Bridging the Epistemic Divide: A Knowledge Management Analysis of Traditional Water Wisdom and Contemporary Governance, Case Study of the Ourika Valley (Morocco)

Mohamed Boukherouk, Mohammed El Aklaa and Tarik El Orfi
Cadi Ayyad University, Faculty of Letters and Human Sciences, Laboratory of Research on Resources, Mobility and Attractiveness, Marrakech, Morocco

m.boukherouk@uca.ac.ma
m.elaklaa@uca.ac.ma
t.elorfi@uca.ac.ma

Abstract: This paper explores the relationship between ancestral water knowledge and contemporary policy in Morocco's Ourika Valley, positing that the current crisis is fundamentally one of epistemic neglect. By examining the transition from community-based management to state-imposed groundwater contracts, the study investigates how modern instruments often devalue the tacit cognitive capital and indigenous knowledge of local populations.Utilizing a qualitative methodology that combines Nonaka's SECI model with a survey of 55 stakeholders, the research analyzes the failure to integrate "tacit knowledge"—the deep, site-specific understanding of mountain ecosystems—into official policy. The analysis reveals a profound disconnect between the "explicit knowledge" utilized by state agencies and the "tacit knowledge" practiced by communities. Results indicate that top-down regulation frequently clashes with customary law, diminishing the social legitimacy of state projects, whereas traditional systems effectively manage scarcity through shared ethical constraints. The paper concludes that a sustainable future requires knowledge hybridization. Rather than substituting technology for tradition, the state must act as a mediator, integrating the precision of ancestral methods into formal legal frameworks. The study advocates for rethinking the water contract, transforming it from a top-down directive into a co-created platform that synthesizes modern technological rigor with the enduring wisdom of indigenous water management.

Keywords: Knowledge management, Indigenous knowledge, Water governance, Customary law, SECI model, Ourika

1. Introduction

Water governance in Morocco faces a stark paradox: despite significant investment in hydraulic infrastructure, such as dams (Messaoudi & Bréthaut, 2026) and water highways (Laassilia et al., 2021), socio-ecological systems remain in deepening crisis (Córdova Morales et al., 2025). The nation is aggressively pursuing a supply-side paradigm, prioritizing 26 desalination plants, 29 new dams, and expanded water infrastructure (Védie, 2025). However, long-term effectiveness depends on demand-driven governance and robust regulatory frameworks to curb industrial and agricultural misuse (CESE, 2014).

This research posits that this impasse originates from epistemic dissonance (Palsson et al., 2013) and injustice (Escobar, 2007; Santos et al., 2007), rather than mere technical inadequacy. In the Ourika Valley, a structural conflict emerges as ancestral knowledge systems (Halford, 2010), which historically ensured survival through communal ethics, are marginalized by a developmental state favoring industrial agriculture despite using participatory rhetoric like aquifer contracts (Del Vecchio, 2019).

By synthesizing Nonaka and Takeuchi's (1995) SECI model with Indigenous environmental justice (McGregor, 2018), this study highlights the limitations of the state's technocratic paradigm. The analysis demonstrates that modernization often involves an extractive process, isolating traditional knowledge from its relational context and converting it into technical indicators frequently rejected by local stakeholders.

This divide produces a double paradox: the technological decoupling of water consumption from environmental limits and the legal marginalization of customary institutions. This article argues that to transcend current failures, Morocco must move beyond vertical, volumetric management toward knowledge hybridization. A sustainable transition requires the state to evolve into a knowledge broker that promotes and integrates traditional practices.

2. Literature Review: The Bureaucratic Paradigm and the Rebound Effect

Human societies have historically harmonized with their environments by developing indigenous knowledge systems (Hountondji, 2009; Battiste, 2005; Kane et al., 2025; Brodt, 2001). Refined through generations of oral tradition, this wisdom is vital for ecological stability, as local ecosystem longevity depends on ancestral stewardship (Appiah-Opoku, 2007). Consequently, the reappropriation of this knowledge is not a nostalgic

endeavor (Botoyiyê, 2010), but an epistemological imperative (Warren et al., 1995) required to address the inherent failures of modern technological interventions.

Despite the adaptive value of local empirical observation, top-down governance (Pressman & Wildavsky, 1973) frequently neglects traditional wisdom. Integrating indigenous knowledge (Siringan, 2025) is now recognized as a prerequisite for sustainable socio-ecological intervention (Tazi Sadeq, 2020). Such intellectual decolonization and knowledge hybridization (Akena, 2012) are essential for rectifying global water governance. While Integrated Water Resources Management (IWRM) (GWP, 2000) promised decentralization, its implementation has often devolved into centralized engineering driven by an epistimocratic bias—a systemic reliance on the assumption that only quantitative, state-sanctioned metrics constitute valid data.

