Reclaiming Traditional Wisdom: The Role of "Khettaras" in Addressing Water Stress and Advancing the SDGs in Morocco

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In recent years, Morocco has found itself increasingly vulnerable to the pressures of water scarcity. With a water stress index reaching 50.75% in 2021, the country falls within the threshold of "high water stress" as defined by international standards. This level of pressure on water resources reflects a growing imbalance between demand and availability, driven by population growth, agricultural needs, and the effects of climate change[2]. The visualization in the appendix 2 shows that 87% of national direct water consumption is allocated to agriculture[3], a sector that contributes over 12% to the national GDP and employs approximately 64% of the rural workforce[4]. This heavy reliance on agriculture not only intensifies Moroccan economy's exposure to climate variability but also highlights a critical insight: water governance in Morocco is fundamentally agricultural water governance. Therefore, identifying resilient and context-specific solutions for rural water management is both a social and environmental imperative.

In this context, the study will focus on the example of the "Khettaras" system to demonstrate how this sustainable, community-based technique can help address water accessibility challenges and optimize water use in the agricultural sector, thereby supporting Morocco's progress toward achieving the United Nations Sustainable Development Goals (SDGs). Against this backdrop of ecological stress and agricultural dependency, the traditional hydraulic system "Khettaras" present an important opportunity for rethinking water resource management. These ancient underground irrigation systems, known as qanats in Persia and foggara in Algeria and Syria, have existed for over 3,000 years and are recognized as remarkable examples of sustainable engineering[5]. In practice, and as shown in Appendix 3, the "Khettaras" system comprises a vertical "mother well"

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[2] *Water stress level: freshwater withdrawal as a proportion of available freshwater resources (Open data from the World Bank provided by the United Nations FAO, accessed on June 30, 2025).*

[3] *SAMIH Ikram, 2020. Modeling Intersectoral Water Consumption in the Moroccan Economy, High Commission for Planning (Haut-Commissariat au Plan)*

[4] *Source: The labour market situation in 2023. Official website of the High Commission for Planning of the Kingdom of Morocco. Retrieved February 10, 2025, from https://www.hcp.ma/La-situation-du-marche-du-travail-en-2023_a3816.html*

[5] *English, P. W. (1968). The Origin and Spread of Qanats in the Old World. Proceedings of the American Philosophical Society, 112(3), 170–181. http://www.jstor.org/stable/986162*

that taps into an aquifer, connected to a gently sloping horizontal gallery through which water is conveyed via gravity. A series of vertical shafts, spaced along the tunnel, serve dual purposes ventilation and maintenance access. These allow community members to monitor flow, detect blockages, and conduct repairs when necessary. One of the system's core advantages lies in its passive operation: unlike modern pumping systems, "Khettaras" function without external energy inputs, significantly reducing both operating costs and environmental impact. This energy-free mechanism makes them particularly suited for water-scarce and economically constrained rural contexts. The resilience, simplicity, and low-carbon footprint of "Khettaras" position them as a technical solution fully aligned with principles of ecological sustainability.

Beyond their engineering value, "Khettaras" hold profound implications for the governance of water as a common-pool resource. Such resources are marked by non-excludability no one can be easily prevented from access and rivalry, meaning use by one individual reduces availability for others. These features make them susceptible to overexploitation, as famously described by *Hardin* (1968) in the "Tragedy of the Commons." However, *Elinor Ostrom* (1990) challenged this deterministic narrative, showing through empirical research that communities are capable of self-organizing to manage common resources effectively, without recourse to privatization or centralized state control.

The Moroccan "Khettaras" exemplify this community-based governance paradigm. In regions such as Tafilalet, water access and maintenance duties have historically been regulated through customary rules (Al Orf or Azref) that structure rights and responsibilities. The allocation of water rights (nouba or fardia) based on individual contributions to construction or maintenance demonstrates a localized, equitable approach to distribution rooted in collective responsibility. Importantly, access to water is not linked to land ownership but to participation in the communal infrastructure itself. *Beraaouz, M., Abioui, M., Hssaisoune, M., & Martínez-Frías, J. (2022).*

This embedded model reflects the institutional capacity of local communities to manage a scarce resource in the absence of formal legal systems. It also validates Ostrom's assertion that local knowledge, mutual monitoring, and social norms are key to successful common-pool resource governance. In the context of climate change and increasing resource pressure, the "Khettaras" offer both historical precedent and contemporary relevance as a model of decentralized, adaptive water management.

