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Sustainable Water Management and Indigenous Socio-Technical Heritage in Marrakech, Morocco

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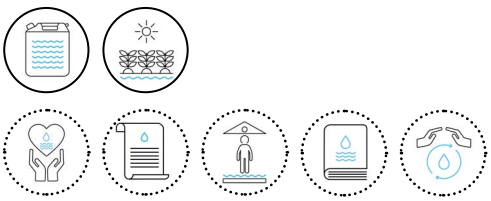
Morocco is considered a water-independent country by the World Bank, yet due to its topographical diversity, considerable land surface, and challenges posed by climate change, it ranks among the most water-stressed countries on the globe. Marrakech, an oasis city in Morocco, thrived for centuries through the ingenious use of khettarat, a traditional system of underground wells and channels that tapped into local aquifers and made use of topography and gravity to sustainably deliver water to the city. Until the early 1990s, Marrakech could still meet all its drinking water demand with the use of khettarat. Owing to a combination of institutional, political and economic factors, the khettarat system went into sharp decline starting in the 1980s and was at risk of disappearing both as a form of heritage and as an Indigenous technology. Recent efforts by multiple stakeholders aim to safeguard and re-introduce khetterat. They demonstrate the importance of local socio-technical systems in ensuring equitable and sustainable development in Morocco and similar arid regions around the world.

Keywords: *water heritage, indigenous technology, Morocco, socio-technical, underground water system*

KEY THEMES



CLIMATE

Bsh
Hot semi-arid climate

< Fig. A seasonal riverbed lies dry except for a small pool of standing water, on the outskirts of the Tata oasis, in southeastern Morocco (Source: Cristiana Strava, 2018).

Introduction

As a water-independent country[1] that does not share ownership or usage rights over its surface water or groundwater with any neighboring state, Morocco enjoys an unusual degree of freedom to determine its domestic water policies (World Bank 2020). However, the country faces challenges due to uneven distribution and uneven access to sustainable water sources across its territory. The situation has been exacerbated by accelerating climate change, as well as by political decisions to pursue water-intensive economic activities like mass tourism and export-oriented agriculture (Davis 2006). These factors have made this structural water deficit a defining feature and pressing challenge for economic and governmental actors. In 2022 Morocco experienced the worst drought in forty years, with ordinary inhabitants feeling the impact throughout the country (Manfron et al. 2023), particularly in the Marrakech region (Elshamy 2022).

The conditions for this deficit were compounded by historical precedents, most of which were set in place during the twentieth century. France's Protectorate in Morocco (1912–1956) was characterized by a settler-colonial form of occupation. Land expropriated from the Indigenous population and export-oriented agriculture became key pillars of the colonial economy (Guerin 2016). The introduction of intensive, irrigated, industrial agriculture during the colonial period overdetermined the direction of water use and water-use policy for decades to come. Historians and political scientists have documented some of the economic and political outcomes of these transformations (Bouderbala 1984; Davis 2007). However, their ecological and social impacts have not been studied as extensively. In the following sections, I present several forms of historical water management, before describing the significance of a new water heritage museum. I then set these historical approaches against the backdrop of challenges posed by accelerating climate change and the return of mass tourism to the Marrakech area, before concluding with a set of recommendations.

Historical Attempts at Local Water Management: From the French Protectorate to Post-independence Morocco

80 cent of Morocco is arid or semi-arid (fig. 1), and water availability has dropped from 3,500 m^3 per person per year in 1960 to 730 m^3 per person in 2005 and 645 m^3 per person in 2015 – well below the "water poverty level" of 1,000 m^3 per person per year as defined by the World Bank. According to the same data from the World Bank and the Moroccan Ministry of Equipment and Water, this ratio is expected to decline to the absolute threshold of 500 m^3 per capita per year by 2030 (Taheripour et al. 2020).

To address these conditions, in the post-independence era (1956–2000s), Morocco's monarchy embarked on several large-scale modernization projects, which led to changes in institutional and practical arrangements for the management of local water systems. This entailed, for example, the building of large hydro-power dams and reforms to ownership regimes that focused on providing incentives to move from communal to private ownership (Simonk 2021). Driven by a commitment to the

1. Water-independence is a measure of how much of the overall volume of a given country's renewable water resources come from sources that are designated as internal or external to that country's sovereign space. For Morocco this measure is 0 for external sources, hence it is a water-independent country. See World Bank (2020).

