Traditional Water Management Systems of India

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Abstract

Water scarcity is becoming a significant issue in the present context not only because of the unrestricted exploitation but also due to water pollution and inequitable distribution of the available resource. In a country like India that has finite sources of water and an ever-increasing population, it becomes critical to manage the water resource.

This paper explores the traditional water management systems used in India and analyses their relevance and application in a contemporary context. For this study, the traditional water management systems are documented and the data analyzed. Some water management systems can be incorporated as is while others can be optimized to increase efficiency for contemporary applications.

The study recommends incorporating traditional water management systems in contemporary practices which can reduce the overall water risk being faced by India.

Keywords: traditional systems, water management system, water scarcity, water conservation.

1. Introduction

Water is a fundamental resource for the survival and development of the biotic environment. At a global level, only 2.7% of total water available is fresh water out of which almost 70% is concentrated in glaciers and icecaps (U.S. Geological Survey, 1993). This means that water is a limited resource and as fresh water is utilized for domestic, agricultural and industrial purposes, water demand is ever increasing with the increase in population and urban development. In the current world scenario, water scarcity is one of the major problems being faced by many countries. Other factors such as water pollution, decreased water percolation, shrinking of water bodies, irregularities in monsoon, excessive use and wastage of water are also responsible for the increase in water scarcity.

As per the data collected by the world resource institute, more than 50% of India is under extreme water stress[1] and more than 80% of the country is under extremely high overall water risk[2].

[1] Baseline water stress measures the ratio of total water withdrawals to available renewable surface and groundwater supplies

[2] Overall water risk measures all water-related risks, by aggregating all selected indicators from the Physical Quantity, Quality and Regulatory & Reputational Risk categories

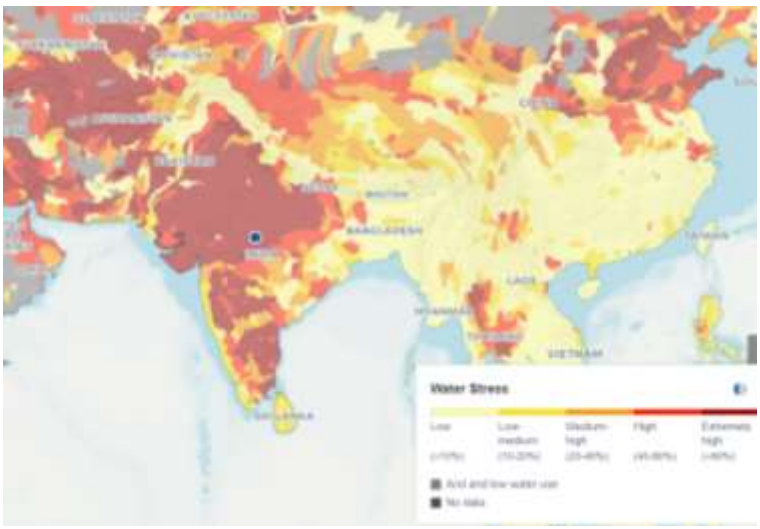

Fig. 1: Map showing the extreme water stressed areas in India
Source: World Resource Institute

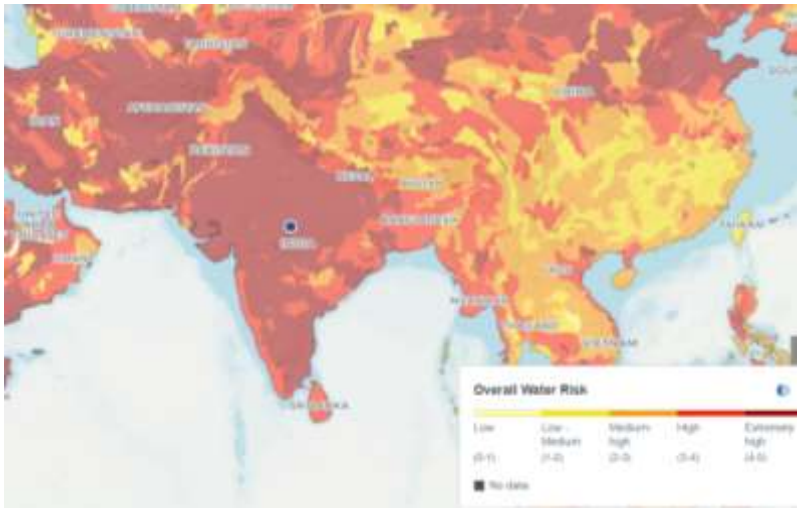

Fig. 2: Map indicating the overall water risk in India
Source: World resource Institute