The “Khettaras” system contributes tangibly to several Sustainable Development Goals (SDGs), not only through its ecological design but also through its embedded role in community resilience. By securing irrigation for smallholder farmers in arid and semi-arid regions, “Khettaras” directly advance SDG 1 (No Poverty) and SDG 2 (Zero Hunger). In Tafilalet, a region located in southeastern Morocco, more than 300 operational “Khettaras” irrigate approximately 16,000 hectares of palm groves, playing a vital role in sustaining rural livelihoods and food production[6].

Moreover, their widespread presence in underserved areas—where modern infrastructure is either unaffordable or impractical—reinforces SDG 10 (Reduced Inequalities) by promoting equitable access to water. Functioning solely through gravitational flow, “Khettaras” do not require electricity or fuel, making them a low-carbon and energy-efficient technology in alignment with SDG 13 (Climate Action). This also contributes to Morocco’s national goals of improving energy efficiency in agriculture. Their underground layout minimizes evaporation, protects aquifer levels, and reduces ecosystem degradation—an essential contribution to SDG 15 (Life on Land).

“Khettaras” also respond to SDG 3 (Good Health and Well-being) by reducing dependence on potentially unsafe water sources in remote areas. Furthermore, the use of local materials, reliance on collective labor, and adherence to traditional governance norms align with SDG 12 (Responsible Consumption and Production). Finally, by supporting water self-sufficiency at the community level, these systems foster rural resilience and autonomy, thus contributing to SDG 11 (Sustainable Cities and Communities) in a meaningful, context-sensitive manner.

In a context shaped by climate variability, rural vulnerability, and the limitations of centralized water systems, the “Khettaras” of Morocco represent a powerful convergence of technical ingenuity and institutional wisdom. Reintegrating such traditional systems into modern water governance frameworks is not merely a matter of cultural preservation—it is a strategic imperative. Their alignment with sustainability principles and their continued relevance to development goals underscore their potential as practical tools for climate adaptation, rural revitalization, and equitable resource management.

[6] *Beraaouz, M., Abioui, M., Hssaisoune, M., & Martínez-Frías, J. (2022). “ttaras in the Tafilalet oasis (Morocco): contribution to the promotion of tourism and sustainable development. Built Heritage, 6(1), 24.*

As water stress intensifies across the Mediterranean and beyond, the "Khettaras" offer a compelling case for rethinking resilience: one that draws upon local knowledge, community governance, and low-tech solutions to meet contemporary challenges. In doing so, they not only contribute to Morocco's water security but also enrich the global discourse on community-based natural resource governance.

Bibliography :

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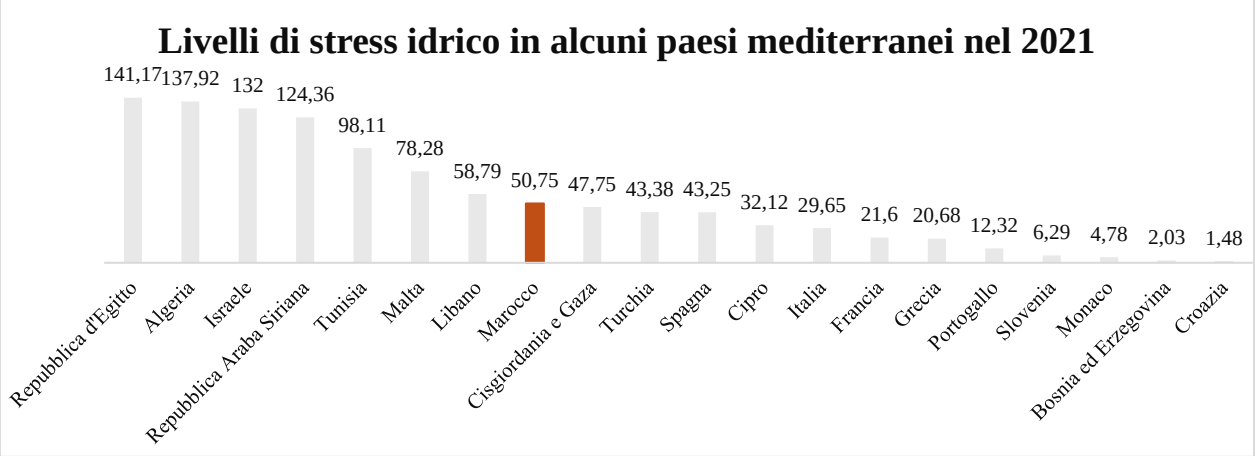
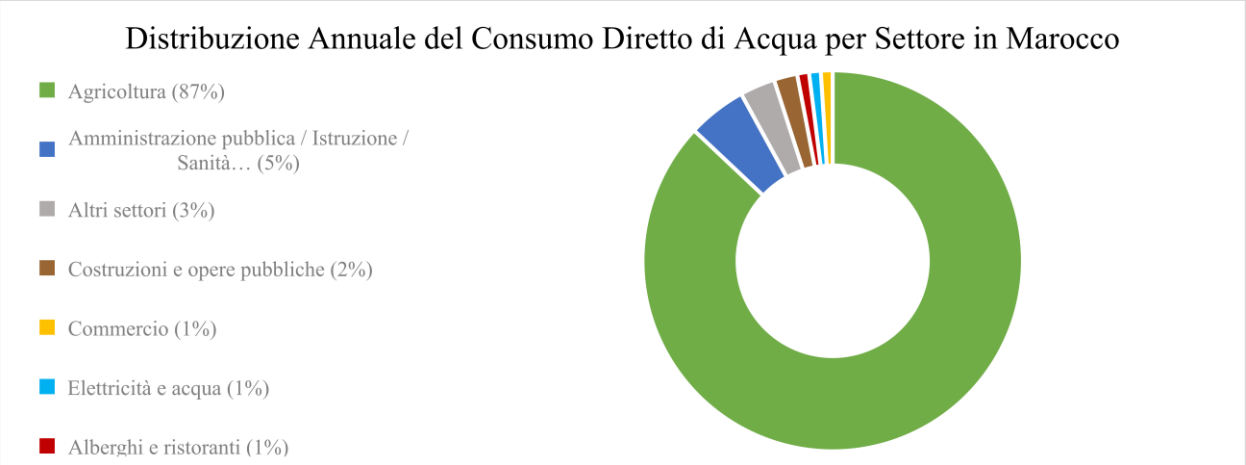
Appendixes:

