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TRADITIONAL WATER MANAGEMENT SYSTEMS IN THE ASIR HIGHLANDS, KSA: AN ENVIRONMENTAL HISTORICAL STUDY

Zuhair Alshehri^{1*}

¹Imam Mohammad Ibn Saud Islamic University (IMSIU), Riyadh, KSA. Email: zaalshehri@imamu.edu.sa

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Corresponding Author: Zuhair Alshehri
(zaalshehri@imamu.edu.sa)

ABSTRACT

This article examines traditional water management systems in the Asir Highlands of southwestern Saudi Arabia as historically embedded socio environmental regimes that evolved in response to specific topographical and climatic conditions. It reconstructs the technical procedures, institutional norms and distributive mechanisms that governed irrigation, water storage and conflict resolution in periods marked by weak or absent state structures. Drawing on local documents, oral statements, archival materials, historical sources and recent scientific studies, the article combines environmental history and common pool resources theory to analyse how these systems sustained and managed water scarcity. It argues that Asir's traditional water management practices constituted comprehensive regulatory frameworks based on decentralised management, community participation and norms of distributive justice. The article then re-introduces these historical experiences for integration into contemporary water resources sustainability in Saudi Arabia, particularly in mountain regions facing water stress and environmental change.

KEYWORDS: Asir Highlands; Traditional Irrigation; Environmental History; Common Pool Resources; Water Resources Management.

1. INTRODUCTION

The Asir Highlands in southwestern Saudi Arabia constitute one of the most distinctive agro-ecological zones of the Arabian Peninsula, where comparatively high rainfall, rugged topography and intensive cereal cultivation have historically combined to produce complex local systems of water management. Prior to the unification of the Kingdom in 1351 AH / 1932 CE, tribal communities in Asir developed and relied on customary norms, hierarchies of authority and written agreements to regulate access to water, organise irrigation and resolve conflicts in the absence of encompassing state institutions. Water management thus became a central arena in which social values, economic needs and environmental constraints intersected.

Environmental-historical research has underscored the risks of relying on short time-horizons when designing environmental policies. Renberg et al. (2009) warn that, "If we base management plans on short-term ecological data and do not realize that humans have affected and reshaped nature for several thousand years and that the current state of the landscape is to a large extent a product of human impact in the past, we risk establishing plans for nature conservation and management that are in fact not sustainable." This insight is particularly relevant to dryland regions such as Asir, where small-scale infrastructures, customary institutions and social memory have long mediated relations between rainfall variability, runoff regimes and agricultural production.

Environmental historians of other regions have similarly emphasised water as a privileged field in which social and ecological change intersect. White (1985) notes that "water development, therefore, involves combat between alternative users and uses, environmental alterations, social changes as water is removed from one region and brought to another, and the threat of eventual depletion as water is drawn from underground aquifers faster than it is replaced." In this sense, Asir's irrigation practices can be read as a local iteration of a wider historical pattern in which water infrastructures crystallise conflicts and accommodations between competing claims, landscapes and economies.

This article approaches traditional water management in Asir not as static folkloric heritage, but as a historically dynamic set of institutions and practices that can be analytically reconstructed and critically evaluated. It advances three main aims. First, it reconstructs the principal technical and organisational features of traditional water systems in the Asir Highlands, including

rainwater-harvesting techniques, the use of wells, springs and underground channels, and the customary rules governing allocation, maintenance and sanctions. Second, it interprets these practices as adaptive mechanisms under conditions of scarcity and climatic variability, highlighting their role in securing subsistence and managing risk. Third, drawing on insights from common-pool resource theory (Ostrom et al., 1994) and environmental history (White, 1985), it identifies institutional principles that may be relevant for current debates on water policy and sustainability in Saudi Arabia.

Therefore, this paper is anchored in an explicitly interdisciplinary framework that brings together two complementary strands: common-pool resources and environmental history. The former is defined as "systems that generate finite quantities of resource units so that one person's use subtracts from the quantity of resource units available to others (Ostrom, 2002; Ostrom et al., 1994). Within the framework of the latter, water has often emerged as a particularly evolving area of research (White, 1985). For instance, "in the western United States water rather than land has emerged as the critical resource in twentieth-century economic development" (1985).