As per the composite water management index published by NITI Aayog, the total precipitation received by India is 4000 BCM out of which only 1869 BCM (46.7%) is considered as the water resource potential. Out of this, only 1123 BCM (28.1%) is the actual usable water resource. Further study presented by the Central Soil and Materials Research Station in New Delhi shows that the water availability in terms of cubic meter per person will decrease by about 20% by 2050 (from 1439 cum/person to 1140 cum/person) whereas the total water demand is set to increase by 32%.

Apart from the obvious disparity in the supply and demand of the water resources, another major issue is the inequitable distribution of freshwater due to the large temporal and spatial variation resulting in rainfall as low as 100mm annually in regions like Rajasthan and heavy monsoon with almost 11000mm annual rainfall in regions such as Meghalaya (Development Alternatives Group). Therefore, critical steps such as water management need to be taken to reduce the water stress and ensure water sustainability.

A planned system to conserve and efficiently utilize the water resources is considered as a water management system. Many water management systems have been developed over the

years across the world to maintain the region's water resources. Depending on the climate, terrain, people, culture and resources of a region, water management systems vary greatly. The system can be as basic as a lake or something complex like an IoT based smart water management system. Even though the use of traditional water management systems has declined in recent years due to the usage of bore-wells and tube wells, the traditional systems are more eco-friendly, simple and effective.

One of the earliest water management systems ever developed was in the Indus valley civilization that had proper water supply and drainage network. Despite the hot and dry climate and low rainfall in the region, the civilization had achieved water sufficiency for its residents (Virtual Academy of Ancient Knowledge systems). Their water management system is considered to be one of the most well developed in the world and the Indus valley civilization is considered as an urban settlement due to these advancements.

Fig. 3: The water supply and drainage system in Indus Valley Civilization
Source: https://www.ancient-civilizations.com/

Later systems such as Kunds served multiple purposes as they were used for domestic as well as religious functions making them culturally significant. Other intricate systems such as Jhalaras and Baolis became tourist attractions contributing to the economy of the regions.

Fig. 4: (left) Radha Kund in Uttar Pradesh and (right) Rani ki Vav in Gujarat
Source: The Economic Times (indiatimes.com)

Therefore, it is important to study such traditional water management systems that were not only uniquely designed and fulfilled their function efficiently, but also had significant socio-economic and cultural impacts on the regions housing them. This paper aims to study the traditional water management systems and their relevance in contemporary context. The aim is achieved through the objectives i.e. 1. How these traditional water management structures have fulfilled the needs of the people? 2. how it got influenced the socio-cultural activity of the people?

2. Methodology

The region selected for this study is India. This study is done by documenting the traditional water management systems of the region. The methodology covers various traditional management techniques been practices in several subregions in India. The impact of the water storage structures on socio and cultural aspects of the settlement is also discussed. Each water management system had taken its shape as per the local environment depending upon the available construction techniques and the material available. Majority of the structures are to store the water for future usages addressing the domestic purposes (Gupta et al, 2014). The rainwater harvesting structures are varying with the materials used, some are built with dressed stone masonry, some are built with soil and rubble, some are underground tanks, some are having an earthen bund (Divy et al, 2009).

2.1.Traditional Water management Systems

India has a very diverse terrain which affects the climate of different regions resulting in distinctive summer, winter and monsoon seasons. Due to reasons such as dependency on monsoon, scarcity of water because of climate or lack of sources of water, many regions in India developed their own water management systems to conserve water.

Some of the most well-known water management systems can be seen in the State of Rajasthan which has a hot and dry climate and consists of the Thar desert which has very few sources of fresh water.

