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ANCIENT IRRIGATION CIVILIZATION OF ARABIA FELIX (YEMEN): CULTURAL HERITAGE, HISTORICAL CULTURAL GEOGRAPHY, TOURISM DEVELOPMENT

Abstract: Historical geography remains a pertinent scientific discipline. The aim of this paper is to conduct a historical and geographical analysis of Yemen's irrigation systems, investigate disparities in reservoir systems across different regions, and identify prospects for the development of cultural and educational tourism in the republic. The history of irrigation in Yemen spans many centuries. Yemen harbors the greatest density of cultural and historical monuments compared to all other Middle Eastern states. Many structures have preserved their original appearance, while select sites and attractions carry global significance, earning recognition as UNESCO World Heritage properties. Spanning millennia, anthropogenic hydrotechnical developments have indelibly affected the history and culture of various societies. Particularly notable are Yemen's unique hydrotechnical infrastructures, which gave rise to a distinct model of water management and urban organization. Foremost among these are the iconic Ma'rib Dam, the reservoir network in Aden, and extensive canal systems supplying consistent water access in the harsh semi-desert environment. The historical significance of Yemen's hydrotechnical structures cannot be overstated. This innovative design facilitated intense agricultural productivity, transforming arid Yemeni lands into verdant farmlands. Beyond their utilitarian value, these installations performed critical cultural roles. Construction projects symbolized authority and prestige for ruling dynasties, serving as epicenters of communal life, gathering points, and commercial hubs. Consistent placement near residential areas and sacred sites formed cohesive urban layouts. Presently, Yemen's hydrotechnical structures acquire fresh significance as cultural heritage and drivers of tourism. However, protecting this legacy presents daunting challenges. Many structures suffer from dilapidation, urgently needing repair and renovation. Added complications arise from natural calamities, political turmoil, and inadequate financial allocations for monument preservation. Urgency underscores the need for protective measures, considering their immense scientific and cultural worth. Yemen possesses substantial potential for tourism due to its rich and unique tourist attractions, captivating landscapes, and ecological diversity.

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rarely found elsewhere globally. This study aims to outline the historical progression, current state, and primary trajectories of Yemen's tourism sector. Drawing upon secondary data including research studies, e-books, articles, reports, and websites highlighting specific features of Yemen's tourism industry, it establishes that Yemen holds vast opportunities for diverse forms of tourism. However, despite this promising outlook, achieving meaningful success in the tourism domain requires additional critical factors beyond mere potential—factors currently lacking in Yemen, particularly political stability and heightened awareness regarding tourism promotion.

Keyword: Cultural heritage, Arabia Felix, Yemen, irrigation, historical cultural geography, history, Marib Dam, tourism

Introduction

Historical geography represents a contemporary geographic field focused on investigating physical, socio-economic, cultural, and political geographies of past epochs through historical dynamics. Its primary tasks involve locating historical events and geographic objects within previous eras. Historical geography examines the dynamic shifts in internal and external boundaries of states along with their administrative divisions, spatial distribution and topography of cities, towns, villages, fortresses, monasteries, and other settlements, identification of transportation networks and trade routes in historical contexts, mapping historically significant geographical expeditions, voyages, and navigations, determining routes of military campaigns, battlefields, uprisings, and other pivotal historical occurrences (Bergmann, 2024; Maw & Seo, 2024; Legg et al., 2025).

It is well established that cultural geography sets forth practical objectives related to designing and implementing strategies aimed at conserving cultural heritage. This discipline assumes a central function in accumulating and utilizing cultural capital to safeguard identity and foster national development. Having crystallized as a specialized branch of socio-economic geography, cultural geography explores spatial and cultural distinctions across Earth's regions, characterizing geographic spaces according to their unique cultural attributes. General trends suggest that cultural geography constitutes an interdisciplinary research domain necessitating broad interpretation within extensive historical and cultural frameworks (Nautiyal et al., 2025).