This combination is intended to illuminate both the historical specificity of Asir's water systems and their potential contemporary relevance. First, environmental history provides the main interpretive approach for reconstructing long-term interactions between society and environment in the Asir Highlands. Rather than treating climate, topography and hydrology as a static backdrop, environmental history examines how human communities have adapted to, modified and interpreted their ecological surroundings over time. In this perspective, traditional water systems are understood as socio-environmental assemblages in which physical infrastructures, social institutions and cultural norms co-evolved in response to rainfall patterns, slopes, soils and runoff regimes. The emphasis falls on processes of adaptation, feedback and change rather than on a timeless "traditional" equilibrium.

By bringing these two strands together, the article develops what it terms a "functional-historical" model of analysis. This model seeks to: (1) situate Asir's traditional water systems within their specific environmental context, and (2) elucidate the institutional logics and social norms that underpinned their functioning and sustainability.

The article is structured as follows. The next section outlines the theoretical framework, drawing on environmental history and common-pool

resources theory. The third section reviews relevant literature on traditional water systems in Asir and comparable cases. The fourth section sets out the methodological approach, sources and analytical procedures. The fifth section presents the discussion and analysis in four parts: the environmental setting; the social structure of water regulation; the technical and institutional arrangements of traditional systems; and how to integrate these principles into contemporary policies. The conclusion reflects on the implications for water resources management and the trajectory of environmental history in Saudi historiography.

2. IMPACT OF GEOGRAPHY AND CLIMATE ON SHAPING WATER SYSTEMS

In the broader field of environmental history, water has been a central theme precisely because it exposes the role of law, economy and ecology. White (1985) has shown for the American West that water rights and institutions evolved as “legal systems contrived out of experiment and compromise in order to further economic development,” and that “water development, therefore, involves combat between alternative users and uses, environmental alterations, social changes as water is removed from one region and brought to another, and the threat of eventual depletion as water is drawn from underground aquifers faster than it is replaced.” Blake’s study of Florida, *Land into Water, Water into Land*, similarly demonstrates how “a changing economic and political context has brought older engineering solutions into conflict with ecological concerns and how environmental mismanagement has transformed the problem from one of having too much water to worries about both water quality and quantity” (cited in White, 1985). Within Saudi Arabia, researchers have increasingly turned to regional case studies, such as Asir highlands, that explore how local societies adapted to and shaped their environments, including work on highland terraces, wadis and oasis communities.

“Asir” refers to the southwestern part of the Arabian Peninsula, located between the Hijaz to the north and Yemen to the south, and the boundaries and names of this region have varied according to social and political circumstances (Al-Barakati, 2009, p. 128; Wahbah, 2000, p. 36; Al-Alma‘i, 1972, p. 84).

What most distinguishes the southwestern region of the Kingdom is the volume of rainfall, which exceeds that of any other region in Saudi Arabia. This is due to the area lying under the influence of two low-pressure belts. In summer it is affected by the Sudan low, which helps draw moist air crossing the

Red Sea coast, heavily laden with water vapour, toward the highlands of southwestern Saudi Arabia in the form of rain-bearing southwesterly winds. The region is also slightly affected by the winter East Mediterranean low, which prevails the area along the Red Sea coast and causes winter rainfall over parts of the region (Al Misheet, 2021, p. 803).

In addition to the influence of the seasonal Sudan low, the Indian monsoon, the East Mediterranean low and shifts in the Intertropical Convergence Zone (ITCZ), elevation, represented by the mountain chain running parallel to the Red Sea coast. This plays an important role in forming the rainfall systems of southwestern Saudi Arabia. The mountainous zone of this region experiences the highest rainfalls, especially in summer (Almazroui, 2023, p. 43).

Asir is classified as a moderately elevated highland region with relatively regular rainfall (al-‘Uqayli, 1984, p. 15). Rainfall amounts vary between the mountainous areas, the Tihama lowlands that extend as coastal plains between the Red Sea and the Sarawat Mountains, and the eastern areas stretching toward Najd in central Arabia. Rain falls heavily on the Sarawat highlands and then decreases gradually toward the Tihama and the eastern parts. From this rainfall, runoff forms in the wadis flowing east and west; some of these streams run throughout the year, while others percolate into the ground and are extracted from wells (Wahbah, 2000, pp. 35, 38; Jirees, 1993, p. 27).