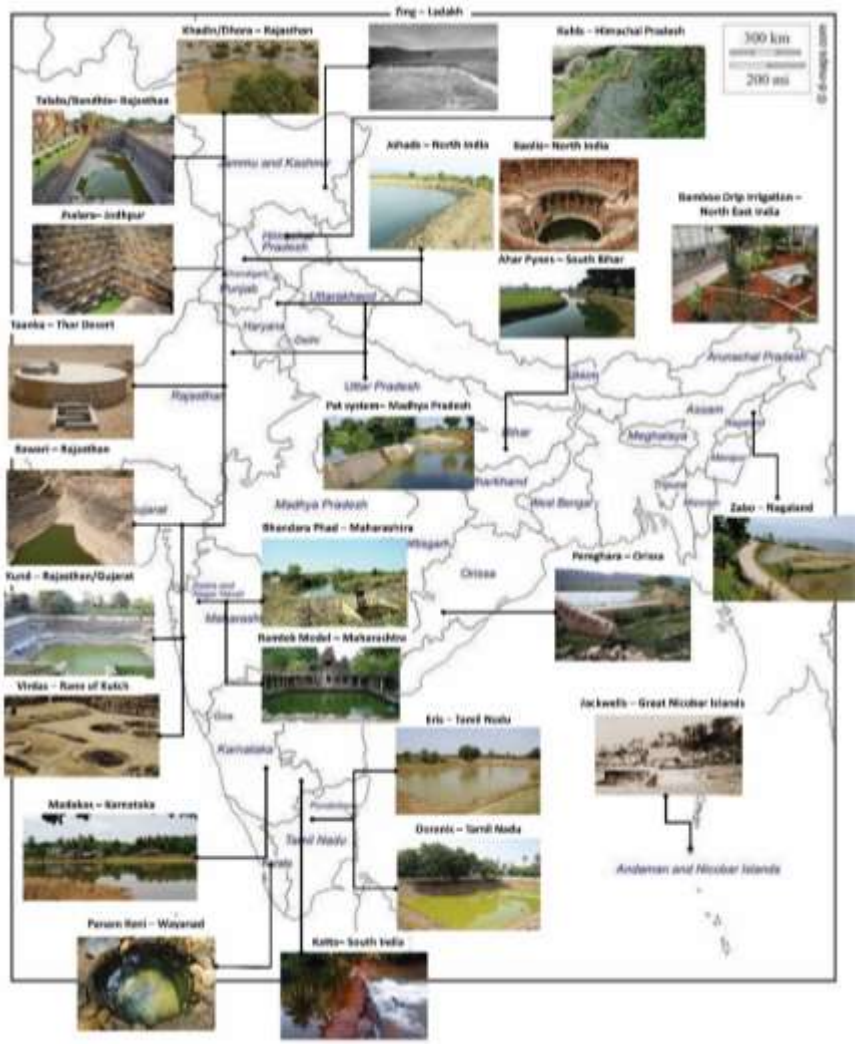

Fig. 5: Map showing the different water management systems in different regions of India
Source: author

2.1.1. Northern Region

The region of Ladakh is a cold desert that lies in the northern part of India. It is the country's highest plateau and is surrounded by mountain ranges resulting in the cold and dry climatic conditions of the region. The climate along with low annual precipitation and sparse vegetation is responsible for the region being one of the most water scarce places in the country. The most easily accessible source of water in this region are the glaciers containing fresh water. Parts of the glaciers naturally melt under the sunlight during the day and the water from it is guided and collected into tanks called "Zings" through a network of channels. The water channels are kept smooth and compact and are cleaned regularly to maintain an unobstructed and steady flow of water. The slope for the channels is not too steep so as to avoid run off (Tundup et al.,2017). An official referred to locally as the "*Chirpun*" is responsible for overseeing the tanks and its equitable distribution among the community to fulfill their farming requirements.

Fig. 6: Zing in Ladakh
Source: https://www.thebetterindia.com/

Due to receding glaciers, another method used by the locals as an alternative is creating artificial glaciers. During the winter, the excess run-off water is guided towards the shaded parts of the mountain where its flow is further slowed down using retaining walls so that in the absence of heat from the sun, it will freeze. As this artificial glacier is at a lower altitude and much closer to the villages, they melt earlier at the start of the summer around April and provide water for the crops (Norphel et al, 2009).