There exist various definitions of historic-cultural tourism; however, according to prominent modern approaches, cultural tourism can be defined as the movement of individuals outside their usual place of residence, motivated entirely or partially by interest in visiting cultural sites encompassing cultural events, museums, historical locations, art galleries, musical and dramatic theaters, concert venues, and places representing local residents' traditional leisure activities. These destinations reflect historical heritage, contemporary artistic creativity, performing arts, traditional values, activities, and daily lifestyles of inhabitants. Cultural tourists seek new information, experiences, and impressions to satisfy their cultural needs (Zheng et al., 2025). In today's globalized society, cultural tourism plays a crucial role in fostering moral and educational unity among humanity. It contributes significantly towards promoting tolerance, respect, acceptance, and accurate understanding of the rich diversity of cultures worldwide. Through exposure to different traditions, customs, and heritages, cultural tourism enhances mutual appreciation and recognition of shared human values while celebrating differences (Lukoseviciute et al., 2024). Travel inherently entails intercultural interaction, facilitating exchanges between individuals from distinct societal backgrounds and enabling mutual comprehension and enrichment

through encounters with diverse cultural norms, languages, and traditions (Liao et al., 2025).

A fundamental component of cultural tourism is cultural heritage itself, serving as an object of investigation within cultural geography - a discipline exploring territorial differentiation of culture and its individual elements. Geography of cultural heritage constitutes one of several key sub-disciplines within this broader framework. The significance of cultural heritage preservation for Yemen can be summarized as follows: Retention of Identity: Cultural heritage sites embody the unique identity of Yemeni peoples and serve as invaluable assets essential for the country's recovery and sustainable development. Support for Traditional Crafts: Maintaining traditional crafts not only preserves cultural heritage but also carries economic significance by providing local communities with income-generating opportunities. Promotion of Tourism: Exposure to Yemen's unique historical legacy and traditional culture attracts tourists, fostering tourism development and garnering international attention. Preservation efforts honor legacies of preceding generations while yielding educational, social, economic, and environmental benefits for present and future populations alike (Liu et al., 2025).

The essence of cultural-cognitive activities lies in the fact that, during travels, individuals gain self-awareness and understanding of nature, acquiring knowledge about historical, cultural, and ethnic realities. Additionally, visiting diverse countries fosters affirmation of tolerance, as individuals observe that other races, religions, and nationalities do not diverge significantly from their customary social circles. The ultimate goal of cultural-cognitive tourism for individuals is to obtain knowledge about a specific cultural-historical space and its inherent traditions, lifestyle characteristics, etc. Moreover, cultural-cognitive tourism allows not only the accumulation of knowledge but also the acquisition of invaluable experience through encounters with people belonging to different cultures. Ultimately, this approach facilitates the formulation of one's own value system and priorities.

Cultural tourism provides an opportunity to comprehend interpretations of cultural artifacts, gain insight into local culture, and establish connections with the inhabitants' cultural identities (Wu et al., 2025). Cultural tourism encompasses journeys centered on experiential engagement designed to fulfill cultural needs through acquisition of knowledge and sensations derived from visits to museums, cultural heritage sites, festivals, and culinary landmarks (Tang et al., 2023).

The role of cultural cognition tourism in human development encompasses the following aspects: Self-awareness and understanding of nature - During travels, individuals explore historical, cultural, and ethnic facts. Affirmation of tolerance: Visiting diverse countries demonstrates that races, religions, and nationalities do not differ fundamentally from one's accustomed social circle. Intercultural dialogue: Travels entail intercultural communication, stimulating personal and societal growth. Accumulation of socio-cultural experience: Acquired through encountering unique cultural, historical, and value systems of visited regions. Development of value systems and priorities: Individuals encounter the world, drawing conclusions influencing their lives, behaviors, and actions in specific situations. Additionally, cultural cognition tourism influences all spheres of societal activity, driving advancements in culture, economics, and social life.

Furthermore, it promotes cultural flourishing by enhancing respect for diverse cultures and may lead to preservation, revitalization, and sociocultural transformations (Liu et al.,

2022). Consequently, cultural tourism is inextricably linked to the developmental level of local communities, manifested through their cultural sophistication and prevailing lifestyles (Zheng et al., 2025).

The concept of cultural heritage has gradually transformed and expanded alongside changes in the definition of culture, evolving from traditional perceptions focusing solely on literature and art to embrace a broader perspective incorporating diverse lifestyles, fundamental human rights, value systems, traditions, and others. Initially, cultural heritage referred exclusively to immovable historical, cultural, and natural monuments possessing exceptional significance for the globe, nation, or region.