As a result of rainfall, a moderate climate and the availability of fertile agricultural lands, this region has long been renowned for its abundant production of high-quality grains, and many of its agricultural products historically supplied Najd and the Hijaz (Ibn Al-Mujawir, 1951, p. 27; Ibn Jubayr, 1984, pp. 98–99). The most important cereal crops in Asir are wheat, barley, lentils, corn, millet and sesame (Hamzah, 1968, p. 112). The agricultural lands of Tihama are distinguished by fertile soils for plantation (al-‘Uqayli, 1984, pp. 16–17), and the land there can be harvested more than once a season (Al-Zayla‘i, 1988, pp. 100, 116). The main crops of Tihama are corn, millet, sesame and cotton, while coffee is cultivated on some of the lower mountain slopes (al-‘Uqayli, 1984, pp. 16, 17; al-Na‘mi, 1999, pp. 30–35).

3. SOCIAL STRUCTURE AND CUSTOMARY MANAGEMENT OF WATER

Before the unification of the Kingdom of Saudi Arabia in 1351 AH / 1932 CE, the region experienced turbulent and unstable conditions, coupled with a relatively primitive lifestyle and the absence of

formal regulations and public services. These circumstances made society adhere to its inherent values, customs and norms, which it regarded as the safest refuge for the individual, the family and the community, including the irrigation systems that were directly tied to food security.

The tribal system in Asir has deep historical roots, and the role of the tribe shaped up all spheres of life for the settled village population, politically, socially and economically. These communities were governed by precise, inherited systems, structured in a hierarchical order of chosen figures from each village or cluster of villages, headed by the tribal amir or shaykh. All political powers that successively ruled Asir took this inherent structure into account (Al Zulfa, 1991, p. 152).

To consolidate the customary norms regulating social and economic life, including management of irrigation, local communities relied on governing rules known as *qawa'id* "rules". A *qa'ida* was an agreement concluded internally between individuals or groups with the tribe, or externally with other tribes. Tribal customary laws were protected by a number of traditions that guaranteed effectiveness, continuity and inviolability, as well as measures for the settlement of disputes and breaches, such as *qubala*, meaning selected guarantors (Al Hamid, 2005, pp. 555–557); right to adjudication and arbitration (Al Hamid, 2005, pp. 558–561); the *'udul*, men of expertise who are known for their keenness to reconcile people (Al Hamid, 2005, p. 564); and the *muqatti' al-haqq* or *'arif*, meaning one who is knowledgeable about customs and the procedures of tribal reconciliation and who possesses the capacities, qualities and conciliatory expertise needed to resolve disputes (al-Qahtani, 2003, p. 9). Penalties were also imposed on those proven to have violated tribal customary laws or encroached upon the material or moral rights of others. Penalties varied according to the nature and severity of the offence. One of the most common penalties was *nukal*, meaning punishment or penalty (Al Hamid, 2005, pp. 646–649); *al-burrha*, meaning that the violator of customary laws hosts the injured person or persons for a feast by slaughtering one or more sheep/cattle (Al Hamid, 2005, pp. 662–663); imprisonment (Al Hamid, 2005, pp. 664–671); social boycott and banishment (Al Hamid, 2005, pp. 674–684); and "raising the black banner", namely, a flag raised in markets and public gathering places for those who violate tribal customary laws. This was rarely exercised because individuals were keen to protect their fame. By contrast, the white banner was more commonly raised to celebrate the many

occasions of pride in serving the community; everyone sought to be celebrated in this manner (Al Hamid, 2005, pp. 725–726), among many other practices.

The *qawa'id* recorded agreed-upon regulatory provisions and responses to anticipated circumstances, and they included the names of tribal representatives and guarantors (*qubala' / dumana'*). One or more men would be chosen as guarantor/s for their group, tribe or village to ensure implementation of the agreement. These tribal governing rules were laid down to meet the necessities of the community, aiming, in general, to organise the public life of the tribe (Al Zilfa, 1991, p. 192). On top of these necessities were agricultural production, irrigation systems and the customary regulations of weekly markets; these were all closely related to the people's sustenance and food security in prosperity and adversity.