^ Fig. 2 A diorama inside the Aman Museum showcasing and labeling in three languages the underground components of a *khetarra*: a long gallery that taps into the water table and angles down toward an irrigation field or oasis community, and several maintenance wells that can be accessed from above ground. (Source: Cristiana Strava, 2023).

economic orthodoxies of the 1970s and 1980s, this ultimately prioritized economic growth through free-market logic over communally managed public goods. This in turn contributed, among other things, to the decline of agricultural commons such as the *agdal* and collectively managed water systems such as the *khettarat* (Strava and Amarouche 2022). Marrakech, an oasis city in Morocco, thrived for centuries through the ingenious use of these *khettarat* (fig. 2), a traditional system of underground wells and channels that tapped into local aquifers and made use of topography and gravity to sustainably deliver water to the city (Faiz 2002). Until the early 1990s, Marrakech could still meet all its drinking water demand with the use of *khettarat* (Faiz and Ruf 2010).

Institutional and Indigenous Approaches: Aman Museum for Water Heritage

On 5 January 2017, on the outskirts of the oasis city of Marrakech, Crown Prince Moulay Hassan inaugurated the Mohammad VI Museum of Water Heritage and Civilization - Aman, Morocco's first water heritage museum, built on land donated by the Ministry of Charitable Endowments and Religious Affairs (Ministère des Habous et des Affaires Religieuses, hereafter Habous). Nicknamed the Aman Museum after the local Indigenous Amazigh word for "water," and managed by the Habous, the museum and surrounding site, together with the local institutions involved in its planning, constitute a unique example of not only recuperating socio-technical water knowledge but also ensuring its preservation through education.

The choice of planning, building and managing the museum under the tutelage of the Habous is not as arbitrary or strange as it might first appear. Drinking water fountains and wells, as well as washing fountains needed for the performance of religious rituals and everyday cleaning, have been and continue to be a key infrastructure of Moroccan cities and small towns. Historically, establishing and maintain-

^ Fig. 3 The main atrium of the Aman Museum contains a 3D model of the region's hydrological system and is designed to visually connect all three floors, seeming to reference a deep and wide well (Source: Cristiana Strava, 2023).

ing this infrastructure has been the responsibility of religious institutions like the Habous, whose knowledge and custodianship of these socio-technical systems extend back many centuries (Ftaita 2010).

However, by bringing together previously disparate actors from the Moroccan community, policy and technical sectors, the museum provides an unprecedented example of mixed institutional stewardship. The work of setting up the museum was anchored in an inclusive approach that combines public outreach with public-private partnerships in the work of heritage preservation and knowledge ownership. This approach is further illustrated by the consortium of actors who participated in the planning, financing and scientific coordination of the museum: from the German Technical Cooperation Agency (GIZ; Deutsche Gesellschaft für Internationale Zusammenarbeit), to the local University Cady Ayyad in Marrakech, Moroccan engineers and historians of the environment and international museum consultancies (K Nour). The Aman Museum demonstrates that the preservation, valorization and management of unique water systems and associated forms of heritage can greatly benefit from cross-sectoral and international collaboration. Beyond extending this knowledge and custodianship into the future, the creation of Morocco's first water heritage museum and its location in one the most water-stressed regions of the country might also be interpreted as a statement of commitment by local and international actors to safeguard and valorize Indigenous knowledge systems.

Across ten permanent exhibits, through varied mediums and techniques, the museum traces the historical, bio-chemical, legal, spiritual, polit-

^ Fig. 4 The tops of *khettara* maintenance shafts with signs of dereliction and overgrown vegetation, threatening their collapse, Guelmim region, Morocco (Source: Cristiana Strava, 2010).

ical, socio-economic and geographical aspects of hydrological systems in the country (fig. 3). By placing a particular emphasis on the Indigenous knowledge and practice associated with *khettarat* and the skillful management of water in Morocco's arid regions, the exhibits offer more than educational information. They also remind local and international visitors of the immense knowledge that Indigenous communities already possess – and that this knowledge can be lost unless efforts are made to preserve it and bring it back to life (fig. 4–5).

