a river. When this space is missing due to encroachments, the river surges up and creates destruction. Due to population explosion, encroachment in floodplains is a common problem in India. As a result of this, cases of heavy loss of life and property are increasing. For avoiding heavy loss due to floods, floodplains should be kept clear from encroachments. Many traditional methods are available for diverting flood waters to agricultural fields[32].

Heavy silting and unscientific mining in rivers

Rivers and riverine environment are under serious threat in India due to large scale riverbed mining

operations. Be it threatened aquatic eco-system, precious surface and groundwater resources, costly public infrastructures or land and lives of villagers, all have been paying a heavy price of relentless mining[33]. Strict compliance of environmental laws is needed for controlling unscientific and haphazard river bed mining.

Reduction in unpaved areas and less groundwater recharge

Due to increase in population, urbanization and industrialization, more and more open space is converted to buildings, houses, roads and pavements. Due to continuous reduction in the unpaved area, groundwater recharge is also reducing in urban areas. This leads to severe depletion of groundwater table in towns and cities. Restoration and rejuvenation of natural water bodies, and establishment of new water bodies, wherever feasible, is urgently needed in various cities and towns in India to control the depletion of groundwater table.

Conclusion

From the above discussion it can be concluded that traditional water knowledge can facilitate providing sustainable solution to contemporary water challenges in India. If existing water harvesting structures, rivers, streams, ponds, lakes, etc. are rejuvenated, conserved, and utilized prudently, water security can be achieved on sustainable basis. Wise and judicious water use has always been the ethos of Indian traditional knowledge and culture. Role of community has been instrumental in practicing efficient water use culture.

All possible means of conserving water at domestic, agricultural and industrial levels should be attempted, and every effort should be made for the protection and safety of water sources. To achieve better efficiency, localized irrigation system using traditional structures could be promoted in place of centralized major irrigation projects. Non-rainfall waters (for example, fog and dew) are the least-studied and least-characterized components of the hydrological cycle, although they supply critical amounts of water for dryland ecosystems.

With the modern-day reality of industrialization and urbanization, strict compliance of environmental laws should be ensured by the relevant agencies and heavy penalties should be imposed if these units are found releasing untreated wastewater in water bodies.

A systematic effort is required to bring behavior change in community towards prudent use of water resources. Mass campaigning for changing peoples' lifestyle is needed. Since freshwater is limited, wastewater treatment should be made integral part of water management and recycled water should be used for non-potable purposes.

Acknowledgements

The authors thank the anonymous reviewers of the paper for valuable suggestions and comments.

Conflict of Interest

The authors have not received any funding for preparing this article and there is no conflict of interest of any kind.

Author Contributions

VCG conceptualized the paper and its contents, as well as reviewed, edited and supervised the progress of the paper. MFU developed the structure of the paper and prepared its draft. CP collected information about traditional water systems from different sources and websites.

Ethical Approval

Human/animal experimental models have not been studied in this paper. Therefore, ethical approval from any agency is not applicable.

Informed Consent

We have not used photographs/figures from other published sources. Information taken from other sources has been properly cited in reference section.

Data Availability

Specific data has not been used and interpreted in this paper. This is an attempt to contextualize Indian traditional water knowledge with contemporary water challenges in India.

References

1 Government of India, NITI Aayog, Composite Water Management Index (2019). Available online: https://www.niti.gov.in/sites/default/files/2023-03/CompositeWaterManagementIndex.pdf (Accessed on 23 December 2024).

2 Singh J & Kaur J, India's water crises: Challenges, solutions and barriers: Working paper, Rajeev Gandhi Institute for Contemporary Studies (2019). Available online: http://www.rgics.org/wp-content/uploads/Working-Paper_Indias-Water-Crisis.pdf (Accessed on 23 December 2024).

3 WWAP (UN World Water Assessment Programme), The United Nations World Water Development Report 2017. Wastewater: The Untapped Resource. Paris, UNESCO.

4 TERRE Policy Centre, A review: Traditional methods of water conservation – Think global & act local. Available online: https://terrepolicycentre.com/journal/traditional-methods-of-water-conservation.pdf (Accessed on 25 December 2024).

5 Centre for Science and Environment, Traditional water harvesting systems. Available online: https://www.cseindia.org/traditional-water-harvesting-systems-683 (Accessed on 25 December 2024).

6 Poples' Science Institute Dehradun, Survival lessons: Water management traditions in the Central-Western Himalayas. Available online: https://peoplesscienceinstitute.org/research/Water%20Management%20Traditions%20in%20W%20Himalayas.pdf (Accessed on 25 December 2024).

7 Padre S, Kattas and Madakas: Decline of traditional water conservation methods, *Down To Earth* (27 February 2020). Available online: https://www.downtoearth.org.in/blog/water/kattas-and-madakas-decline-of-traditional-water-conservation-methods-69489#:~:text=Built%20using%20kaccha%20stones%20and,even%20after%20the%20monsoon%20ends (Accessed on 25 December 2024).

8 Vyas K G, Water wisdom of the Gonds of Garha Mandla, *India Waterportal*. Available online: https://www.indiawaterportal.org/groundwater/rainwater-harvesting/water-wisdom-gonds-garha-mandla#:~:text=The%20Gonds%20understood%20the%20water,built%20on%20impervious%20alluvial%20soil (Accessed on 25 December 2024).

9 The Institution of Engineers (India), Water Management Forum, Traditional Indian methods for water management, Ahmedabad: WMF, 1-69.