Individuals were also keen to be good members of their community and gain respect and esteem from others by adhering to the laws and customs of the tribe. They could not easily defy collectively agreed customary laws and regulations, for they felt, at the end of the day, that it was these customary laws that protected them and helped them cope with crises ('Asiri, 1987, pp. 109–110).

4. METHODOLOGY

This study adopts a qualitative approach grounded in environmental history principles and complemented by interpretive engagement with common-pool resource theory. The research design proceeds across three interrelated levels, historical reconstruction, functional analysis, and applied inference, based on three main types of sources. First, local documents and governing rules (*qawa'id*) include written agreements among tribes, villages, or landowners that establish irrigation schedules, water-sharing arrangements, construction and maintenance of bunds and channels, conflict-resolution procedures, and sanctions for violations; dating primarily from the nineteenth and early twentieth centuries, these provide direct evidence of institutional arrangements and normative expectations in pre-unification Asir. Secondly, archival materials and historical correspondence, such as administrative records and letters concerning grain supplies, taxation, and regional authority, illuminate the broader economic and political context of local water systems, particularly during crises like the First World War and subsequent transitions. Finally, unstructured interviews and local knowledge, drawn from conversations with elders,

farmers, and community figures in selected Asir localities, capture experiential insights into traditional practices, technically indigenous terms and perceived changes over time; these oral statements triangulate written sources and interpret the social meanings of institutions.

5. TRADITIONAL WATER MANAGEMENT SYSTEMS IN ASIR HIGHLANDS

The customary laws and experiential knowledge of the Asir community are closely tied to the economic sphere, particularly cereal cultivation. The society, thanks to the customary laws and inherited practices, consistently sought to organise production in ways that ensure food security under conditions of absent state authority and lack of formal regulations and services prior to the Saudi era.

Sources of irrigation were linked to the ownership of agricultural land, which, broadly speaking, was distributed relatively evenly among families so that no one monopolised farmland (al-'Uqayli, 1984, p. 17). Farm tenure ranged from private individual ownership, through inheritance from parents or relatives or through purchase, to various forms of collective ownership (Al Zilfa, 1991, p. 156). Whoever owned a farm would obtain all associated water sources, such as wells, springs, channels from the mountains, as well as paths for people, livestock and pack animals, in addition to any prior customs or agreements attached to the land (Muhammad b. Abdul-Karim Al-Shehri, personal interview, 2021).

A deeply rooted customary principle held that agricultural land, together with its water sources and irrigation arrangements, constituted the very foundation of life for human beings. Individuals devoted themselves to maintaining it and took pride in it, while neglecting or selling such land was regarded as a serious dishonour that could only be effaced by death or immigration (Al Zilfa, 1991, p. 155). In the rare cases where someone attempted to sell farmland, no one would dare to purchase it openly; if a sale did occur, it was conducted in the utmost secrecy and often remained concealed for some time (Al-Bishri, 1982, p. 181). These stringent customary laws of land ownership ultimately aimed at supporting agricultural production and ensuring food security in prosperity and adversity.

Given that irrigation in Asir was a crucial factor in cereal cultivation, farms can be divided into two main types.

The first was *suka* or agricultural lands irrigated by water drawn from wells scattered throughout the villages, especially along the edges of valleys, many of which were dug into rock to access groundwater

(Muhammad b. 'Abd al-Karim al-Shehri, personal interview, 18 August 2021). According to social customary laws regulating irrigation, the wells on which these *suka* plots depended were generally jointly owned by groups of residents. They used camels, cattle and donkeys to draw water, which was then poured into basins near the wells and channelled to the fields through waterwheels. Joint ownership and use were based on criteria such as inheritance or participation in digging and maintaining the water source, which conferred legitimate rights of use, especially in the case of wells. Some farmers owned plots near a well or other water source but did not have recognised rights to use the water because they had not contributed to its establishment or had not adhered to the laws governing that particular source. Their fields were therefore classified as '*athari* plots dependent solely on rainwater (Al Hamid, 2005, p. 929).

