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Study Of Traditional Water Resource Management In Rajasthan

Satyam Kumawat[1*], Dr. Nand Kumar Matwa[2], Aditya Anand[3], Rhitwik Gupta[4], Maitreyi Sapre[5]

[*1]Assistant Professor, Faculty of Architecture and Planning, CODE-VGU, India
[*2]Associate Professor, Department of Architecture and Planning, MNIT Jaipur, India
[*3]Student, Department of Architecture and Planning, MNIT Jaipur, India

[*]**Corresponding Author** Satyam Kumawat
Email: satyam.kumawat@gmail.com

ABSTRACT

With highly variable rainfall patterns, semi-arid and arid regions have faced water scarcity problems from time immemorial. As a result, communities that rely on rainwater for sustenance have developed indigenous techniques and knowledge to collect rainwater. Such rainwater collection structures have stood the test of time when it comes to sustainability. Not only are they compatible with a local livelihood but also local institutional patterns and social systems. In the present times, when water conservation is more critical than ever, it is important to look back and learn from indigenous methodologies. This paper attempts to analyze the traditional water harvesting systems developed in Rajasthan over the centuries and how they are still contextual to cope with present water scarcity issues.

Keywords Traditional water harvesting, Rainwater, Rajasthan, water scarcity, water storage

1. Introduction

Water remains centric in the socioeconomic development of a country as it sustains ecosystems, industrial growth, and food security. Due to a tremendous increase in water consumption over the decades, India is experiencing a huge water shortage. According to a recent report by the United Nations Educational, Scientific and Cultural Organization (UNESCO), Paris, about 2/3rd of the world's population faces water scarcity for at least one month a year (UNESCO), Paris, 2017. Moreover, the 'water crises have recently been observed as the current global risk of highest concern for people and economies for the next decade by the World Economic Forum (Global Risks Report 2016). Therefore, it is quite evident that there is an urgent need to effectively address water scarcity through efficient water resource planning and management in order to ensure social equity as well as freshwater sustainability 478-479. DOI (2015). Such water scarcity problems have been effectively solved through indigenous rainwater harvesting techniques for centuries.

Rajasthan being the largest and most arid state of India, faces water shortages time and again. With more than 10.4% of the country's geographical area, Rajasthan supports more than 5.5% of the human population and 18.70% of the livestock, but only has 1.16% of the total surface water available in the country. The groundwater resources are low due to deep aquifers and low recharge. With no perennial rivers, water scarcity issues are due to fluctuating weather and river systems. Thus, there is a high dependency on deep wells and rainwater harvesting systems.

Over the centuries, local communities have devised various rainwater harvesting systems such as Jhalara, Khadin, Bawari, Nadi, Talab, Kund, Tanka, and roof water harvesting systems. Rather than just a technique, water harvesting became an integral part of socio-cultural frames. Not only are these systems simple, replicable, and cheap but also quite efficient, sustainable, and adaptable. Rainwater harvesting has long-term advantages of increased water use efficiency, improved soil fertility, reduced soil erosion, and increased agricultural productivity. etc. Moreover, it provides for domestic water, drinking water, small-scale irrigation purposes, water for livestock, and recharges groundwater levels (Reiz et al., 1988). Water conservation through harvesting at the micro and macro scale can bring about sustainability, increasing water availability in drought-struck areas. Traditional methods were neglected amidst municipal supplies through government schemes. However, the current crisis of recurring droughts, reducing groundwater, and increasing population has bought attention to traditional methods. Many modern water-collecting technologies are inspired by indigenous practices. Percolation tanks, anicut, ponds with infiltration wells, and subsurface barriers are some such techniques used to rejuvenate depleted freshwater aquifers. (Khan 1996 a,b, Narain and Khan 2000, 2002).

2. Methodology

This paper aims to analyze traditional water harvesting systems in Rajasthan and how they can contribute to the current water scarcity crisis. The objective is to understand the historical evolution of traditional water management practices, their socio-cultural significance, and the current relevance of these practices in addressing water scarcity. The paper will start with a review of the water resource situation in Rajasthan and the challenges faced. It will then delve into the various traditional water harvesting systems, analyzing their design, construction, and maintenance, along with their advantages and limitations. Finally, the paper will conclude by discussing the current status of these practices, their potential to address water scarcity, and their significance in the larger context of water resource management and conservation efforts.

3. Water resource situation in Rajasthan

Rajasthan, being the largest state in India, is known for its rich culture and history. However, despite its grandeur, the state faces a major challenge when it comes to water resources. With more than 10.4% of the country's geographical area, Rajasthan supports more than 5.5% of the human population and 18.70% of the livestock, but only has 1.16% of the total surface water available in the country. The groundwater resources are also low due to deep aquifers and low recharge, making the situation even more critical.

Due to its semi-arid and arid climate, the state of Rajasthan experiences highly variable rainfall patterns and frequent droughts, which have made the people of the state highly dependent on rainwater for sustenance. With no perennial rivers, water scarcity issues are a recurring problem in the state, which has forced the local communities to adopt various traditional rainwater harvesting techniques like kunds, kuis, baoris, nadis, tobas, johads, tankas, and khadins. These techniques have been developed over centuries and have stood the test of time when it comes to sustainability, as they are compatible with local livelihoods and institutional patterns.

Despite the use of these traditional water harvesting techniques, the state of Rajasthan still faces a number of challenges when it comes to water resources. Firstly, the rapid growth of population and urbanization has put a strain on the existing water resources, leading to an increased demand for water. Secondly, the state has experienced a decline in rainfall patterns in recent years, which has further exacerbated the water scarcity issue. Thirdly, the state also faces the challenge of declining groundwater levels, as more and more people are forced to rely on deeper wells for their water needs.

Another major challenge faced by the state of Rajasthan is the lack of proper water resource management practices. Despite the existence of various traditional water harvesting techniques, there is a lack of proper planning and implementation of these techniques, which is leading to their gradual decline. Additionally, there is a need for proper monitoring and maintenance of the existing structures to ensure their effectiveness in the long run.

