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Traditional Water Management in the Thar Desert: The *Khadeen* of Rajasthan, India

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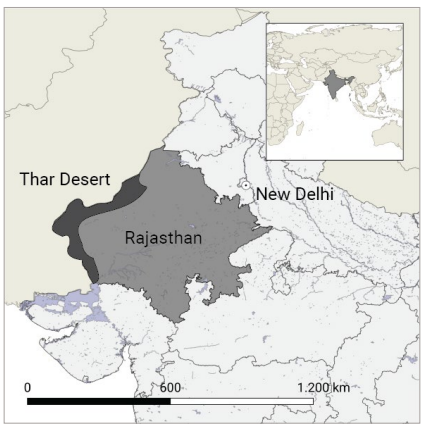
The khadeen system of the Thar Desert, in Rajasthan, is an ancient technology that takes advantage of peculiar geohydrologic formations to create temporary lakes. A careful water management practice, the khadeen are an example of age-old methods of capturing and using seasonal runoff for agriculture, ensuring water access in arid regions. Khadeen have played a crucial role in supporting agricultural activities since the sixteenth century, offering impressive yields in a water-scarce environment. However, the enduring efficacy of khadeen faces contemporary threats, including mining encroachment, labor outmigration and road development. The delicate balance between preserving traditional knowledge and succumbing to external pressures poses challenges to their cultural, ecological and agricultural significance. This paper comments on the historical, hydrogeological and socioeconomic dimensions of khadeen, emphasizing the importance of their preservation in sustaining communities and ecosystems in the Thar Desert area.

Keywords: *nature-based solutions, Indigenous technology, non-motorized irrigation, khadeen, water harvesting*



< Fig. 1 The Masurdi Khadeen (Source: Bhatta Ram, February 2021).

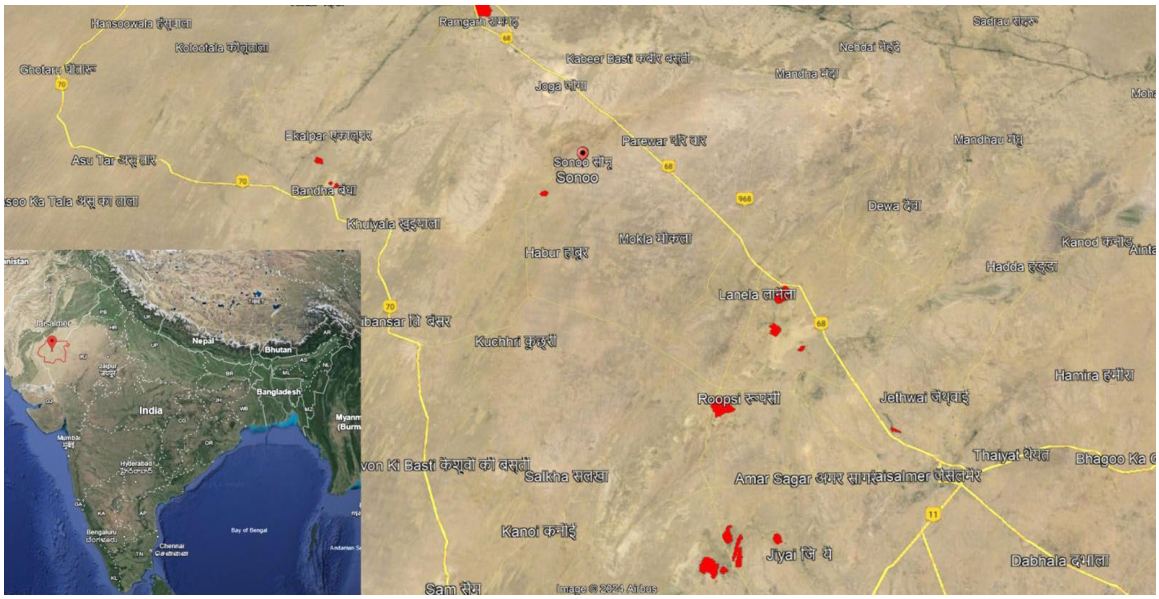
Introduction

In the Jaisalmer district (Rajasthan, India), located in the Thar Desert, water scarcity poses a considerable challenge. In approximately 60 per cent of the region, the annual rainfall is quite low, reaching a meager 200 mm on average. The monsoon season, from July to mid-September, sees 90 per cent of the area's precipitation, usually in the form of torrential rain. In addition to strong winds, high temperatures and elevated groundwater salinity, this contributes to a complex ecosystem where access to water is not a given.