Another similar system to Zings is the Kuhls found in the Kangra Valley system of Himachal Pradesh. Found in the mountainous regions, Kuhls are surface water channels consisting of melted glacier water from the surrounding mountains. There are more than 1000 major and minor Kuhls that were built by public donations or royal orders and were to be maintained by the users. The master of the kuhl known as "*kohli*" oversaw the equitable distribution and settled disputes over water (Moudgil, 2014).

Fig. 7: A Kuhl in Himachal Pradesh
Source: https://www.indiawaterportal.org/

In the lower northern states of Punjab, Haryana and Uttar Pradesh, Johads are one of the oldest and most prevalent water management systems in the region. They are earthern check dams with naturally elevated surface on 3 sides and a retaining wall created from the excavated soil from the storage pit on the fourth side. Their function is to store rainwater and help recharge groundwater. In regions with heavier monsoons, these Johads are interconnected with smaller channels which can be opened up into a stream or river so as to avoid any structural damage to the Johad.

Fig. 8: Photo and Illustration of a Johad
Source: https://www.ntotank.com/blog/

A more complex and intricate system in this region is the Baoli. They are step wells carved motifs, archways and even rooms on the sides that are found mostly in Delhi, Rajasthan and Gujarat. Based on their location, their utility changes. Baolis located in villages were for social gatherings and other utilitarian purposes while those located near travel routes were frequented as resting places for the travelers and traders. The Baolis constructed near agricultural fields provide water only for farming with a network of small channels taking water directly to the fields.

Fig. 9: Feroz Shah Kotla Baoli in Delhi
Source: https://so.city/

One of the more multi-functional systems is the Ahar Pynes of Bihar that work as a rainwater harvesting as well as flood control system. The Ahars are central catchment areas with embankments on 3 sides and diversion channels called Pynes at the fourth side. These Pynes are artificial channels led off from nearby rivers that recharge the Ahars and the stored water can then be used during the dry summer season (Kaul et al.,2012).

Fig. 10: Ahar Pyne in Bihar
Source: https://www.thebetterindia.com/

2.1.2. North Western Region

North western region of India consists of Rajasthan and Gujarat states that have a predominantly hot and dry climate. The annual average precipitation is low resulting in severe water scarcity in some parts of the states. Due to these many different water management systems, indigenous? to this region can be found (Kumar et al, 2010). This include Jhalaras that are rectangular stepwells with tiered steps on 3 or all four sides. They collect the subterranean seepage of a reservoir or lake and the water is used by the community for domestic, religious or ceremonial purposes.

Fig. 11: Chand Baori stepwell of Abhaneri
Source: https://www.thebetterindia.com/

Bawaris are another unique type of stepwells that are older than Jhalaras. The rainfall received in the region would be diverted to these man-made tanks through canals built on the hilly outskirts of cities. The water then percolated and recharged the ground water as well as the aquifers below. Layered steps were built around the wells to deepen and narrow it down to reduce loss of water through evaporation (C.P.R. Environmental Education Centre, Chennai)

Fig. 12: A bawari in Nahargarh
Source: https://www.thebetterindia.com/

Other systems such as Kunds on the other hand were built to store and distribute drinking water. They are more saucer shaped rainwater catchments with slopes leading down towards a central circular underground well. Kunds are known to have been built as early as 1600 AD.

Fig. 13: A saucer shaped Kund
Source: https://www.thebetterindia.com/

Talabs were more simple catchment areas that could be either natural or man-made and the water stored was mostly used for domestic usage. Artificially built traditional talabs are found mostly in Rajasthan whereas the natural talabs are found in most regions of India.

Fig. 14: A man-made talab in Rajasthan
Source: https://www.thebetterindia.com/

The water management system of Taankas is indigenous to the Thar desert in Rajasthan. Rainwater from courtyards, rooftops or artificially prepared catchments flow into a cylindrical paved underground pit known as a Taanka which is covered to reduce the water loss from evaporation. A fully filled Taanka can fulfill the water requirements of a family for the entire summer season.

Fig. 15: A traditional Taanka in Thar region
Source: http://in.peerwater.org/

Khadins or Dhora are also indigenous to this region where rainwater is harvested directly on farmlands with spillways and sluices that help drain the access water into storage pits and the land saturated with water is later used for agriculture purposes.