Furthermore, there is also a need to address the issue of unequal distribution of water resources in the state, as some regions continue to receive an adequate supply of water while others struggle to meet their basic water needs. This highlights the need for a comprehensive and integrated approach to water resource management, which takes into account the needs of all regions and communities.

In conclusion, the state of Rajasthan faces a number of challenges when it comes to water resources. With its semi-arid and arid climate, the state is highly dependent on rainwater for sustenance, which has made the local communities develop various traditional water harvesting techniques. However, despite the existence of these techniques, the state continues to face the challenges of declining rainfall patterns, declining groundwater levels, and a lack of proper water resource management practices. Addressing these challenges and ensuring sustainable water resource management practices is essential for the socio-economic development of the state and the well-being of its people.

4. Traditional Water Harvesting Techniques in Rajasthan

Kund or Kundi:
Kund, a traditional water harvesting system in India, has been widely used in semi-arid regions like Rajasthan for centuries to conserve and store rainwater for later use. This system is often designed and constructed in the form of a large, shallow basin with sloping sides and is typically located near a source of water such as a river, canal, or spring. The basin collects rainwater from nearby catchment areas and stores it for later use, primarily for irrigation and domestic purposes.

The design of a Kund is crucial to its effectiveness. The basin is constructed in such a way that it maximizes the collection and storage of rainwater while minimizing losses due to evaporation and seepage. The sloping sides of the basin promote

the flow of water into the center where it can be collected, while the shallow depth of the basin helps to minimize evaporation losses. The basin is also often lined with clay or other materials to prevent seepage and help maintain the water level in the kund.

Construction of a Kund typically involves digging a large pit in the ground, lining it with clay or other materials, and then constructing the sides with earthen or masonry walls. A small channel may also be built to direct rainwater from nearby catchment areas into the Kund. The construction process can be labor-intensive, but the materials used are typically locally available and inexpensive.

Maintenance of a Kund involves regular cleaning of the basin and removing any debris that may have accumulated in the bottom. The basin may also need to be lined periodically to prevent seepage and maintain the water level. Additionally, the walls of the basin may need to be repaired or rebuilt if they become damaged.
One of the main advantages of a Kund is its ability to store large volumes of water for later use, particularly during dry periods when water is scarce. This can help to ensure a reliable source of water for irrigation and domestic purposes, even during times of drought. The shallow depth of the Kund also helps to reduce evaporation losses, making it a more efficient way to store water compared to deeper systems like wells.

However, there are also some limitations to the Kund system. One of the main challenges is maintaining the water level in the basin, particularly during periods of low rainfall. The Kund may also become contaminated with pollutants from surrounding areas, making the stored water unsuitable for use. Additionally, the construction and maintenance of a Kund can be labor-intensive and expensive, particularly in remote areas where access to resources and labor may be limited.

In conclusion, the Kund is a traditional water harvesting system that has been used in India for centuries to conserve and store rainwater. With its simple design, locally available materials, and ability to store large volumes of water, it can be an effective solution to water scarcity in semi-arid regions. However, careful design, construction, and maintenance are crucial to ensure its long-term effectiveness and maintain the quality of the stored water.

Fig. 1: *Traditional Kund system.*

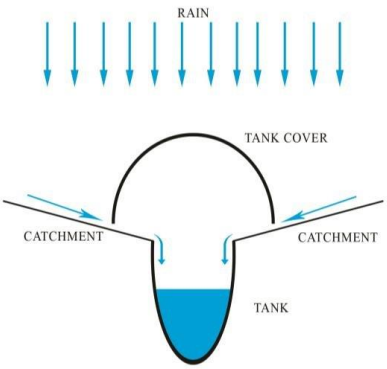

Fig. 2: *Schematic section of kund*

Kuis or Beris:
Kuis are traditional water harvesting structures commonly found in the arid regions of India, particularly Rajasthan. They are designed to collect and store rainwater for later use. The design of kuis consists of a cylindrical or conical pit dug into the ground, with sloping sides to allow water to flow in easily. The top of the pit is covered with a dome-shaped roof made of mud, bricks, or stones, which protects the stored water from evaporation and contamination. The roof also serves as a platform for the collection of rainwater, which is then channeled into the pit through a series of channels or gutters.
The construction of kuis requires minimal materials and can be done by the local communities with traditional techniques. The size and depth of the pit vary depending on the intended use and the amount of water required. A well-constructed kui can store a considerable amount of water, ranging from a few hundred to several thousand liters, depending on its size.

Maintenance of kuis is essential to ensure their longevity and efficiency. This involves regular cleaning and desilting of the pit to remove debris and sediment, which can clog the channels and reduce the storage capacity of the kui. The roof also needs to be repaired or replaced periodically, as it is prone to damage from weather and animal activity. Regular cleaning and maintenance can extend the lifespan of a kui and ensure its continued functionality.

Advantages of kuis include their low cost and simple design, which make them accessible to communities with limited resources. They can provide a reliable source of water for domestic and agricultural use, especially in areas where groundwater is scarce or unreliable. Kuis also help recharge the groundwater table, thus improving the overall water balance in the region.

However, there are also some limitations of kuis. One of the main limitations is their dependency on rainfall, which can be irregular and unpredictable in arid regions. This can result in a lack of water during extended dry spells, which can be a problem for communities that rely on kuis as their primary source of water. Another limitation is the vulnerability of kuis to contamination, as they are often located in close proximity to human settlements and livestock. Improper construction or maintenance can also reduce the effectiveness of kuis and lead to the loss of stored water.

In conclusion, kuis are a traditional and effective water harvesting system that can provide communities with a reliable source of water, particularly in arid regions where groundwater is scarce or unreliable. Despite their limitations, kuis can play an important role in addressing water scarcity, especially in regions where modern water management systems are not feasible or affordable. Regular maintenance and proper construction can ensure the longevity and efficiency of kuis, making them a sustainable solution for communities facing water scarcity.