Irrigation schedules for *suka* plots were governed by well-established social norms. Each village or group benefiting from a water source developed a specific mechanism for irrigating their farmlands. Based on accumulated experience, they estimated the source's yield and assigned each farm or group of farms a fixed period of time for irrigation, one day or half a day, according to certain measures that included farmland size and distance from the source. These arrangements could vary depending on the abundance or scarcity of water, and locals would keep the documents regulating irrigation of these farms (Sulayman b. Saad Al Misfer, personal interview, 7 May 2019). A common customary practice in times of water shortage was that farmers would share the water of the nearest well, addressing the deficit by allocating repeated, rotating turns over days or several days to meet their need. They also developed some criteria to fulfill this purpose, including plot size, quantity of water available, and crop type. Each turn was called a *dawl* or *touf* "round" (al-Bishri, 1982, p. 183).

Suka plots were also irrigated by springs and what was known locally as *kaza'im* (sg. *kazama*). *kazama* is a classical Arabic term that means an underground channel in which water flows. The word is closely associated with the presence of water, particularly springs and fountains that flow across mountains and rocks. They function like small dams. Customary laws also regulated the use of these water sources for nearby farm owners. Water was contained with stones and soil to prevent it from running down the valley. A small opening at one corner, called a *kharza*, was then made and blocked with stones and soil to prevent seepage. Each day at sunset the outlet was

closed, and by dawn the *kazama* would have filled with water. When it was a farmer's turn to irrigate, he would open the outlet so that water flowed along a prepared path bounded by earthen embankments, called *al-qayid* or *saqiya*, directing it to his fields. *Suka* plots were also irrigated from *ghayl* flows, namely, surface water accumulated in valleys during heavy and recurrent floods in certain seasons. This was regulated by well-known customary laws among nearby landowners (Sulayman b. Saad Al Misfer, personal interview, 7 May 2019).

The second type was *al-athari*, referring to agricultural terraces dependent on rainwater, which was channelled from the slopes of neighbouring mountain chains onto the terraced fields (Abdallah b. Ali b. 'Aftan, personal interview, 18 February 2019). When rain falls on the mountains, it is channelled into established conduits, burrowed in the rocks or paved with stones from the nearby mountain ridges down towards the fields. These are known locally as *ashrab* or *masaqi*. Such channels are regarded as common property for all owners of the neighboring lands; no one may appropriate them exclusively. Farmers managed water distribution through the *dawl* "Rota" system, arranging turns in a sequence according to specified time periods proportionate to the area to be irrigated, regardless of whether the land received more or less than its "optimal" requirement. Usually, a turn would last for the whole day and night, or just a day or a night. Irrigation proceeded from the highest plots downward, with no precedence accorded to any one person over another. When the designated time was due, the water was directed to its destination whether or not the owner was present, in order to maintain everyone's rights and interests. Another method of exploiting rainwater was basin irrigation: runoff carrying silt was diverted by earthen bunds to raise water levels and direct flows into fields, and the deposited sediments would enhance soil fertility and increase yields (Muhammad b. Abdul-Karim Al-Shehri, personal interview, 18 August 2021).

Customary laws stipulated that landowners would collectively maintain, service and clean water sources before and during the rainy seasons and on an ongoing basis. This included wells, springs, *kaza'im*, and the *masaqi* or *ashrab* that carry water down mountain slopes to the fields, so that irrigation would not be disrupted. Villagers cooperated closely in performing these tasks, especially neighbouring landowners whose fields depended on the same sources of water. Those who neglected their fields or failed to maintain and service their water sources

incurred communal reproach and social stigma, underscoring the centrality of agricultural land to local livelihoods (Sulayman b. Saad Al Misfer, personal interview, 7 May 2019).

The *masaqi* or *ashrab* that irrigate agricultural terraces dependent on rainwater were particularly important and valued for the terraces. People commonly knew the specific channel serving each plot and its route, and it is widely understood that no one should destroy or obstruct them, whether intentionally or through livestock. Some channels descending from the high mountains would split into two directions at certain points to serve different sets of fields, whether belonging to the same owner or to others (Sulayman b. Saad Al Misfer, personal interview, 7 May 2019).