Pursuant to the 1972 UNESCO Convention concerning the Protection of the World Cultural and Natural Heritage, cultural heritage refers to architectural works, monumental sculptures and paintings, elements or structures of archaeological significance, inscriptions, caves, and collections of items that demonstrate outstanding universal value from historical, artistic, or scientific perspectives. Additionally, cultural heritage encompasses: Ensembles: Groupings of isolated or connected buildings whose architecture, coherence, or link to the surrounding landscape display outstanding universal value in terms of history, art, or science; Outstanding sites: Creations of human endeavor or collective efforts combining human intervention and natural formations, as well as zones containing archaeological sites, exhibiting outstanding universal value regarding history, aesthetics, ethnology, or anthropology.

As stated in the United Nations Charter “In Support of Culture” ratified in June 1997 in Salonika, heritage includes all tangible and intangible components, both natural and cultural. Besides museum-conserved cultural relics, active aspects of ethnic life (ancient technologies, special modes of action, traditions) are also included under cultural heritage. From this standpoint, heritage reflects historical interactions between humankind and nature. Heritage constitutes a segment of the cultural landscape of any given territory, shaped by influences such as ethnicity, economy, history, geography, and other factors. Unique regional traits emerge under the influence of geographical location, natural peculiarities, similar historical fates, reflecting interactions among ethnic groups and formation of isolated local cultures. Regional cultural heritage should be regarded as a historically evolved system intended for monument conservation, forming an integral and significant aspect of national cultural wealth, encapsulating distinctive elements defining indigenous regional culture (Groizard & Santana Gallego, 2018).

Located in the southwestern part of the Arabian Peninsula, the Republic of Yemen ranks among the most ancient countries boasting a rich historical background. Yemen's cultural heritage, accumulated over millennia, incorporates ancient cities, architectural masterpieces, and traditional culture. Nonetheless, recent years marked by political and social challenges have constrained the growth of socio-cultural infrastructure within the country. Yemen's geographical and climatic diversity profoundly affects the breadth of its architectural styles. Renowned for its vibrant cultural legacy encompassing traditional music, dance, craftsmanship, and folk art, public centers serve as platforms for organizing cultural events, exhibitions, concerts, and festivals. Despite the presence of abundant socially-geographic, economically-geographic, historiocultural, archeohistoric, architecturally-artistic, religious, and other forms of heritage, certain regions exhibit incomplete development of the tourism industry. Moreover, not all these sites hold official designations as cultural heritage assets, although many could qualify for inclusion in registers, even if locally

restricted. Currently, tourism ascends to become one of the foremost sectors in the global economy. Despite harboring immense touristic potential, Yemen maintains a modest standing in the global market, especially within the realm of cultural tourism. Recreational resources make a substantial contribution to Yemen's overall tourist appeal, with archaeological monuments, ancient architectural structures, and natural attractions assuming a pivotal role. Empirical observations reveal that regions featuring UNESCO World Heritage Sites tend to exert the greatest magnetic pull on tourists, gaining widespread acclaim (Giumlia-Mair et al., 2000).

As of 2023, the Republic of Yemen officially lists five properties designated under the World Heritage List ("Yemen". UNESCO World Heritage Centre. Archived from the original on 27 October 2005. Retrieved 4 September 2022):

Old Walled City of Shibam (Hadhramaut, 1982) - The fortified city of Shibam from the 16th century is situated on the edge of a vast wadi that runs between mountains along an important caravan trade route. The city features several multi-story mudbrick houses, representing one of the earliest examples of high-rise urban planning. It also serves as a remarkable example of traditional Hadrami architecture dating back to the 16th through 19th centuries. Flooding poses a significant threat to the city's preservation due to the gradual deterioration of traditional water management systems. Additionally, the installation of modern water supply infrastructure with inadequate drainage and changes in livestock management have further exacerbated the condition of the city. Since 2015, this site has been at risk of disappearing owing to threats associated with the ongoing civil war in Yemen.