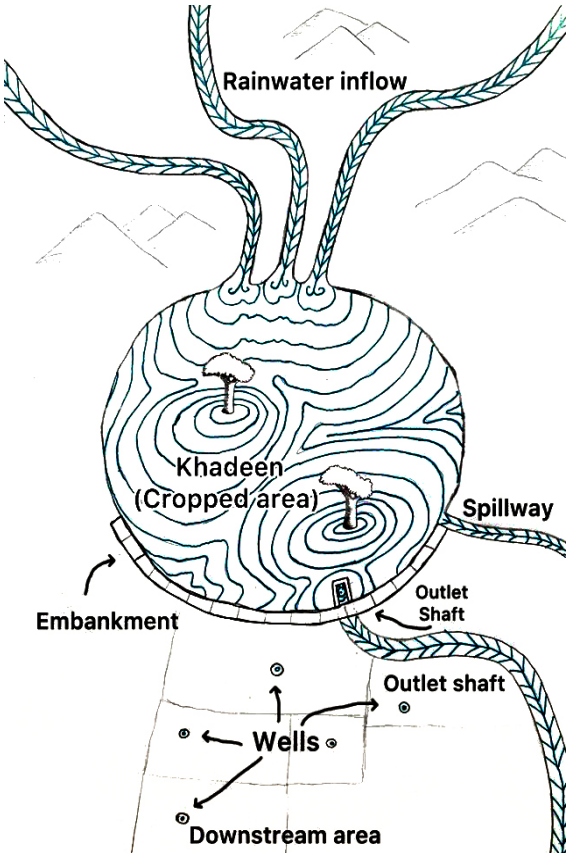
During dry periods, various non-motorized infrastructures used for harvesting, storing and managing water make it possible for area villages to have access to water. Traditional hydrogeological knowledge, with its correlated water practices, is deeply embedded in the cultural and religious ethos of Rajasthan and has played an important role in the economic prosperity of the Thar Desert's urban centers. For instance, elderly community members clean the catchment before the beginning of the rainy season to eliminate rubble and facilitate the centralized collection of rainwater runoff. Additionally, since well-diggers play a crucial role in society, they can count on donations from community members (Miśra 2001). This hydrogeological knowledge revolves around a detailed understanding of where freshwater is likely to be found within the desert landscape, and which tools and practices are needed to access it, resulting in a meticulous approach to water management embedded in people's everyday lives. In areas of the Thar Desert where motorized approaches remain less effective because of material constraints, these non-centralized and non-motorized water practices play an important role in accessing water.

Practices for Water Scarcity

For centuries local people have used a variety of infrastructures to access water in the Thar Desert, including ponds, *kua* (wells), *beri* (narrow, shallow wells) and *khadeen* (temporary lakes)



^ Fig. 2 Shown in red are 19 of the 800 *khadeen* of the Jaisalmer district. The location of the district is highlighted in the map on the bottom-left (Source: Google Earth, 2024, adapted by authors).



^ Fig. 3 Illustration of different elements of a *khadeen* (Source: Pierantonio La Vena, co-produced by Bhatta Ram, 2024).

(fig. 2). These are a lifeline for the local people, granting access to water for domestic uses and livestock (Agarwal and Narayan 1997). While ponds and *khadeen* are used for rainwater harvesting, *beris* allow access to shallow percolation water (locally referred to as *rejani pani*), and *kuas* access the deeper groundwater (known locally as *patal pani*).