Another source of irrigation was the *dubul* (sg. *dibl*), stone-lined watercourses enclosed on all four sides and running by the farmland, particularly in valleys traversing twin ridges where water descends from both sides and must be drained. A key customary rule was that each landowner is responsible for cleaning the *dubul* serving his plots, as well as for monitoring them and maintaining their drainage function by opening or closing their outlets at appropriate times, in ways that would not harm his own fields or those of his neighbours (Sulayman b. Saad Al Misfer, personal interview, 7 May 2019).

Local documents indicate the commitment of community members to the customary laws governing irrigation. One such document, dated Shawwal 1279 AH / March 1863), records a settlement of dispute attributed to the rule of the notable amir of Asir, Tami b. Shu'ayb, regulating irrigation from a well in the village of Tabbab northwest of Abha. Under this arrangement, the well water was apportioned over a ten-day rotation, with five days reserved for the heirs of Tami and five days for the other villagers. It precisely specified the days and the local beneficiaries, in the presence of guarantors (*qubala' / dumana'*). This document clearly shows that, despite the existence of fixed customary rules regulating irrigation, the community could adapt the arrangements to cope with new circumstances and changing conditions affecting individuals, water sources and environmental factors.

Other agreements concerning irrigation and water distribution were also concluded according to inherent customary laws, as confirmed by a range of title deeds and reconciliation documents. One local document (n.d.) records a settlement between the inhabitants of the villages of Al-Malaha and Bani

Razam north of Abha over a *ghayl* “accumulated water in valleys” flowing through their lands. Amir ‘Ayiḍ b. Mar’i (834–1857) appointed two men to mediate between them. The settlement specified that the *ghayl* would run freely for two days, during which all those needing irrigation could benefit from it, afterwards, the people of Bani Razam would divert a portion of the *ghayl* to their village at a designated point, that measured one cubit in length and width.

A further customary practice in the distribution of water was the construction of earthen bunds or dams, known locally as *‘uqum*. A document dated 1305 AH / 1888 CE outlines instructions governing the construction of an *‘aqm* (water barrier) and mechanisms for distributing water among beneficiary farmers. Another document dated 17/2/1345 AH / 25 August 1926 records several important systems and practices. These include granting each farm a period of one and a half day to access well water; prohibiting the closure of connecting cuts (*manasim* or *maghabid*) between fields while floodwater is still running; allowing each farmer, once the flood has stopped behind the bunds, to close the cuts in order to irrigate his plot, and forbidding the removal of the *‘uqum* until all farms have been irrigated. Four trusted persons *‘udul* were appointed to oversee the system, who were alone authorised to permit the removal or alteration of the bunds. If any landowner complained of harm, he was not allowed to act unilaterally but had to present the case first to the appointed four trusted people. If his field experienced damage in walls, soil or other parts, the owners of the other farms were required to repair the damages caused by the flood (Al Zilfa, 2025, pp. 49–60).

Customary irrigation laws continued to be effective in Asir during the Saudi era despite the development of administrative regulations and technology related to water and irrigation. One local document from the village of al-‘Alayah west of Abha, dated 9/6/1389 AH / 22 August 1969, shows the community’s commitment to fair water distribution. It records the allocation of water from a local spring (*kazamat al-naba*) among village families over a five-day cycle, and at the same time anticipates possible declines in spring flow and lays down corresponding reductions in irrigation days. The document also specifies precise financial and moral penalties for anyone who cuts off water, damages conduits to the fields or violates customary norms and regulations (Al Zilfa, 2025, pp. 49–60).

These experiential arrangements in water and irrigation played a central role in shaping consumption patterns that relied on local production

and informed thrifty strategies, thereby realizing food security. This was evident during the First World War, amidst the disruption of imports via Red Sea ports and the increase of conflicts and uprisings between local tribal forces and the Ottomans. Social control practices, including irrigation systems, contributed to food security of grain supplies (Al Hamid, 2005, pp. 964–965). This was evident in a letter sent by Sharif Husayn b. Ali, ruler of Mecca, to the tribes of Asir and neighbouring areas on 15 Rajab 1334 AH / 17 May 1916, requesting to purchase their surplus grain (al-Saluk, 2002, p. 213).