Appendix 1: Water stress level: freshwater withdrawal as a proportion of available freshwater resources



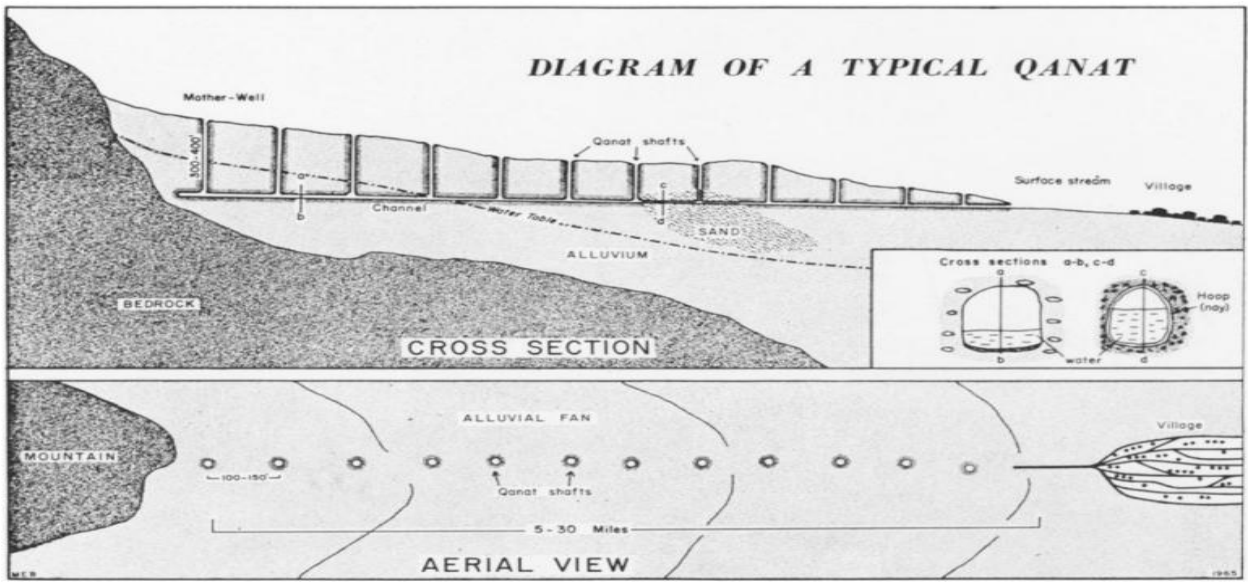
(Open data from the World Bank provided by the United Nations FAO, accessed on June 30, 2025).

Appendix 2: Intersectoral Water Consumption in the Moroccan Economy



SAMIH Ikram, 2020. Modeling Intersectoral Water Consumption in the Moroccan Economy, High Commission for Planning (Haut-Commissariat au Plan)

Appendix 3: Illustration of a typical qanat: profile view, cross-sections, and aerial perspective showing the varying dimensions of the tunnel and vertical shafts.



English, P. W. (1968). The Origin and Spread of Qanats in the Old World. Proceedings of the American Philosophical Society, 112(3), 170–181. http://www.jstor.org/stable/986162