This administrative vulnerability is exacerbated by intensifying hydroclimatic stress. In arid and semi-arid regions, the convergence of population growth, agricultural intensification, and climate variability places unprecedented pressure on freshwater ecosystems (Boutagayout, 2025). Morocco, a designated climate hotspot, exemplifies these risks; renewable water availability has plummeted from 2,560 m^3/capita/year in 1960 to less than 620 m^3 today (Boutagayout, 2025), bringing the nation to the precipice of absolute water scarcity.

State-led strategies, such as the National Water Conservation Program for Irrigation (PNEEI) (ADB, 2009), often reduce water to a purely technical resource (Minati, 2024). This reductionism overlooks the complex socio-historical networks identified by Pascon (1977), who argued that structural interventions often disregard the legal frameworks essential to local management. Furthermore, technical initiatives like drip irrigation often trigger the Jevons paradox, where improved efficiency encourages agricultural expansion and accelerates aquifer depletion (Water Policy, 2024).

Global precedents, such as the acequias of New Mexico (Rivera & Martínez, 2009; Lamadrid & Rivera, 2023) and Iranian qanats (Abadi et al., 2023; Jomehpour, 2009), demonstrate that traditional allocation frameworks offer superior resilience. Operating on principles of collective equity and localized ecosystem limits (Garrigues-Cresswell & Lecestre-Rollier, 2025), these systems prioritize sustainability over mechanical extraction. In the Ourika Valley, hydrological modeling suggests that engineering-based adaptation is insufficient to ensure long-term viability (Ayt Ougougdal et al., 2020). Ultimately, governance must shift from large-scale infrastructure toward socio-institutional adaptability, fostering a synergy that integrates traditional knowledge as an active, fundamental component of environmental management (Shemshad et al., 2025; Rosso, 2025)

3. Methodology

This research employs a mixed-methods case study of the Ourika Valley to evaluate epistemic dissonance using Nonaka and Takeuchi's SECI framework. It isolates structural disconnects between traditional wisdom and technocratic management through four knowledge interaction phases: Socialization (tacit ancestral rights), Externalization (translating oral norms), Combination (aggregating regulatory frameworks), and Internalization (integrating policies into local water use), mapping the friction between governance systems.

Table 1: Sample Size and characteristics

Stakeholder	Role/Actor	Sample Size	Primary Contribution to SECI Analysis
Primary Tacit Holders	Smallholder Farmers (Upstream vs. Downstream)	40	Provide grounded evidence of customary water-sharing rules and lived experience.
Social Actors	*Jemaa* (Water Councils) & *Amghar* (Traditional heads)	5	Represent the social spaces where informal water management is practiced and debated.
Institutional Mediators	Rural Commune Heads & NGO Representatives	5	Offer insights into the political challenges of translating local needs into regional policy.
Explicit Controllers	Basin Agency Technicians & Regional Agricultural Office (ORMVA)	5	Provide access to official technical data, hydrological maps, and formal planning frameworks.

Source: Author

A purposive, stratified sampling strategy includes 55 participants balanced between tacit holders (smallholders, Jemaa councils) and explicit holders (ABH-Tensift technicians, authorities). Triangulation uses legislative text analysis, semi-structured surveys, and stakeholder mapping. Qualitative data from interviews and documents were analyzed using thematic analysis, employing Sphinx software to code transcripts and legislative texts for

recurring structural themes. These coded insights were then cross-verified with survey findings via a matrix analysis tool to systematically link evidence to conclusions across SECI phases.

4. Results

Located 30 km south of Marrakech in the High Atlas, the 1,163 km² Ourika sub-basin (AHT group AW & Resing, 2016) supports approximately 297,871 inhabitants in 1994 (AHT group AW & Resing, 2016) and exactly 79,507 inhabitants in the three communes of the Ourika Valley (Ourika, Sidi Fatma, and Oukaïmeden) according to the 2024 HCP (2024) . Its economy relies on a climate-sensitive hydrological regime, small-scale farming, craft workshops, and tourism. The area is currently experiencing a socio-technical transition, marked by friction between two incompatible water management regimes (Table.2).