Climate Impacts and Sustainable Tourism

The Aman Museum's proximity to Marrakech is not arbitrary and acts as a stark reminder of the human and climatic challenges faced by already stressed water systems. Until the early 1990s, Marrakech could still meet all its drinking water demand with the use of khettarat. However, at present, the oasis city consumes 66 million m3 of fresh water per year which can lead to severe aquifer depletion. One significant factor is the over-pumping of groundwater from wells for intensive agricultural uses and leisure activities (thirteen golf courses, five waterparks and many private lawns and pools) that give the city its reputation as the "Las Vegas of Morocco."

As the city's tourism industry has returned to activity levels matching the years before the COVID-19 pandemic, pressure on the local aquifer is set to increase. Recent studies also highlight the impending threat posed by the rapid depletion of underground aquifers resulting from a decrease in rainfall and from their being heavily tapped for agricultural expansion (CESE 2014). For three consecutive years (2020, 2021, 2022),

^ Fig. 5 Inside an underground desiccated gallery of a *khettara* light shines from above through the maintenance shafts. The gallery is tall enough for an average-sized person to stand up straight and wide enough to comfortably walk through. (Source: Cristiana Strava, 2010).

the region recorded a steady drop in precipitation, with 2020 being one of the driest years on record since 1981. Aquifer water has also been degraded by seawater intrusion, nitrate pollution (from fertilizers or untreated sewage) and natural increases in salinity (Hssaisoune et al. 2020). Given the slow recharge rate of these aquifers, their depletion and degradation will have severe effects on Morocco's water systems.
However, like many other middle-income countries in the Global South, Morocco's national strategy for economic development continues to rely heavily on both a strong tourism sector as well as export-oriented agriculture. Taking into account the urbanization and population growth required to keep these sectors profitable, current predictions warn that unless urgent measures are enacted, Morocco expects to reach "absolute water scarcity" (less than 500^2 m per person per year) by 2030 (Taheripour et al. 2020).

Conclusion

Recent efforts at recuperating, revitalizing and celebrating Morocco's rich Indigenous water heritage have been instrumental in mitigating, and in some cases even reversing, some of the most detrimental effects of previous water-management policies and practices in the country's arid regions (Dahan 2017).

Public-private partnerships and the phased but sustained introduction of renewable sources of energy can help alleviate water stress in Morocco's arid regions, while also helping to mitigate risks in other regions where flooding and

coastal erosion pose a threat to local communities and their livelihoods. Artificial recharge of existing aquifers, seawater desalination and wastewater reuse are some of the promising approaches currently being tested across the country. Alongside efforts to revitalize local socio-technical water heritage, these approaches stand to offer viable solutions that have the potential to ensure equitable sustainable water futures for all (Hssaisoune et al. 2020).

However, it is also clear that current models of development that remain wedded to capitalist, market-driven and financial incentives cannot, in the long run, safeguard water resources and will ensure neither the survival of heritage practices nor that of communities who have developed and preserved these practices for centuries. Instead, the recuperation of Indigenous water-management knowledge in Morocco demonstrates that to build and maintain resilient and locally-adapted solutions, decentralized, collective and communal forms of resource use and stewardship like the *khettarat* merit broader support and a more central role in water-management plans.

Policy Recommendations

- Establish new or reinforce existing partnerships between governmental agencies and local communities in charge of safeguarding water resources.
- Allocate structural funding to local efforts that integrate Indigenous knowledge in national water-management strategies.
- Concerted efforts can together ensure sustainable, participatory and locally appropriate approaches to water conservation, in Morocco as well as in similar semi-arid countries.

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References

Bouderbala, Négib. 1984. "Le régime juridique des eaux à usage agricole au Maroc" ["The legal regime for agricultural usage in Maroc"]. In *La question hydraulique. Petite et moyenne hydraulique au Maroc* [*La question hydraulique. Petite et moyenne hydraulique in Maroc*], edited by Paul Pascon Paul et al., 45–117. Graphitec: Rabat.