10 Debnath S, Adamala S & Palakuru M, An overview of Indian traditional irrigation systems for sustainable agricultural practices, *Int J Mod Agric*, 9 (4) (2020) 12-22.

11 Bhattacharya S, Traditional water harvesting structures and sustainable water management in India: A socio-hydrological review, *Int Lett Nat Sci*, 37 (2015) 30-38. DOI: 10.18052/www.scipress.com/ILNS.37.30.

12 Mansi S & Raju K V, Water: A heritage perspective, In: *ISEC-DF Workshop*, January 25, 2012, DOI:10.13140/RG.2.2.25064.88328. Available online: https://www.researchgate.net/publication/317304861_'Water'_-_A_Heritage_Perspective (Accessed on 25 December 2024).

13 Consortium of 7 "Indian Institute of Technology" s, Ganga River Basin Management Plan-2015, Mission 1 : Aviral dhara (January 2015). Available online: https://nmcg.nic.in/writereaddata/fileupload/8_Mission%201_Aviral%20Dhara.pdf (Accessed on 28 December 2024).

14 Jain S K, Agarwal P K & Singh V P, *Hydrology and Water Resources of India*, (Springer, Dordrecht), (2007) 58-62.

15 TERI, Water-Key facts for its sustainable management in India. Available online: https://www.teriin.org/sites/default/files/2021-06/water-factsheet.pdf (Accessed on 12 January 2025).

16 UNESCO, The United Nations World Water Development Report, 2022: Groundwater making the invisible visible, Paris: UNESCO, 2022, 6. Available online: https://unesdoc.unesco.org/ark:/48223/pf0000380721 (Accessed on 15 July 2022).

17 Pal S, Modern India can learn a lot from these 20 traditional water conservation systems. Available online: https://thebetterindia.com/61757/traditional-water-conservation-systems-india/ (Accessed on 28 December 2024).

18 Agarwal A, Narain S & Khurana I, *Making water everybody's business: Practice and policy of water harvesting*, (Centre for Science and Environment, New Delhi), (2005) xxxii

19 Central Water Commission, Water and related statistics, (2021) pp xxiv. Available online: https://cwc.gov.in/sites/default/files/water-and-related-statistics-2021compressed-2.pdf (Accessed on 10 January 2024).

20 USDA Natural Resources Conservation Service, Water: Inefficient use of irrigation water. Available online: https://efotg.sc.egov.usda.gov/references/public/AR/Excess_Water_Insufficient_Water_Inefficient_Use_of_Irrigation_Water.pdf (Accessed on 28 December 2024).

21 Foodwise, 10 ways farmers are saving water. Available online: https://cuesa.org/article/10-ways-farmers-are-saving-water (Accessed on 28 December 2024).

22 British Columbia, Ministry of Agriculture, Water Conservation Facts Sheets: Soil water storage capacity and available soil moisture. Available online: https://www.droughtmanagement.info/literature/BC_MA_Soil_Water_Storage_Capacity_2005.pdf (Accessed on 28 December 2024).

23 Gatiboni L, Kulesza S & Rivers E, Soil and water quality: Soil facts, NC State Extension Publications, 2020. Available online: https://content.ces.ncsu.edu/soils-and-water-quality (Accessed on 31 December 2024).

24 WWF, Threats: Soil erosion and degradation. Available online: https://www.worldwildlife.org/threats/soil-erosion-and-degradation# (Accessed on 31 December 2024).

25 Kala C P, Traditional ecological knowledge on characteristics, conservation and management of soil in tribal communities of Pachmarhi Biosphere Reserve, India, *J Soil Sci Plant Nutr*, 13 (1) (2013) 201-214. DOI: http://dx.doi.org/10.4067/S0718-95162013005000018.

26 United Nations, UN Water, Water quality and waste water. Available online: https://www.unwater.org/water-facts/quality-and-wastewater/ (Accessed on 31 December 2024).

27 Varkey A J, Purification of river water using *Moringa Oleifera* seed and copper for point-of-use household application, *Scientific African*, 8 (2020) e00364, DOI: https://doi.org/10.1016/j.sciaf.2020.e00364.

28 World Meteorological Organization, Flood and drought management through water resources development in India. Available online: https://wmo.int/media/magazine-article/flood-and-drought-management-through-water-resources-development-india (Accessed on 03 January 2025).

29 UNESCO, Intergovernmental Hydrological Programme, Hydrological systems, climate change and adaptation. Available online: https://en.unesco.org/themes/water-security/hydrology/water-related-disasters (Accessed on 03 January 2025).

30 Bolan S, Padhye L P, Jasemizad T, Govarthanan M, Karmegam N, *et al*, Impacts of climate change on the fate of contaminants through extreme weather events, *Sci Total Environ*, 909 (2024) 168388, DOI: https://doi.org/10.1016/j.scitotenv.2023.168388.

31 Singh R R, Kaur N & Goyal N, Drainage on Roads, *Int J Prog Civ Eng*, 1 (1) (2014) 19-21.

32 Prevention Web, India: Why floodplains need to be protected. Available online: https://www.preventionweb.net/news/india-why-floodplains-need-be-protected (Accessed on 03 January 2025).

33 SANDRP, Riverbed mining India 2021 overview: Destruction of rivers, infrastructure, governance. Available online: https://sandrp.in/2022/01/01/riverbed-mining-india-2021-overview-destruction-of-rivers-infrastructures-governance/ (Accessed on 03 January 2025).