- The Historical Evolution of Moroccan Water Legislation and the new water actors system

Prior to the French Protectorate, Moroccan water management relied on decentralized customary law (*'urf*), which prioritized communal equilibrium over individual extraction (Rensen, 2025). Governance by the *Jmaa* council and the *Amghar n'ouman* ensured resource distribution through intergenerational consensus. These systems, utilizing traditional rules and infrastructures, embedded governance within the social fabric. Mechanisms such as *touiza* (collective labor) and *Agdal* cycles fostered long-term ecological stability and tacit, site-specific expertise (Dominguez, 2021; Mendes, 1988), standing in stark contrast to modern (Montginoul & Molle, 2019), top-down bureaucratic paradigms (Lightfoot, 1996; Boubou et al., 2025).

Table 2: Comparative Analysis: traditional Systems vs. Modern Mechanized Mobilization in Morocco

	Method	Mechanism	Key Function	Disadvantages
Traditional system	**Seguia & Ougoug**	Gravity canals fed by sacrificial diversion dams.	Manages flood risk through communal rebuilding and timed water sharing.	Requires constant communal maintenance (*touiza*) and is vulnerable to complete destruction during major floods.
	Khettara	Underground galleries tapping the water table via slope.	Transports groundwater over long distances with zero evaporation loss.	Extremely labor-intensive to construct and maintain; flow rates are non-adjustable and declining.
	Matfia	Subterranean cisterns with sloped *impluvium* catchment.	Harvests and stores surface runoff for reliable local water access.	Limited storage capacity; relies entirely on local precipitation, making it vulnerable to drought.
	Agdal	Customary watershed and rangeland governance.	Protects vegetation and soil to ensure downstream spring recharge.	Can restrict local economic activities due to seasonal closures and requires high social cohesion to enforce.
Modern system	**Motorized Pumping**	Diesel or electric pumps tapping sub-surface aquifers.	Provides reliable, on-demand water access independent of seasonal flow.	High operational costs (fuel/electricity); leads to aquifer depletion and conflicts over groundwater rights.
	Solar Pumping	PV-array-powered pumps removing fuel costs.	Enables continuous, high-volume extraction at near-zero marginal cost.	Encourages over-extraction; lacks "brakes" on consumption, leading to rapid groundwater collapse.
	Macro-Infrastructure	Concrete canals, deep wells, and inter-basin transfers.	Supplies massive volumes for industrial agriculture and urban expansion.	Highly centralized and expensive; causes displacement of local water access and damages downstream ecosystems.

Source: Author

Modernity disrupted this cohesion via mechanized groundwater extraction (Suder, 2026). The shift to motorized tube wells and solar-powered pumping decoupled water access from seasonal cycles, incentivizing intensive individual consumption. This transition has depleted communal sources, marginalized smallholders, and rendered ancestral knowledge (Kchikech et al., 2024).

State-centric governance emerged from early 20th-century colonial mandates, notably the 1914 Dahir, which established the domaine public hydraulique (BO, 1914). This consolidated state control and initiated the transition from fragmented, usage-based customs to a centralized legal architecture. By the late 20th century,

Law 10-95 introduced the hydrological watershed as the primary unit of management, utilizing Basin Agencies to regulate the marketization of common-pool resources (BO, 1995).

Contemporary legislation, particularly Law 36-15 (BOl, 1996), signifies a climate-defense phase (Ezzerouali et al., 2025; Mangal & Govind, 2025).). By incorporating non-conventional water sources and empowering the Police des Eaux to combat overdraft, the state seeks to reconcile competing urban, industrial, and rural demands. Accordingly, the evolution of Moroccan water law reflects an ongoing attempt to transition toward a data-driven, resilient model, despite the persistent challenge of integrating centralized oversight with the socio-technical realities of water-stressed landscapes (El-Abassi & Assir, 2026; Moumen et al; 2015).

The sub-basin governance landscape is defined by the intersection of state-led institutional frameworks and ancestral community systems (table 3). While state entities rely on legal mandates, administrative indicators, and technology, local farmers depend on oral tradition, customary law, and seasonal observation to manage essential gravity-fed irrigation.

Table 3: Consolidated Stakeholder Analysis: Ourika Sub-basin

Stakeholder Category	Specific Stakeholder	Primary Knowledge Base	Source of Power	Core Objective
Institutional / Statutory	ABH-Tensift	Hydrological telemetry, GIS mapping, Law 36-15	Statutory authority, state funding, drilling control	Basin balance, macro-economic efficiency, regulating rights
	ORMVAH / DPA / ONCA / DREF / ONEE /ANEF/ Prov. Services	Agricultural planning, technical regulations, state policy	Institutional mandate, administrative budget, public sector hierarchy	Irrigation management, resource protection, potable supply
Elected Instances	Regional Council / Provincial Council / Rural Communes	Territorial planning, local administrative data	Political mandate, local governance authority	Local development, conflict resolution
Water Users & Local Actors	Traditional Farmers & Amghars	Customary law ('urf), oral histories, seasonal rules	Local legitimacy, historic tenure, community consensus	Subsistence agriculture, maintaining seguia networks, equity
	Modernized Agriculturalists	Agro-industrial metrics, mechanical engineering	Capital access, state subsidies (Generation Green)	Maximizing yield, securing on-demand water via boreholes
	Tourism Operators	Market demand, commercial real estate patterns	Economic capital,, official licences	Revenue, landscape aesthetics, water access
Associative	AUEA / AEP / Development Associations	Local field data, community operational experience	Law 91.05 (for AUEA), social mobilization	Managing irrigation/potable systems, community development