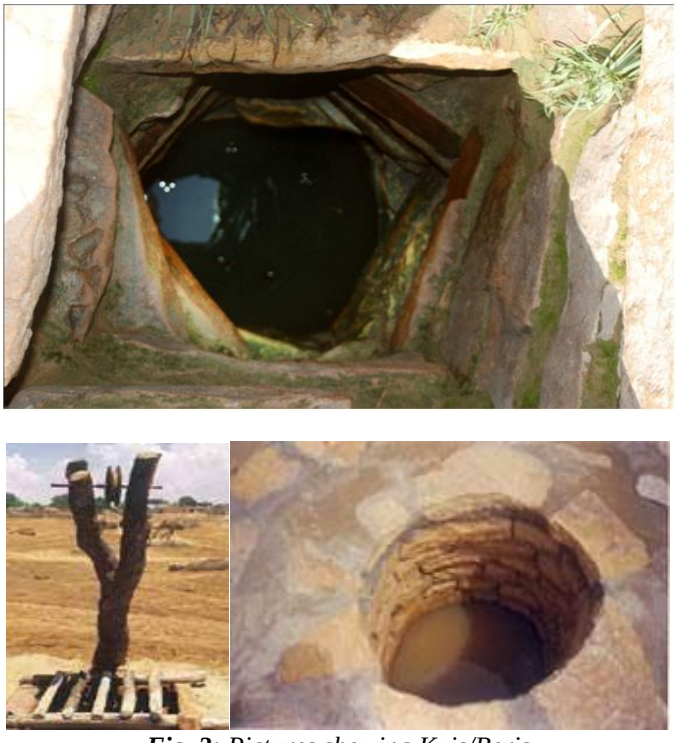

Fig. 3: *Pictures showing Kuis/Beris*

Baoris:
Baoris are traditional water harvesting systems found in the Indian state of Rajasthan. They are large stepped wells, used to store water during the rainy season and provide a reliable source of water during the dry seasons. Baoris are primarily found in the semi-arid regions of Rajasthan, where water is scarce and temperatures can soar up to 50°C.

Design: A typical baori consists of a series of stepped terraces leading down to a well. The steps are used as a platform to access the water stored at the bottom of the well. The well itself is lined with stone or brick masonry to prevent the water from seeping into the ground. The size of a baori can vary from a small structure that serves a single household to large ones that serve an entire village. The depth of the well can also vary, ranging from a few meters to several tens of meters.

Construction: Baoris were primarily constructed by the local communities, using locally available materials such as stone, mud, and brick. The construction process involved digging a large hole in the ground and lining it with stone or brick masonry. The steps were built around the well and the entire structure was covered with a dome or a roof to protect the water from contamination.

Maintenance: Baoris require regular maintenance to ensure their functionality. The steps need to be cleaned regularly to prevent the accumulation of debris, and the masonry of the well needs to be checked for any cracks or damage. The water in the baori also needs to be regularly checked for any signs of contamination, and appropriate measures need to be taken to prevent it.

Advantages: Baoris have several advantages. Firstly, they provide a reliable source of water during the dry seasons, when other sources of water may be scarce. Secondly, they help in recharging the groundwater table, by allowing water to percolate into the ground. Thirdly, they also serve as a source of water for irrigation and for livestock. Finally, baoris are also significant from a cultural and historical perspective, as they have been in use for centuries and are an integral part of the cultural heritage of Rajasthan.

Limitations: Despite their advantages, baoris also have some limitations. Firstly, the water stored in the baoris is susceptible to contamination, especially if the structure is not properly maintained. Secondly, the water in the baoris can also become depleted during times of drought, if there is a heavy demand for water and insufficient rain to refill the well. Finally, the construction of baoris requires a significant investment in terms of labor and materials, and maintenance can also be a challenge, especially in remote areas where there is a lack of resources.

In conclusion, baoris are an important traditional water harvesting system in Rajasthan, providing a reliable source of water and serving as an integral part of the cultural heritage of the region. Despite their limitations, baoris continue to play an important role in addressing water scarcity in the region, and their significance cannot be overlooked. It is important to maintain and preserve these traditional water harvesting systems, as they hold the key to sustainable water management in the future.

Fig. 4: *Stepwell in Rajasthan*

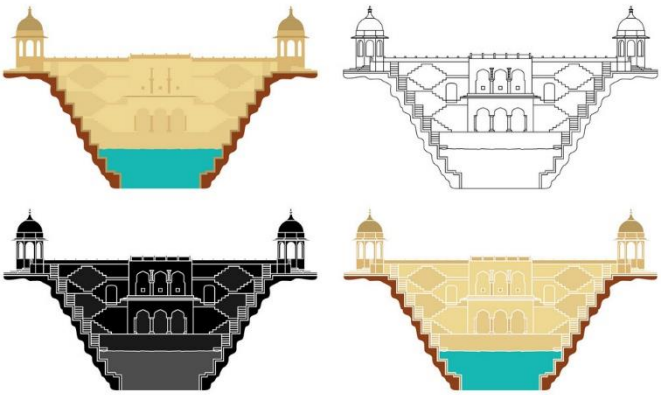

Fig. 5: *Baori/stepwell section*

Nadi:
A nadi is a traditional water harvesting system used in the arid regions of India, particularly in Rajasthan. It is a simple and effective method of conserving and storing rainwater for future use. The design of a nadi involves excavating a trench or channel in the ground, which is lined with stones and mud to prevent seepage. The channel is then connected to a storage tank or pond, which collects the rainwater.

The construction of a nadi requires careful planning and proper execution to ensure its effectiveness. The first step is to choose an appropriate location for the channel, taking into account the slope of the land, the direction of the water flow, and the availability of water sources. The excavation of the channel must be done in such a way that it maximizes the collection of rainwater and minimizes the loss of water through seepage. The lining of the channel must be done using materials such as stones and mud, which are locally available and are effective in preventing seepage. The channel must be connected to a storage tank or pond, which is capable of holding the collected rainwater.

The maintenance of a nadi is an important aspect to ensure its long-term effectiveness. The channel and the storage tank must be cleaned regularly to remove any debris and sediment that may accumulate over time. The lining of the channel and the storage tank must be inspected regularly for any signs of damage or wear and tear, and repairs must be carried out promptly to prevent water loss. The water levels in the storage tank must be monitored regularly and the tank must be refilled when necessary.