6. INTEGRATING TRADITIONAL PRACTICES INTO CONTEMPORARY WATER POLICIES

Saudi Arabia today faces severe water stress, driven by aridity, over-extraction of groundwater, population growth and climate change. National strategies have prioritised large-scale technological solutions such as desalination, dam construction and demand-management programmes, but there is a growing recognition that effective water governance also requires attention to local institutions, social norms and ecological knowledge. Against this backdrop, Asir’s historical experience offers an instructive reference point.

The point is to treat traditional water systems not as technical relics to be replicated, but as repositories of organisational and ethical principles: cooperation, controlled consumption, primacy of the collective interest, shared responsibility and context-specific adaptation. Mobilising these principles requires their translation into modern governance frameworks while maintaining awareness of historical differences in scale, demography and political authority. This approach aligns with environmental history’s insistence on the co-evolution of society and nature.

Traditional knowledge can be incorporated into water-studies and planning for the identification of public and private property, mapping of natural flow paths, identifying flood destinations and drainage areas, balancing of construction and watercourses, investing of floods, developing of advanced water barriers, designing of inter-farm drainage channels, and distributing of water equitably. At the same time, it can inform the development of broader frameworks for “water governance” by translating the human and ethical aspect of social practices into legal and institutional arrangements, as in the case of customary laws, village and family narratives and collective water rights, and seeking to harmonise law and customs. Local principles of water distribution justice could be explicitly incorporated into

regulations governing the distribution of irrigation water in highlands, while new local administrations for managing rainwater could be established based on historical runoff maps and residents' deep knowledge of the landscape.

Restoring agricultural projects on terraces by renovating these terraces, engaging youth, supporting food security and reinforcing policies of shared responsibility for water, drawing inspiration from Asir's customary laws that link consumption, social behaviour and environmental responsibility. It is also important to document historical knowledge that was transmitted orally by recording the experiences and narratives of elders and compiling glossaries of indigenous concepts and terms, together with local maps of water resources.

Traditional practices can be combined with today's irrigation techniques and the restoration of terraces rather than relying exclusively on water-intensive flat-field agriculture. Studies have shown that the agricultural terraces cutting across Asir help conserve soil, reduce evaporation and sustain production, despite scarcity of water (Alzaghloul & Al-Husban, 2021, pp. 19–29).

Recent research also underscores the importance of designing water policies in Asir that rely on rainwater catchment and storage, using three key factors, including slopes, rainfalls and soil structure. Further, there are seven socio-economic variables: distance to the drainage network, distance to roads, proximity to international borders, urban areas, vegetation cover, existing dams and geological depressions. Similar tensions are evident in other arid river systems, where debates over storage and diversion were closely linked to fears of losing local control over scarce water supplies and protecting established water rights (Hundley 1975).

On this basis, topographical data were reclassified and linked to suitability values to produce a map showing the degree of suitability of different locations for rainwater catchment. Some studies used geographic information systems (GIS) and remote-sensing data and found that vast areas in Asir are highly suitable for rainwater farming systems. Approximately 14,261.76 km² (18.5% of the study area) turn out to have high or very high suitability for installing rainwater farming systems, while 9,626.99 km² (12.5% of the total area) have not. Fieldwork was conducted, in other studies, to ensure that the land use is optimised (either for agriculture or urban development), thereby validating the results and their practical applicability. Such studies identified vast areas in Asir could be utilised for rainwater catchment efficiently, based on a combination of

natural and human factors. The above factors could help draw an accurate map for the optimal utilisation of rainfall. The use of GIS and multi-criteria analysis provides a comprehensive understanding of how to invest rainwater in the region and can serve as a scientific basis for sustainable water policies. Such studies can, in turn, build on inherently traditional practices that had long identified natural sites and assessed their effectiveness, providing foundational insights and guiding principles for future water policy frameworks and for linking traditional knowledge with modern technology (Alzaghloul & Al-Husban, 2021, pp. 19–29).