Source: Author

A profound friction exists between state regulatory objectives and local socio-technical realities. Intensifying water scarcity and the erosion of traditional practices, legacy issues accelerated by agricultural modernization—compound this crisis. While Law 36-15 empowers agencies to prioritize administrative efficiency and volumetric control, communities rely on ancestral norms. Conflicts arise when technocratic state data ignores site-specific expertise, pitting legal authority against historical legitimacy. By favoring centralization, the system undermines community resilience. The Ourika Valley exemplifies this divide: state-driven control versus traditional ecological systems. Reconciling this epistemic gap is essential to sustain the basin's socio-ecological fabric and protect its vulnerable future.

- Confrontation of knowledge and epistemological gap

Tensions in the Ourika Valley stem from fundamentally irreconcilable objectives. Modernized agriculture and tourism prioritize profit and on-demand access, while smallholders emphasize subsistence and equity. As water scarcity intensifies, this becomes a zero-sum conflict, further exacerbated by top-down state initiatives that frame water as a commercial asset, thereby marginalizing traditional management and eroding local autonomy.

Governance friction manifests in three ways. First, a formal-tacit divide exists: state agencies use GIS and telemetry for macro-efficiency, disregarding local oral traditions and gravity-based allocation. Second, statutory

power held by the ABH-Tensift clashes with the historical legitimacy of community consensus, particularly when drilling mandates undermine traditional seguia networks. Finally, the competing goals of yield maximization versus communal subsistence turn limited water resources into sites of direct competition, deepening socio-economic inequalities and systemic power imbalances within the sub-basin.

Field study results reveal a demographic and intellectual bifurcation hindering water governance. Gender disparity is stark: 74.5% male representation confirms that "tacit" water management remains curated within patriarchal structures. Furthermore, an educational divide complicates integration: 50.9% of participants, primarily "tacit holders," lack formal education, while 18.2% of "explicit controllers" possess university degrees. This gap catalyzes translation failures between communities and state authorities. Conversely, 80% of participants were born in the valley, proving that traditional systems are products of deep, intergenerational environmental interaction. Despite this high place-based expertise, the socio-economic and educational chasm between stakeholders creates significant barriers to aligning local realities with institutional mandates, ultimately undermining the effectiveness of regional water management efforts.

Table 5: Demographic Stratification of Study Participants (N=55)

Demographic Variable	Category	Frequency (n)	Percentage (%)
Gender	Male	41	74.5%
	Female	14	25.5%
Age	18–35	11	20.0%
	36–55	25	45.5%
	56+	19	34.5%
Education Level	No Formal/Primary	28	50.9%
	Secondary/Vocational	17	30.9%
	University	10	18.2%
Origin (Place of Birth)	Local (Ourika Valley)	44	80.0%
	Regional (Haouz/Marrakech)	8	14.5%
	National (Outside Region)	3	5.5%

Source: Author

Water management in the sub-basin is defined by institutional friction between rigid state apparatuses and fluid customary practices, rooted in divergent epistemic foundations. Field observations interpreted through the SECI framework reveal significant dissonance. Formal governance, exemplified by Law 36-15, fails to integrate the tacit, ancestral logic of local irrigation. This failure in the externalization and combination phases underscores the state's inability to translate multigenerational social negotiations into standardized legal registers, often perceived as an erasure of historical legitimacy (Quote 5).

This epistemological divide creates a profound implementation gap. State institutions prioritize abstract hydrological modeling, disregarding the socio-technical resilience of local landscapes. Consequently, technocratic interventions lack social legitimacy by ignoring the proven efficacy of traditional systems (Quote 3).

The internalization phase is marked by stagnation. Top-down policies incite passive resistance and opportunistic behavior, such as the proliferation of unregulated solar-powered pumping. This defensive response shifts water allocation from a collective, managed resource to an individualized commodity, undermining traditional ecological governance (Quote 9).