The advantages of a nadi are that it is a simple and cost-effective method of conserving and storing rainwater. It provides a reliable source of water for various purposes, such as domestic use, irrigation, and livestock. It also helps in recharging the groundwater table and reducing soil erosion. Moreover, it is a sustainable method of water conservation and does not require any power or other resources to function.

The limitations of a nadi are that it may not be effective in areas with high rainfall or areas with frequent flooding, as the excess water may not be properly managed. The construction of a nadi requires manual labor, which may be a challenge in areas with a shortage of labor. The maintenance of the channel and storage tank must be carried out regularly to ensure its effectiveness, which may be a challenge in remote or inaccessible areas. Finally, the availability of materials for the construction of the channel and storage tank, such as stones and mud, may be a limiting factor in some areas.

In conclusion, a nadi is a traditional water harvesting system that has been used for centuries in India to conserve and store rainwater for future use. It is a simple, cost-effective, and sustainable method of water conservation, which provides a reliable source of water for various purposes. However, it also has some limitations, such as its effectiveness in areas with high rainfall or areas with frequent flooding, the requirement of manual labor for its construction, and the availability of materials for the construction of the channel and storage tank.

Fig. 6: *Picture showing Nadi*

Tobas:
Tobas are traditional water harvesting systems used in arid and semi-arid regions, especially in Rajasthan, India. They are often found in rural areas and serve as a source of water for domestic and agricultural purposes. Tobas are small earthen reservoirs with slopes and bunds on three sides and an outlet on the fourth side to control water flow.

The design of Tobas varies, but generally, they are constructed on high ground so that water can be collected and stored during the rainy season. They have an embankment on the fourth side that serves as a dam, and the water is collected on the inner side of the dam. The slope of the dam is designed to ensure the stability of the structure and prevent water from flowing back. The outlet is used to regulate the release of water and ensure a constant water supply throughout the year.

Construction of Tobas requires proper planning and site selection. The site should be located on high ground, away from human settlements and animal grazing areas to minimize the risk of contamination. The soil should be compact, free from cracks and well-drained. The embankment should be constructed with soil from the surrounding area and compacted thoroughly. A spillway or outlet should be constructed to regulate the release of water, and a proper slope should be maintained to prevent erosion.

Maintenance of Tobas is essential to ensure their longevity and efficiency. The embankment should be checked regularly for cracks or signs of erosion and repaired promptly. The spillway should be cleaned regularly to prevent blockages, and the outlet should be kept clear to ensure a continuous supply of water. Regular inspections should also be conducted to identify and repair any other damage or issues.

Advantages of Tobas include the ability to store and conserve water, improve groundwater recharge, and provide water for domestic and agricultural purposes. They are also cost-effective and can be easily constructed and maintained by local communities. In addition, Tobas help to prevent soil erosion and improve soil fertility by increasing water availability for crops.

However, Tobas also have some limitations. They are dependent on rainfall and can be subject to water loss due to seepage and evaporation. The design and construction of Tobas require proper planning and site selection, and if not constructed properly, they can be unstable and prone to collapse. Tobas are also vulnerable to contamination from human and animal waste. Therefore, regular maintenance and monitoring are essential to ensure the longevity and efficiency of Tobas.

In conclusion, Tobas are a traditional water harvesting system used in arid and semi-arid regions that serve as a source of water for domestic and agricultural purposes. They are cost-effective, easily constructed and maintained, and have the potential to improve water availability and soil fertility. However, proper planning, site selection, and maintenance are essential to ensure their longevity and efficiency.

Fig. 6: *Picture showing Tobas*

Johad:

Johads are a type of traditional water harvesting system commonly found in the semi-arid regions of India, particularly in the state of Rajasthan. The design of johads involves the construction of a circular or rectangular earthen dam, with sloping sides, in order to capture and store rainwater runoff. The dam is usually surrounded by an embankment and can be up to 30 meters in diameter. The collected water is then used for irrigation, drinking and livestock purposes.

Construction of johads is a community-led effort, with the local villagers participating in the excavation and construction of the dam. The construction material for the johads typically consists of soil, sand, and gravel and is easily available in the local area. In addition to the dam, there may also be a system of channels and drainage to direct water into the johad and to prevent soil erosion.

Maintenance of johads is typically carried out by the local community, with regular cleaning and desilting of the dam and channels to maintain their efficiency. The community also takes responsibility for ensuring the security of the johad, as it is a critical source of water for the villagers.
Advantages of johads include:

- Improved water availability: Johads provide a reliable source of water for irrigation, drinking, and livestock purposes, particularly in areas with limited water resources.
- Community involvement: Johads are constructed and maintained by the local community, which fosters a sense of ownership and responsibility towards the water resource.
- Cost-effectiveness: The construction and maintenance of johads is relatively inexpensive, as the materials used are readily available in the local area.
- Ecological benefits: Johads help to recharge groundwater and promote the growth of vegetation, which can have a positive impact on the local ecosystem.

Despite their many advantages, johads do have some limitations. One of the major limitations is the limited storage capacity of the dam, which can result in water scarcity during periods of low rainfall. Additionally, johads can become silted over time, reducing their storage capacity and effectiveness, and requiring regular maintenance.

In conclusion, johads are a cost-effective and community-led water harvesting system that has proven to be a valuable resource in the semi-arid regions of India. Despite their limitations, they have been instrumental in addressing water scarcity and improving water availability for irrigation, drinking and livestock purposes. The continued promotion and adoption of johads as a traditional water management practice can play a significant role in addressing water scarcity and ensuring the sustainable use of water resources in the future.

Fig. 7: *Picture showing Johad*

Khadins:
Khadins are traditional water harvesting systems found primarily in the arid regions of Rajasthan in India. They are usually built to store and conserve rainwater, and they are an important source of irrigation and drinking water for the communities that rely on them.

Design: Khadins are large, underground water storage systems that are typically built in low-lying areas, such as the bed of a dried-up river or seasonal stream. They are usually circular or oval in shape, with a diameter ranging from 50 to 200 meters. The walls of the khadins are made of masonry or earthen bunds, and they are topped with a layer of clay or soil to prevent the water from evaporating. The khadins are built to store the maximum amount of water possible, and they are typically deep enough to store water for the entire year.