CESE. 2014. "Gouvernance par la gestion intégrée des ressources en eau au Maroc: levier fondamental de développement durable" ["Governance by integrating the resources in Morocco: providing a foundation for durable development"]. Circular AS no. 15 of the Conseil Economique, Social et Environnemental, Rabat, Morocco. https://www.cese.ma/media/2020/10/Avis-Gouvernance-des-ressources-en-eau.pdf.

Dahan, Stephane. 2017. "Managing Urban Water Scarcity in Morocco". World Bank, Washington, DC.

Davis, Diana K. 2005. "Indigenous Knowledge and the Desertification Debate: Problematising Expert Knowledge in North Africa." *Geoforum* 36, no. 4: 509–24. https://10.1016/j.geoforum.2004.08.003

Davis, Diana K.. 2006. "Neoliberalism, Environmentalism, and Agricultural Restructuring in Morocco." *Geographical Journal* 172, no. 2: 88–105. http://www.jstor.org/stable/3873982.

Davis, Diana K.. 2007. *Resurrecting the Granary of Rome: Environmental History and French Colonial Expansion in North Africa.* Athens: Ohio University Press.

Elshamy, Mosa'ab. 2022. "Climate Crisis Threatens Centuries-Old Oases in Morocco." *Aljazeera* (December 27). Accessed December 14, 2023. https://www.aljazeera.com/gallery/2022/12/27/photos-climate-crisis-threatens-centuries-old-oases-in-morocco.

Faiz, Mohammed El. 2002. *Marrakech: Patrimoine en Péril* [*Marrakech: Heritage in Danger*]. Arles: Acte Sud.

Faiz, Mohammed El, and Thierry Ruf. 2010. "An Introduction to the Khettara in Morocco: Two Contrasting Cases." In *Water and Sustainability in Arid Regions,* edited by Graciela Schneier-Madanes and Marie-Françoise Courel, 151–163. Springer: Dordrecht.

Ftaita, Toufik. 2010. "L'hydraulique arabe, innovations techniques et transmissions des savoirs et savoir-faire" ["Arab hydraulics, technical innovations and transmission of knowledge and know-how"]. In *Ce que l'Occident doit aux Arabes. Cultures et sociétés* [*What the West owes to the Arabs. Cultures and societies*]*,* n°14, edited by Toufif Ftaita. Paris: Editions Téraèdre.

Guerin, Adam. 2016. "Disaster Ecologies: Land, Peoples and the Colonial Modern in the Gharb, Morocco, 1911–1936." *Journal of the Economic and Social History of the Orient* 59, no. 3: 333–65. https://doi.org/10.1163/15685209-12341401

Hssaisoune, Mohammed, Lhoussaine Bouchaou, Abdelfattah Sifeddine, Ilham Bouimetarhan and Abdelghani Chehbouni. 2020. "Moroccan Groundwater Resources and Evolution with Global Climate Changes" *Geosciences* 10, no. 2: 81. https://doi.org/10.3390/geosciences10020081.

Manfron, G., L. Nisini and L. Panarello. 2023. "Crop Monitoring European Neighbourhood - Morocco, Algeria, Tunisia, Libya and Egypt. In *JRC MARS Bulletin: Global Outlook*, edited by G. Manfron, M. Van Den Berg and B. Baruth. Luxembourg: Publications Office of the European Union. https://doi:10.2760/244512, JRC133197.

Simon, Sandrine. 2021. *Reviving Indigenous Water Management Practices in Morocco: Alternative Pathways to Sustainable Development.* London: Routledge.

Strava, Cristiana, and Amarouche, Maryame. 2022.

"Introduction to the Themed Section: 'Commoning the Future': Sustaining and Contesting the Public Good in North Africa." *Journal of North African Studies* 28, no. 1: 9–15. https://doi: 10.1080/13629387.2021.2020481.

Taheripour, Farzad, Wallace E. Tyner, Iman Haqiqi and Ehsanreza Sajedinia. 2020. *Water Scarcity in Morocco: Analysis of Key Water Challenges*. World Bank: Washington, DC.

World Bank. 2020. "Renewable internal freshwater resources, total (billion cubic meters), 2020." *data.world.bank.* Retrieved 2024-01-20.

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