This governance deficit represents a communication failure rather than a purely infrastructural one. As noted by Basin Agency experts, the primary obstacle is the systemic inability to reconcile mountain communities' logic with the binary requirements of national statutes (Quote 10). Addressing this requires shifting beyond infrastructure-centric solutions toward a nuanced framework that bridges state-level abstraction with local socio-technical realities.

The persistent failure to incorporate localized knowledge into policy illustrates a systemic disconnect where tacit expertise is marginalized by centralized legal frameworks. Applying Nonaka's SECI model clarifies this failure (Table 6):

- **Socialization:** Water management relies on tacit, collective traditions. This expertise is highly effective yet difficult for state agencies to capture.
- **Externalization:** Bureaucracies prioritize explicit hydrological data, failing to articulate nuanced, informal sharing rules. Since this local knowledge remains uncodified, it is rendered invisible, resulting in top-down regulations that contradict existing social orders.
- **Combination:** Official strategies synthesize technical data while excluding local insights. Because foundational expertise is never successfully externalized, it cannot be integrated into policy. Consequently, these sophisticated frameworks lack the social license necessary for community acceptance, creating persistent friction.
- **Internalization:** The learning loop stagnates. Formal policies fail to align with local realities; rather than fostering a collaborative knowledge spiral, this misalignment triggers resistance or indifference as imposed rules fail to resonate with site-specific needs.

Table 6: SECI Analysis Grid: Water Rights in the Ourika Valley

SECI Phase	Characteristics in Ourika	The "Failure" Point	Resulting Consequence
Socialization (Tacit to Tacit)	Oral traditions, local *Jemaa* councils, and informal sharing of *seguia* water.	Knowledge remains confined to small, localized community circles.	Official policy remains unaware of the complexity of local distribution logic.
Externalization (Tacit to Explicit)	The attempt to translate traditional irrigation norms into formal legal rights.	Local customs are rarely codified or documented in policy frameworks.	Policy assumes a "blank slate" rather than respecting established rights.
Combination (Explicit to Explicit)	Integrating hydro-technical data, GIS mapping, and national water laws.	Official data excludes the "human" factor of traditional water rights.	Policies are technically sound but socially disconnected and unenforceable.
Internalization (Explicit to Tacit)	Trying to apply top-down water regulations to local agricultural practices.	Local farmers find state mandates incompatible with their lived reality.	Low policy adoption and continued reliance on informal/illegal water access.

Source: Author

The case study shows that unless governance frameworks effectively translate tacit customary logic into formal policy, implementation will encounter resistance. Such failures drive exclusionary water-access strategies, undermining resource sustainability and state legitimacy. This disconnect is a structural barrier rather than a mere technical oversight. Without a collaborative inclusion of tacit and explicit knowledge, state interventions will continue to suffer from implementation deficits and local discord.

5. Discussion

This study demonstrates that the water governance crisis in Morocco's Ourika Valley reflects profound epistemic frictions and difficulties in integrating ancestral knowledge. However, attributing this entirely to a systemic organizational oversight risks oversimplifying institutional constraints. While Nonaka's SECI model highlights a gap between explicit state frameworks and tacit ancestral practices, technocratic rigidity may stem less from a deliberate rejection of local knowledge than from administrative imperatives and a logic of standardization and resource control applicable at the national level.

Thus, top-down imposed instruments, such as groundwater exploitation contracts, conflict with customary law and treat traditional systems as mere knowledge commons. They obscure potential internal power asymmetries, generational shifts, and the control exerted by local elites, all factors that can render customary mechanisms equally exclusive.

Therefore, policymakers must consider whether knowledge can bridge structural divides without hindering rapid crisis management, rather than viewing crises as simply a failure of state intervention. Reconfiguring water contracts into co-created platforms, that includes indigenous knowledge, offers potential for collaboration, but true sustainability requires determining how decentralized frameworks reconcile competing local interests with state-level water security objectives.

6. Conclusion

Water governance in the studied area stands at a critical juncture, where friction between centralized state mandates and ancestral customs has evolved into a localized epistemic crisis. Within the Ourika sub-basin,

shifting from community-based management to technocratic models has marginalized indigenous knowledge. While highlighting this integration failure, these dynamics remain specific to Ourika's socio-ecological conditions and cannot be generalized across Morocco. Furthermore, relying on qualitative stakeholder perspectives limits the ability to quantify the precise impact of customary versus modern systems on water tables amid industrial extraction.

Fostering sustainability requires shifting toward knowledge hybridization. State institutions must become knowledge mediators, reimagining water contracts as co-created platforms synthesizing scientific rigor with indigenous ecological wisdom to reconcile policy with heritage.