In short, traditional irrigation practices in Asir were not merely a technical response to the problem of water, but a deep, cumulative human experience that forged a relationship of balance and responsibility between people and their environment. This relationship generated sustainable food security and proved its effectiveness over time, demonstrating that historical knowledge can inspire and guide contemporary policy and practices.

Comparative research on water governance in the American West shows that irrigation and groundwater institutions often evolve incrementally in response to drought, regulation, and social conflict, rather than through abrupt institutional redesign. Loos et al. (2022) argue that sustainable groundwater governance requires locally designed, adaptive institutions, especially under climate uncertainty. Using four Colorado basins, Loos et al. (2022) show that governance changes gradually through shocks, path dependence, and collective action, as users move from resisting regulation to self-regulation. Studies of Colorado, for example, demonstrate that local water users may shift from individual coping strategies to collective action and, in some cases, to self-regulation when scarcity becomes severe and the costs of uncoordinated use rise. These findings support reading the Asir Highlands case as part of a broader historical pattern in which community-based institutions emerge to manage common-pool water resources under environmental stress.

7. CONCLUSION

The traditional water management systems of the Asir region constituted, over the centuries, a profound and integrated historical experiment in managing water resources, distinguished by their efficiency and their capacity to adapt to the environmental and climatic conditions of the area. These accumulated experiences demonstrated the

ability of local communities in Asir to attend to their environment across multiple domains, while developing organisational and technical arrangements that played a central role in sustaining water resources, securing food supplies and confronting periods of crisis.

The study has shown that these experiences were not merely ad hoc or spontaneous initiatives, but rested on human capacities, clearly articulated social norms and locally embedded regulatory practices that organised irrigation with both efficiency and equity, while maintaining sufficient flexibility to adapt to changing circumstances. These factors underpinned fair and prudent use of water resources.

The findings further indicated that the principles and practices of these traditional irrigation systems intersect in significant ways with contemporary concepts and experiments in integrated water resources management and environmental sustainability. This convergence underscores the potential for investing in historical experience and goes beyond conventional descriptive historiography.

The study reveals that Asir's traditional water systems were grounded in a set of key organisational principles, including decentralised resource management, justice in distributing water operationalised through rotational irrigation schedules, community participation in the maintenance of water sources, the availability of customary mechanisms for dispute resolution and flexible regulatory rules responsive to climatic variability. These principles enabled local society to manage scarcity and emergencies with notable effectiveness, to achieve a high degree of water and agricultural sustainability, and thereby to reinforce food security.

The significance of this historical experience lies in its provision of a concrete example of managing scarcity through decentralisation and community-based governance, which lends it explanatory value in current debates on water security and sustainability. The study thus

underscores the role of environmental history combined with common-pool resources theory within Saudi historical studies, by transforming historical knowledge from a purely descriptive corpus into an analytical tool with contemporary policy horizons.

The analysis also highlights the importance of integrating historical knowledge with modern instruments in the formulation of contemporary water policies. Traditional experiences can offer both a scientific and ethical foundation for developing sustainable water management in the Kingdom of Saudi Arabia, particularly through organisational principles that may inform the design of context-sensitive water policies, on the condition that they are treated as historical experiences open to analysis and critical appropriation, rather than as models to be transferred mechanically to the present. In this sense, they can be incorporated into current plans and policies in light of scientific knowledge and modern technologies, and through their gradual integration into institutional and legislative frameworks that remain attentive to regional specificities and constraints.

Within this perspective, there are clear opportunities for alignment between historical practices and contemporary governance, including the delineation of private and public water rights, the regulation of flow paths, catchment areas and drainage channels, the utilisation of runoff from terraced fields, the construction of small-scale barriers and diversion canals between farms, the equitable distribution of water and the promotion of efficient, just patterns of consumption. Such an approach can support the development of public policies for water governance that incorporate the human dimension and the accumulated traditions of ethical-social regulation. Accordingly, historical knowledge of traditional water practices in Asir should not be seen as a mere record of the past, but as a scientific foundation that can help to shape water policies that are more sustainable and more firmly anchored in local social and environmental realities.

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