Construction and Maintenance: Constructing a khadin is a complex process that requires a great deal of planning and coordination between the local community and the relevant authorities. The first step in building a khadin is to locate a suitable site, and then to clear the area of all vegetation. Next, the bunds are built around the perimeter of the khadin, and the clay or soil layer is added on top. Finally, the khadin is filled with water and allowed to settle for several months to allow the soil to compact.
Maintenance of khadins is important to ensure their longevity and effectiveness. This includes regular cleaning and repairing of the bunds to prevent leaks, and ensuring that the water in the khadin is not contaminated. In addition, the water level in the khadin should be monitored regularly, and steps should be taken to prevent over-extraction of water, which could lead to a decline in the water table.
Advantages: The main advantage of khadins is their ability to store large amounts of water, which can be used for irrigation and drinking water. This makes them particularly valuable in regions where water is scarce and the rains are unpredictable. In addition, khadins can help to recharge the groundwater, which is an important resource for communities in arid regions. Another advantage of khadins is that they are built and maintained by the local community, which fosters a sense of ownership and responsibility among the people who use them.
Limitations: Despite their many benefits, khadins are not without their limitations. One of the main limitations is the high cost of construction, which can be prohibitively expensive for some communities. In addition, maintaining khadins requires a great deal of effort and resources, which can be difficult for some communities to sustain over the long term. Finally, khadins are vulnerable to contamination from agricultural and industrial pollutants, which can render the water in them unsafe for human consumption.
In conclusion, khadins are an important and valuable traditional water harvesting system that play a crucial role in addressing water scarcity in arid regions. However, their success and sustainability depend on the cooperation of the local community, the involvement of relevant authorities, and the allocation of sufficient resources for their construction and maintenance.

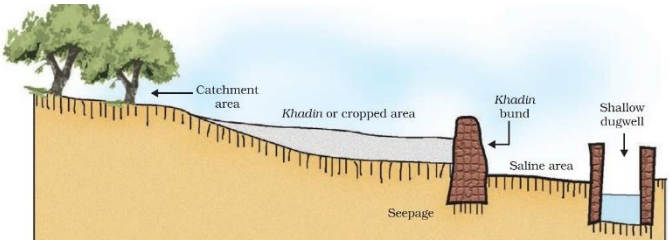

Fig. 8: *Section showing Khadin system*

Tankas:

Tankas (small tank) are underground structures and mostly found in the houses of Bikaner. They are built in the main house or in the courtyard. They were circular holes made in the ground, lined with fine polished lime, in which rainwater was collected. *Tankas* were often beautifully decorated with tiles, which helped to keep the water cool. The water was used only for drinking purpose (Ministry of rural development, 2004).

The construction of a Tanka requires the use of local materials such as mud, sand, and stone. The excavation of the pit is done manually, and the mud wall is built by layering mud and sand, which is then reinforced with stones. The wall is then plastered with mud to make it waterproof. The water stored in the Tanka is used for various purposes such as irrigation, drinking, and livestock consumption.

The maintenance of a Tanka is relatively simple and involves cleaning it regularly to remove debris, repairing cracks or damages to the wall, and maintaining the water level. The water in the Tanka is replenished by rainwater, and the water level is maintained by the use of an inlet and outlet system.

There are several advantages of using a Tanka for water harvesting. One of the main advantages is that it provides a reliable source of water even during periods of drought. The water stored in the Tanka is also clean and safe to use, as it is protected from contamination by the mud wall. Additionally, Tankas are relatively easy to construct and maintain, making them accessible to a wide range of communities.

However, there are also some limitations to using Tankas for water harvesting. One of the main limitations is that the storage capacity of a Tanka is limited, which means that it may not be sufficient to meet the needs of larger communities. Additionally, the water stored in the Tanka may become stagnant if not used regularly, which can lead to the growth of harmful microorganisms. Finally, the mud wall may become damaged over time due to erosion, which can lead to the water seeping out and being lost.

In conclusion, Tankas are a traditional water harvesting system that has been used for centuries in India to store rainwater for later use. They are simple in design and construction, and are easy to maintain, making them accessible to a wide range of communities. However, their storage capacity is limited, and the water stored in them may become stagnant if not used regularly. Nevertheless, Tankas remain a relevant and effective solution for addressing water scarcity in India.

In conclusion, Tankas are a traditional water harvesting system that has been used for centuries in India to store rainwater for later use. They are simple in design and construction, and are easy to maintain, making them accessible to a wide range of communities. However, their storage capacity is limited, and the water stored in them may become stagnant if not used regularly. Nevertheless, Tankas remain a relevant and effective solution for addressing water scarcity in India.

Fig. 9: *Picture showing underground tanka*

Fig. 10: *Picture showing human-made tank in Nahargarh fort, Rajasthan*

5. Current status of Traditional practices

The current status of traditional water management practices is a mixed bag, with some of these practices continuing to be used and others falling into disuse. In many parts of India, particularly in rural areas, traditional water harvesting techniques such as kunds, baoris, johads, and tankas are still widely used for collecting and storing rainwater.

However, the increasing urbanization and modernization of society has led to the decline of these practices in some areas. This has been accompanied by a shift towards more modern and technological water management solutions, such as large dams and pipelines. While these modern solutions have brought many benefits, they have also led to the neglect of traditional water management practices and the loss of traditional knowledge and skills associated with these practices.

In terms of maintenance, many of these traditional water harvesting systems have been neglected over time and have fallen into disrepair. This is due in part to a lack of resources and government support for their maintenance, as well as a lack of knowledge and skills among the local communities about how to maintain these systems.

Despite these challenges, there is a growing recognition of the importance of traditional water management practices and the role they can play in addressing the current water scarcity crisis. There are initiatives underway to revive these practices, and to train people in the skills and knowledge required to construct and maintain them.

One of the key advantages of traditional water harvesting systems is their low cost and ease of construction. These systems can be built using locally available materials and can be constructed with simple tools and techniques. This makes them an ideal solution for rural communities who may not have access to expensive modern water management technologies. In addition, these traditional practices are often integrated into the cultural and social fabric of local communities, and play an important role in shaping the identities and values of these communities. This cultural significance makes these practices more sustainable and resistant to change, as they are deeply rooted in local traditions and knowledge.