Future research should prioritize translational governance that formalizes customary rules without stripping their social legitimacy. Ensuring traditional practices are empowered as functional governance components offers a pathway for resource sustainability, social equity, and collective resilience.

Acknowledgments

We extend our sincere gratitude to the community members, farmers, and stakeholders for their generous participation. We are deeply indebted to all who shared their invaluable insights and time; their availability and openness were essential to documenting the lived realities of local water management.

AI Declaration: Artificial intelligence tools were used exclusively to enhance English language proficiency, grammar, and structural clarity. The authors maintained full authority over the conceptual framework, data analysis, and intellectual synthesis.

Ethics Declaration: This research adheres to the highest ethical standards, ensuring informed consent from all Ourika Valley stakeholders while strictly protecting their anonymity and rights. We prioritize the preservation of intellectual property regarding customary knowledge, treating oral traditions with cultural sensitivity. By maintaining a reflexive stance on researcher bias and power imbalances, the study ensures that local voices are validated rather than marginalized. Ultimately, this work is committed to empowering the community, ensuring that all findings promote equitable water governance without compromising the ecological or socio-economic security of participants.

References

Abadi, B., Sadeghfam, S., Ehsanitabar, A., & Nadiri, A. A. (2023). Investigating socio-economic and hydrological sustainability of ancient Qanat water systems in arid regions of central Iran. *Groundwater for Sustainable Development*, 23, Article 101007. https://doi.org/10.1016/j.gsd.2023.101007

African Development Bank (ADB). (2009). Environmental and social management plan: APNEEI [Project assessment]. https://www.afdb.org/fileadmin/uploads/afdb/Documents/Environmental-and-Social-Assessments/PGES%20APNEEI%20HS%20nov%209%2009.pdf

AHT Group AG & RESING. (2016). Diagnostic du sous-bassin d'Ourika [Rapport technique]. Programme d'Appui à la Gestion Intégrée des Ressources en Eau (AGIRE) ; Agence du Bassin Hydraulique du Tensift (ABHT).

Akena, F. A. (2012). Critical analysis of the production of Western knowledge and its implications for indigenous knowledge and decolonization. *Journal of Black Studies*, 43(6), 599–619.

Appiah-Opoku, S. (2007). Indigenous beliefs and environmental stewardship: A rural Ghana experience. *Journal of Cultural Geography*, 24(2), 79–98. https://doi.org/10.1080/08873630709478212

Ayt Ougougdal, H., Yacoubi Khebiza, M., Messouli, M., & Lachir, A. (2020). Assessment of future water demand and supply under IPCC climate change and socio-economic scenarios, using a combination of models in Ourika Watershed, High Atlas, Morocco. *Water*, 12(6), 1751. https://doi.org/10.3390/w12061751

Battiste, M. (2005). Indigenous knowledge: Foundations for First Nations. *WINHEC: International Journal of Indigenous Education Scholarship*, 1, 1–17. http://winhec.org/wp-content/uploads/2016/06/WINHEC-Journal-2005.pdf

Botoyiyê, G. A. D. (2010). *Le passage à l'écriture*. Presses universitaires de Rennes. https://doi.org/10.4000/books.pur.9814

Boubou, Y., Fastner, K., & Buerkert, A. (2025). Rural-urban transformation shapes oasis agriculture in Morocco's High Atlas Mountains. *Scientific Reports*, 15, Article 20. https://doi.org/10.1038/s41598-024-81569-7

Boutagayout, A. (2025). Towards sustainable water management in Morocco: Assessing resources, challenges, and adaptation strategies. *Frontiers in Sustainable Food Systems*, 9, Article 1666555. https://doi.org/10.3389/fsufs.2025.1666555

Brodt, S. B. (2001). A systems perspective on the conservation and erosion of indigenous agricultural knowledge in Central India. *Human Ecology*, 29, 99–120.

Bulletin officiel (BO). (1914). Dahir du 1er juillet 1914 sur le Domaine public. Bulletin officiel n° 89.

Bulletin officiel (BO). (1995). Loi n° 10-95 sur l'eau. Bulletin officiel n° 4325.

Bulletin officiel (BO). (2016). Loi n° 36-15 relative à l'eau. Bulletin officiel n° 6494.

CESE. (2014). La gouvernance par la gestion intégrée des ressources en eau au Maroc : Levier fondamental de développement durable [Rapport]. https://www.cese.ma/media/2020/10/Rapport-Gouvernance-des-ressources-en-eau.pdf

Córdova Morales, E., El Arabi, S., Sahraoui, N., & Perrodin, L. (2025). Habiter la crise environnementale. *Mondes & Migrations*, 1351, 37–45.