Fig. 16: A Khadin in Jaisalmer
Source: https://www.thebetterindia.com/

Like Taankas and Khadins, the Virdas is the indigenous water management system in the Rann of Kutch region in Gujarat. Virdas, also known as sand bores, were a unique rainwater harvesting system developed to retain and store freshwater as the major chunk of the water resource available was saline in nature. In the natural low depressions occurring on the plains, shallow wells called virdas are dug to collect rainwater. The topmost layer is groundcover (grass) under which the rainwater gets accumulated. The groundwater is salty but the layer containing rainwater is at least 1 m above the ground water level. Between these 2 layers exists a layer of brackish water. The water doesn't mix due to the difference in density and therefore can be extracted easily for domestic use.

Fig. 17: Virdas or Sand Bores in Gujarat
Source: https://upsctree.com/

2.1.3. North Eastern Region

Zabo literally means 'impounding run-off' in the native language and is a system indigenous to Nagaland that combines forestry, animal husbandry and agriculture with water conservation. Also known as the Ruba system, the rainwater from the forest covered hilltop is collected in a pond-like structure created on the terraced hillsides with the help of channels that pass-through cattle yards collecting animal waste along the way. This water is then used for fish rearing and growing medicinal plants.

Fig. 18: A Zabo in Nagaland
Source: https://www.thebetterindia.com/

Bamboo Drip irrigation System is a type of micro irrigation system being practiced in North east India for the past two centuries that diverts water from perennial springs into terrace fields using bamboo pipes of variable shapes and sizes. The water is directly delivered to the roots of the crops and this system is most efficient for low water demanding crops. This method is predominantly used for black pepper cultivation by the farmers of Khasi and Jaintia hills.

Fig. 19: Bamboo drip irrigation in a garden
Source: https://www.thebetterindia.com/

2.1.4. Central Indian Region

Pat system of Madhya Pradesh developed in the Bhitada village in Jhabua district uses the peculiarities of the terrain to divert water from hill streams into irrigation channels. The water is diverted using leakproof bunds made from stone, mud and teak leaves. The water channel is arranged to pass through deep ditches and aqueducts cut into stone cliffs to create an efficient irrigation system used by the farmers.

Fig. 20: A pat or check dam in Madhya Pradesh
Source: https://www.thebetterindia.com/

Bhandara Phad is a check dam (*bhandhara*) system built across a river with canals (*kalvas*) branching out and carrying water to the fields in the agricultural blocks (*phad*) for irrigation. Escape outlets known as *Sandams* are provided to remove any excess water from the canals by distributaries (*charis*) and field channels (*sarangs*). This system is managed by the community and is used predominantly on the rivers of Tapi Basin (More, 2016)

Fig. 21: A Bhandara on a river
Source: https://www.thebetterindia.com/

The Ramtek model is indigenous to Maharashtra and is named after the town of Ramtek where it was first applied. It is a network of groundwater and surface water bodies and is constructed and maintained mostly by the landowners also known as the "*malguzars*" of the region. The Ramtek model is a series of tanks that are connected by both surface and underground canals, forming a chain that extends from the foothills to the plains. After the tanks located at the foothills are filled to capacity, the water flows down and fills the successive tanks, ending in a small pool. It is a very efficient system and conserves up to 60-70% of the runoff water (Gupta et al., 2014).

Fig. 22: A surface water body at Kali Mata's Temple, Ramtek
Source: https://www.chaitanyaproducts.com/blog/

2.1.5. Southern Indian Region

One of the earliest water management systems in India that still exist are the cascading water storage tanks of Tamil Nadu called Eris that were developed to irrigate the agricultural lands due to a lack of perennial rivers in the region. They also acted as a flood control system, helped recharge ground water and prevented soil erosion by restricting run-off during rainfall. They were designed to be either system eris? that are fed by water channels diverted from a river or non-system eris that relies solely on rainwater. The tanks were further interconnected to help extend the reach of the water source to far away villages and at the same time balance out the water levels in case of an excess in supply (Jalyatra, 2008).

Fig. 23: Small tank (eri) near Thalambedu in Kanchipuram
Source: https://www.indiawaterportal.org/

Every hamlet in Tamil Nadu has three water bodies: one for irrigation, another for cattle, and a drinking water Oorani (pond). They're all rain-fed. Because to these catchment bodies, many villages have thrived for millennia.