The *khadeen* is a traditional water infrastructure used in Rajasthan, which accumulates seasonal runoff, enabling agricultural practices even for relatively water-intensive crops (fig. 3). The study of *khadeen* allows stakeholders to appreciate how practices of care for water resources have ensured the continuous inhabitation of this region, within strict hydrogeological and climatic constraints.

These temporary lakes were (and are) created to capture rainwater during the monsoon season, storing it in the shallow layers of the soil during drier months. They are built by interrupting the course of seasonal rivers with an embankment, creating a reservoir fed by the upstream catchment (fig. 4). The resulting structure ensures the practice of agriculture even in years of scarce rainfall.

Building a well-functioning *khadeen* requires locating specific characteristics in a landscape, such as the course of temporary rivers and shallow groundwater quality. In most parts of the Thar Desert, the deeper groundwater is too saline for human consumption or agricultural use. To preserve freshwater after precipitation, the *khadeen* is built as an artificial perched water table, constituted by an impervious geologic layer, below a previous layer (fig. 5). This protects the infiltrated water both from surface temperatures and subsoil contamination.

Construction and Functionality of a *Khadeen*

A *khadeen* creates an artificial lake from the seasonal precipitation falling in a valley (or water catchment). An embankment, or wall, is the main structural element of the *khadeen*, preventing lake water from flowing away. The embankment can be built out of stone, dirt and, in recent years, cement. In addition to the embankment, the construction of *khadeen* can involve raising dikes along the two sides. The length of the dikes is calculated based on the expected seasonal influx of water in the reservoir and can sometimes reach 5 to 7 km.

The lakes created in this manner infiltrate gradually downstream and dry up. The speed of this process depends on the underlying impervious layer, the amount of yearly rainfall and the integrity of the catchment. *Khadeen* are usually emptied of water in September so that wheat can be sown on the lakebed for the winter season (from October to March). The water is let out through an outlet shaft, and it is used to irrigate other fields downstream (fig. 6).

The sediments collected in the catchment and the biotic activity in the lake confer fertility and humidity to the soil at the bottom of the basin. These conditions allow the cultivation of wheat and other (relatively) water-demanding crops in a region where their growth would otherwise be impossible. In normal conditions, *khadeen* have a relatively high productivity, yielding 15 to 20 times the amount of wheat sown (Miśra 2001). Downstream from the embankment, agriculture is supported by shallow well irrigation, fed by the gradual percolation of the lake's reservoir.

***Khadeen* and Heritage**

Khadeen have played an important role in defining local people's relations with water, inspiring a cautious use of scarce water resources. Their dependence on rainfall demands a meticulous approach to preserving rainwater. To this day, *khadeen* allow irrigation in the area more reliably than modern, motorized water technologies.

According to Mishra (2001), it is likely that *khadeen* were originally created as a replica of naturally occurring water pools (known locally as *deobandh*), which allowed access to water along the trade routes crossing the Thar Desert. However, *khadeen* construction was initially occasional, sparse and marginal. Since the thir-

^ Fig. 4 Stone embankment overrun by vegetation at the Bada Bagh Khadeen (Source: Pierantonio La Vena, 2023).