However, there are also limitations to traditional water harvesting practices. For example, these systems are often designed to collect water from relatively small catchment areas, and may not be suitable for large-scale water management projects. In addition, many of these systems rely on the presence of vegetation in the catchment area to maintain water quality, and this can be disrupted by land use changes or other environmental factors.

In conclusion, while traditional water management practices continue to face challenges in terms of maintenance and declining usage, they still play an important role in addressing water scarcity and in preserving the cultural heritage of local communities. There is a growing recognition of the value of these practices and efforts are underway to revive and promote their use.

6. Present scenario of Water Management

The present scenario of water management is a complex and pressing issue, with increasing demands for water in various sectors, coupled with challenges such as climate change, water pollution, and over-extraction of groundwater resources. This has resulted in water scarcity in many regions and has affected the sustainable development of many communities and nations.

To address these challenges, many countries have adopted integrated water resources management (IWRM) approach. This approach considers the interdependence of water supply and demand, and the interlinkages between different sectors

and stakeholder groups. IWRM involves a comprehensive and participatory approach to water resources management, with the aim of ensuring equitable access to water, preserving ecosystem health, and promoting economic growth.

The main difference between IUWM and conventional methods is how IUWM redefines a city's connection to water and other resources. The manner in which we see and utilize water resources are reconceived by IUWM. To better grasp these resources and take advantage of their numerous advantages, it also uses innovative, environmentally friendly techniques and technology. Though, current water management is just utilizing the available water resources in a very unsustainable manner, surface water resources are depleting and built development with impervious surface in an urban area led to over-exploited groundwater.
In the urban sector, there is a growing focus on the use of innovative water management technologies, such as rainwater harvesting, greywater reuse, and wastewater treatment. These technologies aim to conserve water and reduce water pollution, and can also help to mitigate the impacts of water scarcity in urban areas.
In the industrial sector, there is a growing focus on reducing water pollution, improving water efficiency, and conserving water resources. Companies are adopting water stewardship initiatives, such as implementing water management plans, monitoring water use, and reducing water pollution.
Traditional water management practices have been used for centuries to harvest and conserve water in various regions of the world, including India. In many parts of the country, these practices have been in use for hundreds of years, providing a reliable source of water to support agriculture, livestock, and human needs. In the present time, water scarcity has become a major concern in many regions, with increasing demands on finite water resources and a growing population. Given the growing demand for water, the potential of these traditional practices in addressing water scarcity has been widely recognized, and has been the subject of numerous studies and initiatives in recent years.

India has a long history of collecting rainwater (RWH). But in order to close the growing gap between supply and demand, modern water management mainly relies on expensive long-distance water transfers, which also overuses in-situ groundwater resources. Understanding the value of rain is necessary for sustainable water management and making the best use of rainwater where it falls.

RWH is a technique for gathering rainwater and stopping its evaporation, runoff, and seepage for effective use and conservation. The ideal choice is to collect rainwater where it falls and properly store it (either on the surface or in an aquifer) for later recovery and usage as needed. RWH is also a useful technique for using enormous amounts of high-quality water that would otherwise be wasted or used up in flooding or waterlogging.

7. Best practices of Traditional Water-Harvesting knowledge in present context

Cities all over the world are showcasing the deployment of creative and inexpensive techniques focusing on a comprehensive and integrated approach to water management in response to the growing need for sustainable urban water management.
The case studies that follow look at various facets of the urban water cycle. The selected case studies demonstrate how the following water-efficient techniques can be linked with coordinated spatial planning:
- Mitigating flood risk and managing surface wate
- Enabling pollution control and natural water purification
- improving local water resources
- Fostering biodiversity
- Providing recreational facilities for the public

Case study 1: Birkha Bawri at Umaid Heritage Site, Jodhpur, Rajasthan

Fig. 11: *Birkha Bawri, Jodhpur, Rajasthan*

Situated southeast of Jodhpur's Umaid Bhawan Palace, Umaid Heritage Site is a private township that was facing an acute shortage of water. To solve the issue, a rainwater harvesting system was put in place inside the housing complex. The Birkha Bawri is used to collect rainwater from the site catchment area and was built in the style of the local traditional stepwells.

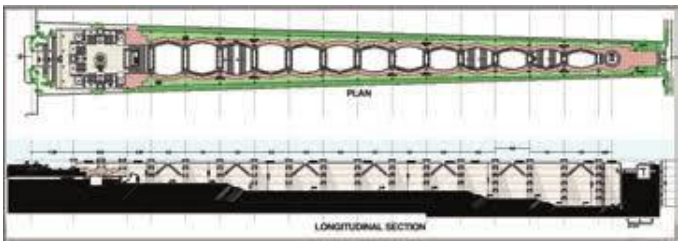

Fig. 11: *Plan and section of Birkha Bawri*

The project focus on efficient water management in the apartment complex in addition to water conservation through storage. It reduced water logging in the area and collected extra runoff. Rooftops are utilized to collect the water of the houses that are connected through drainage conduits as well as from the open areas via natural slopes. The Bawri can hold 17.5 million litres of reclaimed water yearly and allows water to enter from both sides. It provides a dependable source of water for landscaping needs as well. Due to a steep depth of 18m, water is shaded which in turn reduces evaporation losses. The stored water in Bawri serves as a water supply source to the residents during times of need as well as meets the landscaping irrigation requirements.

Achievements:

The stepwell-inspired Rainwater harvesting system reduced dependence on groundwater extraction and municipal water supply by 50%. Reduction in demand for water tankers has led to huge economic benefits, saving over 2.36 crore annually. Moreover, the Birkha bawri demonstrates a perfect amalgamation of contextual architectural design with green spaces in a scanty rainfall region, thus increasing the property value of the complex. The overall dependence on municipal supply has drastically reduced. Moreover, concerns like stormwater runoff and waterlogging are effectively solved. The conserved water is used for landscape maintenance in a very sustainable way.