Traditional systems are well-known, as the XI-five-year-plan (Rural Drinking Water and Sanitation in the Eleventh Plan Period – Excerpts) shows. "The traditional Ooranis or ponds have actually proven to be a godsend for the people of Tamil Nadu," it continues. The Ooranis were created centuries ago as the primary supply systems in Tamil Nadu. These earthen bunded ponds were built throughout time by the joint efforts of the people and have been designed hydrologically to have adequate and consistent water levels.

Fig. 24: Oorani in Pattikadu village in Thirukazhukundram block
Source: https://www.indiawaterportal.org/

Mullu Kurauma hamlets use a specific form, well-known as 'Panam Keni.' Kurumas have been using this style of well for hundreds of years. Kenis are found near woodlands and on the edge or in the middle of paddy fields. They are cylindrical in shape, with a diameter and depth of about four feet. Toddy palms line the wall (Caryota urens). Typically, the bottom stem portion of giant palms is utilized to construct wooden cylinders after being soaked in water for an extended period of time, allowing the inner core to rot and decay while the hard outer covering remains. The wooden cylinders are submerged in areas with good ground water springs, which is the secret to ample water even in the desert.

Fig. 25: A Panam Keni in Wayanad
Source: https://www.thebetterindia.com/

Other water management systems like the Madakas of Karnataka and Pemghara of Orissa are similar in structure and work with the Johads seen in the Northern states of India.

Fig. 26: (left) Pemghara of Orissa and (right) Madaka of Karnataka
Source: https://www.thebetterindia.com/

The Kattas found in the southern states of Kerala and Karnataka are similar to the Pat water management system of Madhya Pradesh i.e., they are temporary check dams built with stone, mud and wood during winter to retain water for the summer season (Waternama, 2007).

Fig. 27: (left) an underconstruction katta and (right) fully functional katta
Source: https://www.deccanherald.com/

Jackwells are pits encircled by bunds made from logs of hard wood that cover the low-lying region of the nicobar island used for rainwater harvesting. A full-length bamboo is cut longitudinally and placed on a gentle slope with the lower end leading the water into the jackwell. Often, these split bamboos are placed under trees to collect the runoff water from leaves. Big jackwells are interconnected with more bamboos so that the overflow from one jackwell leads to the other, ultimately leading to the biggest jackwell. This system is indigenous to the Shompen tribe of the Great Nicobar Islands.

Fig. 28: A jackwell of Great Nicobar Island
Source: https://www.thebetterindia.com/

3. Discussion

It can be seen from the above study that these water management systems are not only unique but also have socio-economic and cultural significance. If maintained properly, these systems can last for decades. Systems such as bunds are made of locally available material which is eco-friendly whereas systems that require wells or water channels have low environmental impact. They are also adaptable in nature as systems like Baolis, Johads and Kattas/Pats are seen to have been implemented in multiple regions regardless of the climate. In most cases, separate officials are appointed to ensure an equitable distribution of water which is also an important aspect largely ignored in many modern water management systems.

In a country like India, where the majority of the population relies upon agrarian activities, water is a key resource. Untimely rainfall or lack of it during required times can potentially ruin the whole harvest. Therefore, alternative sources of water need to be available. One major source are the perennial rivers that carry freshwater. But rivers are effective only in areas where they are present and even then, due to water pollution, the source is rendered less viable. Other modern methods such as borewells or tubewells can be exploitative, adversely affecting the ground water tables and in some cases like that of Punjab, it can cause groundwater poisoning. As a result, traditional water management systems become the more dependable and efficient choice.

4. Conclusion

In conclusion, the traditional water management systems are a more agreeable option as they promote social cohesion by compelling the members of a community to come together to construct and maintain the systems. They also incite social harmony due to its equitable nature and is economically viable as a tourist or religiously relevant space. In terms of sustainability, they last longer, are simple to build and use, less exploitative than modern systems and just as effective if not more. Therefore, the existing systems should be maintained, the derelict systems should be revitalized and regions with no such systems should adapt them to tackle the water scarcity issue, reduce the water stress and achieve long term sustainability.

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