Del Vecchio, K. (2019). Le « contrat de nappe » du Saïss au Maroc, figure d'un État aménageur libéral. In D. Blanchon & B. Casciarri (Eds.), *L'accès à l'eau en Afrique: Vulnérabilités, exclusions, résiliences et nouvelles solidarités* (pp. 121–138). Presses de Paris Nanterre. https://halshs.archives-ouvertes.fr/halshs-02971192

Domínguez, P. (2021). Assessing the economic contribution of the pastoral common of the Yagur: A pastoral territory managed communally by the traditional Berber system of the Agdal (Moroccan High Atlas). *Quaderni Storici*, 168(3), 799–822. https://doi.org/10.1408/104535

El-Aabssi, A., & Assir, A. (2026). Governing the digital transformation of Moroccan irrigation from intelligent to wise systems: A conceptual and policy analysis of edge-AI architectures and adoption barriers. SSRN. https://doi.org/10.2139/ssrn.6696198

Escobar, A. (2007). Worlds and knowledges otherwise: The Latin American modernity/coloniality research program. *Cultural Studies*, 21(2–3), 179–210. https://doi.org/10.1080/09502380601162506

Ezzerouali, S., Banane, M. C., Anaya, H., & El mountafia, R. (2025). The constitutionality of water irrigation policy in Morocco: Sustaining agricultural security amid climate change. *Journal of Indonesian Constitutional Law*, 2(2), 103–127. https://doi.org/10.71239/jicl.v2i2.63

Garrigues-Cresswell, M., & Lecestre-Rollier, B. (2025). Local irrigation systems, governance, and climate change in the High Atlas Mountains of Morocco. *Water Policy*, 27. https://doi.org/10.2166/wp.2025.013

Global Water Partnership (GWP). (2000). Integrated water resources management. TAC Background Papers No. 4. GWP Secretariat.

Halford, G. S., Wilson, W. H., & Phillips, S. (2010). Relational knowledge: The foundation of higher cognition. *Trends in Cognitive Sciences*, 14(11), 497–505. https://doi.org/10.1016/j.tics.2010.08.005

HCP. (2024). Population légale du Royaume du Maroc, selon les résultats du Recensement Général de la Population et de l'Habitat de 2024. https://www.hcp.ma/Population-legale-du-Royaume-du-Maroc-repartie-par-regions-provinces-et-prefectures-et-communes-selon-les-resultats-du_a3974.html

Houdret, A. (2021). How can water sector cooperation support democratic governance? Insights from Morocco. *Middle East Law and Governance*, 13(1), 72–97. https://doi.org/10.1163/18763375-13010004

Hountondji, P. J. (2009). *L'Ancien et le Nouveau : La production du savoir dans l'Afrique d'aujourd'hui*. Centre africain des hautes études.

Jomehpour, M. (2009). Qanat irrigation systems as important and ingenious agricultural heritage: Case study of the qanats of Kashan, Iran. *International Journal of Environmental Studies*, 66(3), 297–315. https://doi.org/10.1080/00207230902752629

Kane, A., Seck, M., & Ndiaye, M. (2025). Étude des processus de production, de dissémination et de valorisation des savoirs endogènes par les peuples autochtones au Sénégal. *Communication, Technologies et Développement*, 17. https://doi.org/10.4000/1414c

Kchikech, Z., Bouzidi, Z., & Faysse, N. (2024). More collectives, less differences: Unveiling unexpected social changes in a groundwater economy in the middle atlas, Morocco. *Water Alternatives*, 17(1), 73–93. https://hal.science/hal-05182168

Laassilia, O., Ouazar, D., Bouziane, A., & Hasnaoui, M. D. (2021). Estimation of excess water in the Sebou basin for an interbasin water transfer. *Journal of Applied Water Engineering and Research*, 9(1), 69–87. https://doi.org/10.1080/23249676.2021.1884616

Lamadrid, E. R., & Rivera, J. A. (Eds.). (2023). *Water for the people: The acequia heritage of New Mexico in a global context*. University of New Mexico Press.

Lightfoot, D. R. (1996). Moroccan khettara: Traditional irrigation and progressive desiccation. *Geoforum*, 27(2), 261–273.

Mangal, M., & Govind, A. (2025). Water, agriculture, and climate: A study of Moroccan agricultural water management policy. *Water Policy*, 27(9), 941–960. https://doi.org/10.2166/wp.2025.313

McGregor, D. (2018). Indigenous environmental justice, knowledge, and law. *Kalfou*, 5(2), 279–296. https://doi.org/10.15367/kf.v5i2.212

Mendes, L. (1986, February 12). Private and communal land tenure in Morocco's Western High Atlas Mountains: Complements, not ideological opposites [Paper presentation]. International Rangeland Development Symposium, Annual Meeting of the Society for Range Management, Boise, ID, United States.