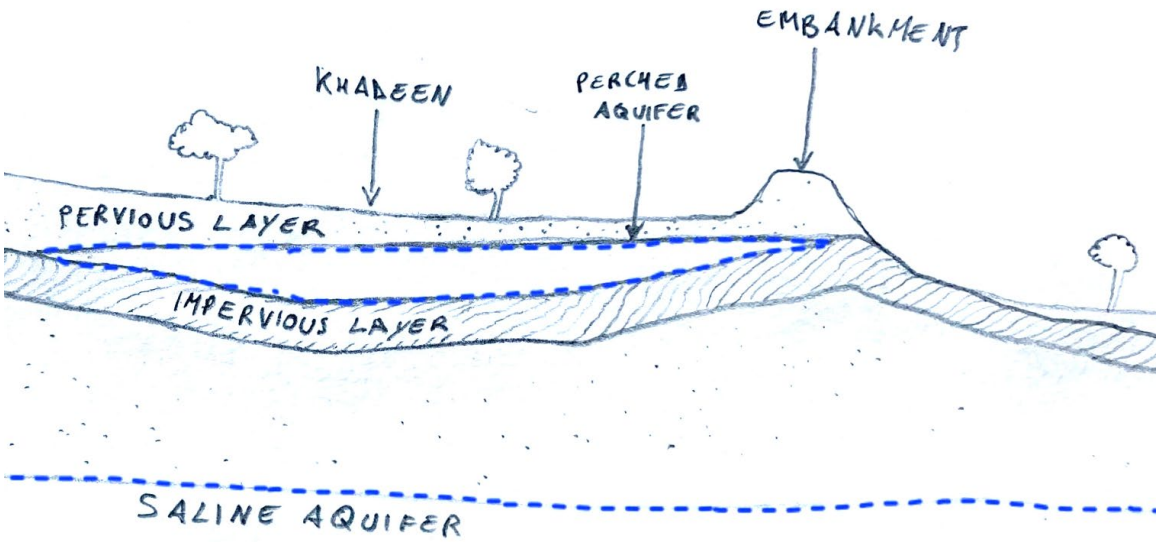
teenth century, the district of Jaisalmer has witnessed creation of several *khadeen*, including interconnected khadeen systems, at the hand of the Paliwal Brahmins. Originally from Pali (central Rajasthan), the Paliwal Brahmins seem to have played a crucial role in transforming the landscape of the Jaisalmer district, particularly in the emergence of agriculture, until they abandoned the area in the early eighteenth century, allegedly due to conflicts with local rulers (Rezavi 1995). Although isolated *khadeen* were previously used in the area, this group is credited for the construction of interconnected systems of *khadeen*, which drain into one another (Miśra 2001).

Khadeen often take the name of the village in which they are located. For example, the Masurdi Khadeen takes its name from the nearby village of Masurdi. It is not easy to establish the total number of *khadeen* present in the region: Malik and Singh (2023) mention a total of 650 structures, while Singh and Singh (2018) report 800 of them, including those of more recent construction. The local government has promoted the construction of new *khadeen*, both to encourage settled livelihoods and to promote agriculture. However, according to Agarwal and Narain (2008), the older *khadeen* are structurally more solid in a way that is difficult to replicate in more modern ones.

These more recently built *khadeen* tend to be smaller and are meant for individual rather than communal use (Agarwal and Narain 2008). The *khadeen* in Dabbla Par and Ekla Par have been built with the specific purpose of supporting the settlement of nomadic groups such as the Bheel tribal community.

Among the *khadeen* of older manufacture, the Lanela Khadeen extends over 758 ha, and is used in a communal capacity by members of a dozen villages (Singh and Singh 2018). Masurdi Khadeen (fig. 1) spans over 300 ha and is used communally by ten villages. The Jajia Khadeen, extending over a few hundred hectares, will be decommissioned in the upcoming years as its catchment will be converted into a mining site (Malik and Singh 2023).

The Bada Bagh Khadeen extends over 29 ha and



^ Fig. 5 Hydrogeological cross section of a *khadeen* (Source: Pierantonio La Vena, co-produced by Bhatta Ram, 2024).

^ Fig. 6 Outlet shaft at the Bada Bagh Khadeen (Source: Pierantonio La Vena, 2023).

historically belongs to Jaisalmer's royal family. Its imposing stone embankment is adjacent to a complex of cenotaphs commemorating royal family members and is often visited by tourists. Although *khadeen* are (and have been) generally used communally, the use of Bada Bagh Khadeen has recently been privatized, with a yearly contract that yields up to ₹600,000.00 (roughly $642.00) to its owners. The local community of Mali, an occupational caste group traditionally working as orchard gardeners and farming the *khadeen* under a sharecropping system – which allowed the community to cultivate the land in exchange for 50 per cent of the agricultural yield – has lost access to the land.