Case study 2: Central University of Rajasthan, Kishangarh, Rajasthan

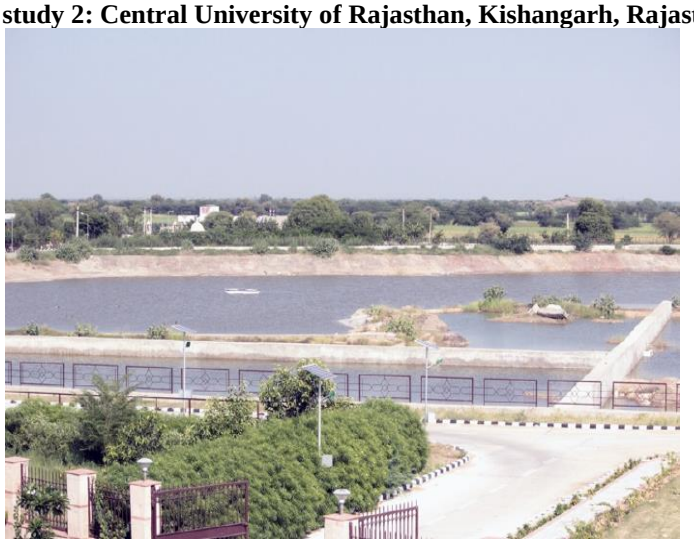

Fig. 12: *Central University of Rajasthan view from water-body*

The Central University in Kishangarh is a contemporary example of the implementation of traditional water harvesting techniques in a modern context. The university adopted these techniques as a part of its sustainable campus development initiatives. The location of the site is in the Rajasthan state's hot, semi-arid region, where water is a rare natural resource. Potable ground water is not readily available due to the rough, rocky geology.

The collection of surface runoff (during rain) is crucial in such a situation. In order to control surface runoff, raise the groundwater table, and improve the campus's overall ecological and environmental state, the Integrated Micro Watershed Management Plan has been adopted as a tool. The exercise increased the designated campus's capacity and guaranteed

water supplies for future generations. Because the surface area of the stored water has decreased, deepening the water bodies has enhanced the ground water recharge rate while also lowering direct evaporative losses to the environment.

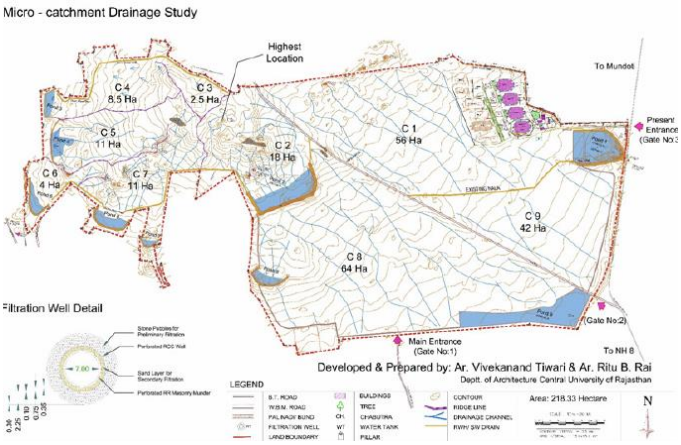

Fig. 13: *Micro-catchment Drainage Map of CURaj*

The traditional knowledge in the form of age long successful practices should be adopted for the construction of medium scale water bodies. The construction of the water bodies has traditionally been done with earthen embankments. In several areas of Rajasthan, a dirt similar to bentonite known as murud is used to line these water bodies. The resurgence of constrained aquifers is assisting vegetation growth and ensuring groundwater supplies during the dry months. Many bird species in this area have been drawn to the water bodies as a result of this resurgence.

Fig. 14: *Human-made Pond on CURaj site*

Within the site boundaries, a micro watershed management plan allows for the collecting of rainwater. They choose the Decentralize & Channelized water collecting system, which consists of little Earthen Bunds, RR masonry, and RCC reservoir, based on the site dynamics.

Heavy siltation caused by excessive water runoff is bad for the vegetation cover and the capacity of ponds. The inclusion of native species in the landscape plan is necessary to prevent this siltation. A 6 inch layer of dirt has been put on the bottom to cover the HDPE sheet in order to prevent any seepage via cracks created in hard rock or weathered rock.

Fig. 15: *Heavy siltation due to high-run-off*

Achievements:
Once a dry area is now converted into a good water available area. Water demand for the campus is fulfilled with the harvested water, also this water is serving nearby villages too. This was a great approach to water urbanism with filled waterbody having backdrop of built form.

Fig. 16: *Filled waterbody with built form backdrop*

The waterbody has become natural habitat for many birds.

Fig. 17: *Natural Habitat for birds on CURaj site*

8. Result and Discussion:

The study of traditional water management practices has shown that these practices, such as kunds, kuis, baoris, nadis, talabs, tobas, johads, tankas, and khadins, have played a significant role in addressing water scarcity in the past. These practices have been developed over centuries and are deeply rooted in the socio-cultural significance of the regions where they are found.

The design, construction, and maintenance of these traditional water harvesting systems are unique to each system, with different advantages and limitations. For example, kunds are large, shallow water storage structures that are best suited for small scale irrigation and water storage, while tankas are underground cisterns that can store large quantities of water, but can be expensive to construct.

The current relevance of these traditional practices in addressing water scarcity is clear. Despite advances in modern technology and water resource management, many regions still suffer from water scarcity and droughts. Traditional water harvesting systems can play a critical role in augmenting water resources and reducing the impacts of water scarcity. Moreover, many of these practices are sustainable, low-cost, and easily accessible to communities, making them ideal for implementation in rural areas.

However, the current status of these traditional practices is mixed. In some regions, these practices are still widely used and maintained, while in others, they have been largely forgotten. The potential of these practices to address water scarcity in the present time is significant, but it will depend on the revitalization of these practices and the integration of traditional knowledge into modern water resource management and conservation efforts.

After independence, the original RWH structures were abandoned as piped water became more widely accessible. Over time, they either ceased to exist or were not being used to their full potential. The government has responded by taking various steps to enhance the RWH structures after realizing this. However, there is more work to be done in this area. The current drought situation, groundwater shortage, and population growth have drawn attention to traditional approaches. Indigenous traditions are the source of inspiration for many current water collection devices. Such methods include using percolation tanks, anicuts, ponds with infiltration wells, and subsurface barriers to restore depleted freshwater aquifers that are part of the IUWM.