Messaoudi, I., & Bréthaut, C. (2026). Building a dam without water? Unraveling paradoxes and modernization discourses in Morocco, the case of El Hajeb Province (Saïss Plain, Morocco). *Political Geography*, 123, 103588. https://doi.org/10.1016/j.polgeo.2026.103588

Minati, G. (2024). Theoretical reflections on reductionism and systemic research issues: Dark systems and systemic domains. *Systems*, 12(1), 2. https://doi.org/10.3390/systems12010002

Montginoul, M., & Molle, F. (2019). *Modernisation des périmètres irrigués au Maroc : Une solution aux effets contrastés pour les agriculteurs et la ressource en eau. Le cas d'un périmètre du N'Fis - Haouz* [Research report]. Irstea; IRD - Institut de recherche pour le développement; UMR G-Eau. https://hal.science/hal-02963118 .

Moumen, A., Oulidi, H. J., Khazaz, L., & El Mansouri, B. (2015). Système d'Information d'Eau au Maroc : Etat d'art, problématique, approche et prototype. Actes des Journées Doctorales en Systèmes d'Information, Réseaux et Télécommunications, 12–13.

Nonaka, I., & Takeuchi, H. (1995). *The knowledge-creating company: How Japanese companies create the dynamics of innovation*. Oxford University Press.

Palsson, G., Szerszynski, B., Sörlin, S., Marks, J., Avril, B., Crumley, C., Hackmann, H., Holm, P., Ingram, J., Kirman, A., Pardo Buendía, M., & Weehuizen, R. (2013). Reconceptualizing the 'Anthropos' in the Anthropocene: Integrating the social sciences and humanities in global environmental change research. *Environmental Science & Policy*, 28, 3–13. https://doi.org/10.1016/j.envsci.2012.11.004

Pascon, P. (1977). *La question hydraulique : Petite et grande hydraulique au Maroc*. Université Mohammed V, Institut Agronomique et Vétérinaire Hassan II.

Pressman, J. L., & Wildavsky, A. (1973). *Implementation: How great expectations in Washington are dashed in Oakland*. University of California Press.

Pronti, A., Vallino, E., & Mazzanti, M. (2024). Good (or bad) water governance: A macro empirical analysis of the determinants of Integrated Water Resources Management (Emerging Economies No. 26). Osservatorio sulle Economie Emergenti. Torini.

Rensen, B. (2024). Mobility, infrastructure, and peacebuilding: (Im-)mobilising Morocco's waters in the early French Protectorate, 1912–1925. *The Journal of Transport History*, 46(1).

Rivera, J. A., & Martínez, L. P. (2009). Acequia culture: Historic irrigated landscapes of New Mexico. *Agricultura, Sociedad y Desarrollo*, 6(3), 195–213.

Rosso, R. (2025). On seven principles of water governance. *Water*, 17(6), 896. https://doi.org/10.3390/w17060896

Santos, B. D. S., Nunes, J. A., & Meneses, M. P. (2007). *Opening up the canon of knowledge and recognition of difference. Another knowledge is possible*. Verso.

Shemshad, M., Synowiec, A., Kopyra, M., & Benedek, Z. (2025). The community-driven ecosystem resilience and equity framework: A novel approach for social resilience in ecosystem services. *Sustainability*, 17(8), 3452. https://doi.org/10.3390/su17083452

Siringan, B. (2025). Integrating traditional ecological knowledge in modern conservation practices. *Ukrainian Journal of Ecology*, 15, 19–21.

Studer, H. (2026). Water practices: Communal water rights in Moroccan river oases in times of climate change. *Planning Perspectives*, 1–21. https://doi.org/10.1080/02665433.2026.2614301

Tazi Sadeq, H. (2020). Water governance in a context of scarcity. *Field Actions Science Reports*, (Special Issue 22). http://journals.openedition.org/factsreports/6257

Védie, H.-L. (2025). Désalinisation, barrages et autoroutes de l'eau: les incontournables de la lutte contre le stress hydrique au Maroc (Policy Paper No. PP_19-25). Policy Center for the New South. https://www.policycenter.ma/publications/desalinisation-barrages-et-autoroutes-de-leau-les-incontournables-de-la-lutte-contre

Warren, D. M., Slikkerveer, L. J., & Brokensha, D. (Eds.). (1995). *The cultural dimension of development: Indigenous knowledge systems*. Intermediate Technology Publications.