Discussions over the heritage dimension of *khadeen* cannot ignore how local communities are entangled in wider socio-political tensions resulting from increasingly neoliberal policymaking in the region, which in some cases prevents vulnerable social groups from accessing the cultivable land central to their agrarian livelihood.

Concerns for the Future

Traditional water management practices related to *khadeen* face contemporary challenges threatening survival. The recent advent of mining industries constitutes one significant threat. The extraction of minerals and natural resources can disrupt the natural flow of water in a catchment, affecting the recharge of *khadeen*. Additionally, contamination stemming from mining activities has the potential to adversely affect the quality of water stored in *khadeen*, putting agricultural practices at risk.

Another pressing challenge is the outmigration of labor from rural areas to other regions in Rajasthan or beyond. As younger generations seek better economic opportunities in urban centers or near the Indira Gandhi Canal Irrigation Scheme – a canal stretching 650 km from the Harike Barrage in Punjab to the district of Barmer in Rajasthan built to expand the area of irrigated land in the Thar Desert and increase the local production of food crops – the communities that have historically maintained and nurtured *khadeen* find themselves dwindling. This outmigration results in a decline of traditional knowledge and a disconnection from age-old water conservation practices. Dwindling numbers of committed community members can jeopardize the maintenance and upkeep of khadeen, putting these vital water reservoirs at risk.

Urban development threatens *khadeen*, since it may lead to encroachment on *khadeen* areas. The development of roads disrupts the natural flow of water to the basin at the bottom of the catchment. These changes compromise the natural flow of water into the *khadeen*, reducing their ability to collect and store water for extended periods. Furthermore, in an era where water is increasingly commodified, communities practicing traditional water conservation face increasing pressures to participate in the water market, leading to the exploitation of local water resources for profit. As scarce water resources are diverted toward the tourism and mining industries, less water is allocated to agriculture and communal use. *Khadeen*, originally designed for community sustenance, are challenged with resisting such external commercial and market forces, which alter their original purpose and raise issues of distributional justice.

Conclusion

The study of *khadeen*, along with other water conservation structures, illustrates how practices of care for water resources ensure sustainable and resilient livelihoods in an environ-

ment characterized by water scarcity. In the Jaisalmer district, these structures have been and continue to be instrumental to agriculture for centuries, yielding impressive production in the face of scarce precipitation. However, these time-tested structures face contemporary threats, which can compromise the community-based capacity in which they function.

The delicate balance between traditional practices and external pressures necessitates urgent attention to safeguarding the social, ecological and food-security significance of *khadeen* in the Thar Desert. As challenges loom, concerted legal and administrative efforts are needed to ensure the preservation and revitalization of these ancient water harvesting systems, securing a sustainable future for the communities they have long supported.

As these structures are being converted to serve private and commercial interests, historically marginalized communities are denied access to the source of their subsistence. This process, considered functional to the industrialization of rural spaces, leaves skilled farmer groups with no other option but to migrate to urban areas and seek work as "unskilled laborers."

This results in the gradual delegitimization of the water practices surrounding the *khadeen*, which can ultimately threaten the existence of an invaluable system of water knowledge. The loss of *khadeen*, which depend on communal efforts and practices, would represent the loss of an irreplaceable chapter on adapting to water scarcity. As more and more regions of the globe experience unprecedented levels of water scarcity, *khadeen* and their communities could instead play a central role in shaping successful adaptation to climate change.

Policy Recommendations

- There is an urgent need for the government of Rajasthan to adopt an integrated policy approach and support *khadeen* as a cultural and ecological resource. Policies should focus on providing legal recognition to *khadeen*, increasing community awareness, and promoting sustainable tourism in the Thar Desert area.
- The government should recognize the *khadeen* as protected heritage sites, as well as support local communities and encourage community-led restoration projects by expanding existing governmental schemes (e.g., the Mahatma Gandhi National Rural Employment Guarantee Act) to support the restoration and protection of *khadeen* and provide employment for local communities.
- The preservation of historical *khadeen* for the present and the future should include related water management knowledge in school curricula and efforts to raise public awareness about their importance.

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