According to historians and scholars, water scarcity wasn't an issue when the community organizations were robust and people relied on their own wisdom to develop harvesting systems rather than relying on state for water supply. Further, such structures provided space for people to come together for sociological and religious needs as well as holds cultural and architectural significance. Traditional rainwater harvesting systems are an excellent example demonstrating how sustainability can be achieved by modifying simple historical concept to suit the modern context; in order to better utilize and conserve in-situ resources. The traditional wisdom ensured adequate availability of water for all, which consequently formed the basis of comprehensive development. It is time to reflect upon the ancient knowledge to ensure a safe future.

One of the primary advantages of traditional water management practices is their simplicity and low cost. These systems are typically constructed using locally available materials and labor, which makes them an affordable solution for communities with limited financial resources. The design of these systems also tends to be highly adaptable to local conditions, with the ability to adjust to changes in topography, water flow, and other factors.
In addition to their low cost and adaptability, traditional water management practices also offer several advantages in terms of water conservation. For example, systems such as kunds, kuis, baoris, and nadis are designed to store water and ensure that it is available even during dry periods. This is achieved through a combination of features, including the construction of underground chambers and the use of percolation pits, which allow water to filter down into the soil and recharge the water table. The result is a reliable source of water that is available even during periods of drought.

Another key advantage of traditional water management practices is their ability to promote water conservation. These systems are often designed to minimize the amount of water that is lost to evaporation and seepage by collecting and storing water in underground chambers and percolation pits. This helps to conserve water resources and also helps to maintain the health of local ecosystems by preventing the depletion of water tables and the drying up of streams and rivers.

Despite these advantages, traditional water management practices are not without their limitations. For example, many of these systems require regular maintenance, including cleaning, repairing, and upgrading. This can be a significant challenge, especially in communities with limited financial and technical resources. Additionally, these systems are often built using local materials, which may not be as durable as modern materials and may deteriorate over time.

There is a need for an integrated approach to water resource management, combining traditional knowledge and modern technology. This approach not only helps to conserve precious water resources but also to revive the dying traditional practices which are the backbone of water management systems. The traditional practices of water harvesting like Kunds, Baoris, Nadi, Tobas, Johads, Tankas, and Khadins are the solutions that have been proven over the centuries to provide adequate water resources in the arid and semi-arid regions of the country. These practices can be combined with modern technology to address present-day water scarcity and to ensure sustainable water resource management.

To implement the integrated approach, the following measures can be taken:

- **Revival and protection of traditional water harvesting systems:** To revive and protect the traditional water harvesting systems that have been forgotten over the years. This can be done by restoring the existing systems and building new ones in areas where they are required. The government and local communities should work together to achieve this objective.
- **Awareness and education:** To create awareness about the significance and importance of traditional water harvesting systems. This can be done by educating the local communities, schools, and colleges about traditional water harvesting practices and their role in water resource management.
- **Combination of traditional knowledge and modern technology:** To combine traditional knowledge and modern technology to address the current water scarcity. For example, traditional water harvesting systems like Kunds, Baoris, Nadi, Tobas, Johads, Tankas, and Khadins can be integrated with modern technology like rainwater harvesting, recharge wells, and water conservation methods.
- **Capacity building and skill development:** To build the capacity and skills of the local communities to manage and maintain the traditional water harvesting systems. This can be done through training programs, workshops, and hands-on experience.
- **Promotion of interdisciplinary collaboration:** Interdisciplinary collaboration between various stakeholders, including water experts, farmers, engineers, and policy makers, is essential for the successful implementation of an integrated approach. This can be achieved through regular meetings, workshops, and forums where stakeholders can share their knowledge and experiences.
- **Monitoring and evaluation:** To monitor and evaluate the impact of the integrated approach on water resource management. This would help to identify the challenges and opportunities for improvement and make necessary changes.

By implementing the above measures, traditional water harvesting practices can be integrated with modern technology to ensure sustainable water resource management. This would not only provide adequate water resources to meet the needs of the growing population but also revive the traditional practices which are the backbone of water resource management.

An integrated approach of traditional and modern water management practices can be a valuable solution to address water scarcity and improve water resource management. It is important to prioritize the documentation and preservation of traditional knowledge, encourage community involvement, integrate traditional practices into modern water management

planning, promote interdisciplinary collaboration, and provide financial and technical support to ensure the successful implementation of this approach.

9. Conclusion:

Rainwater harvesting systems have always been an integral part of local communities of the North-west region of India. With the changing terrain, these systems have also evolved using age-old wisdom and knowledge. They have served the indispensable need of water requirement of the people, livestock and for irrigation purposes, especially in water-scarce areas of the Thar Desert in Rajasthan. They were replenished annually by monsoon rain and provided year-round assistance to the population. These utilized low-cost, simple technologies were also environmentally friendly. However, such water harvesting systems have been left barren and discarded with the passing of time. It is high time that such structures should be revived and taken inspiration from to stand against the present water crisis. They are a perfect example of sustainable practices and water management practices in low-rainfall regions, displaying effective conservation of rainwater.

Traditional water management practices, such as Kunds, Baoris, Johads, Tankas, and Khadins, among others, have been in existence for centuries and have proven to be effective in conserving water in regions with limited water resources. The research has highlighted the advantages of these practices, such as their cost-effectiveness, ease of maintenance, and positive impact on the environment.
However, the study also highlights the limitations of these traditional practices, such as their limited water storage capacity and the need for maintenance and repair work. To address these limitations, it is necessary to adopt an integrated approach, which combines traditional water harvesting techniques with modern practices. This approach can leverage the strengths of both traditional and modern practices and provide a sustainable solution to water scarcity.
In conclusion, the research highlights the importance of preserving and promoting traditional water harvesting techniques, which have been passed down from generation to generation. By adopting an integrated approach, it is possible to conserve water and address water scarcity in a sustainable manner. The research also highlights the need for continued efforts to understand and improve these traditional practices so that they can be effectively used in addressing water scarcity in the future.

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