Historic Town of Zabid (Sanaa, 1986) - Sana'a has been inhabited for over 2,500 years and played a pivotal role during the early years of Islam. Its Great Mosque was among the first mosques constructed outside Mecca and Medina, making it one of the original centers for the dissemination of Islamic faith. The walled city comprises numerous traditional multistory buildings made from rammed earth and baked bricks, adorned with decorative brickwork and white gypsum patterns. However, these architectural treasures are threatened by new constructions and inappropriate conservation methods.

Historic Town of Zabid (Al Hudaydah, 1993) - Zabid, a coastal town located in Yemen, served as its capital from the 13th to the 15th century. Fortified with four gates, watchtowers, citadel, and remnants of defensive walls, Zabid emerged as a significant center of learning during the early Islamic period starting from the 7th century onwards, featuring numerous mosques and madrasas. Architecturally notable is its inner courtyard design characteristic of the Tihamah style typical of southern Arabia's coastline. However, contemporary challenges such as concrete and steel structures alongside overhead electrical cables jeopardize its historical integrity. Since 2000, the site has faced imminent peril due to the deteriorating state of historic edifices.

Socotra Archipelago (Socotra, 2008) - The Socotra Archipelago consists of four islands and two rocky islets. Both terrestrial and marine environments exhibit exceptional biodiversity. The archipelago hosts numerous endemic plant species, including *Dracaena cinnabari*, as well as endemic reptiles and land snails. Populations of both terrestrial and seabirds inhabit the islands, while coral reefs within the surrounding waters support diverse fauna, encompassing various fish species, crabs, lobsters, and shrimp.

Landmarks of the Ancient Kingdom of Saba (Marib, 2023) - Marib served as the central hub of the Sabeen Kingdom, potentially overlapping with the Sheba Kingdom. This kingdom controlled substantial incense trade across the Arabian Peninsula and played a crucial role in cultural exchange with regions around the Mediterranean Sea and East

Africa. Monuments dating from the first millennium BCE up until the advent of Islam circa 630 CE include the Bar'an Temple, Awam Temple, ancient Marib City, Old Ma'rib Dam, and the ancient settlement of Sirwah. Due to immediate threats posed by the ongoing civil conflict in Yemen, this site was promptly listed as endangered. The aim of this paper is to conduct a historical and geographical analysis of Yemen's irrigation systems, investigate disparities in reservoir systems across different regions, and identify prospects for the development of cultural and educational tourism in the republic.

Material and Method

A systematic review of peer-reviewed journal articles, online publications, historical photographs, monographs, and books was conducted using combined scientometric and content analysis methods based on extracted data from selected studies. The research employs several methodological approaches to achieve a documentary-historical approach, descriptive approach, and comparative analytical approach. This study adopts rigorous methodology to examine the preservation of cultural heritage and its implications for sustainable development in Yemen, emphasizing the potential application of cultural heritage for sustainable tourism advancement in the republic.

Geography of Yemen's irrigation systems

“Arabia Felix” the ancient designation for the southern portion of the Arabian Peninsula, was employed by Romans to describe what is presently known as Yemen (Fig. 1). The term translates to “happy, fortunate, blessed”, as well as “fertile, fruitful”. Arabia Felix constituted one of three regions into which the Roman Empire divided the Arabian Peninsula. Traditional irrigation systems represent ancient, sophisticated hydro-social systems embedded within intricate networks of socio-technical and ecological interconnections that have endured for centuries (Weerahewa et al., 2023). Traditional irrigation systems have persisted across centuries worldwide, spanning Central Europe, Mediterranean regions, Africa, Asia, and the Americas. These systems draw upon methodologies originating from ancient civilizations, exemplified by those in Mesopotamia, the Near East, Monsoon Asia, and Peru's Andean mountains (Leibundgut, Kohn, 2014). Traditional irrigation systems confront threats associated with rural desertification, climate change, and inadequate maintenance. These systems rely on generational transmission of knowledge and adaptive practices tailored to local ecological, social, and economic conditions. In Africa, traditional irrigation supports rainfed agriculture but faces degradation risks typified by phenomena such as kettaras (Branco et al., 2025; Kahimba & Maluka, 2025).



Fig. 1. Arabia Felix (Arabie Heureuse, Yemen) map, 1787, by a Frenchman Clouet, J. B. L.

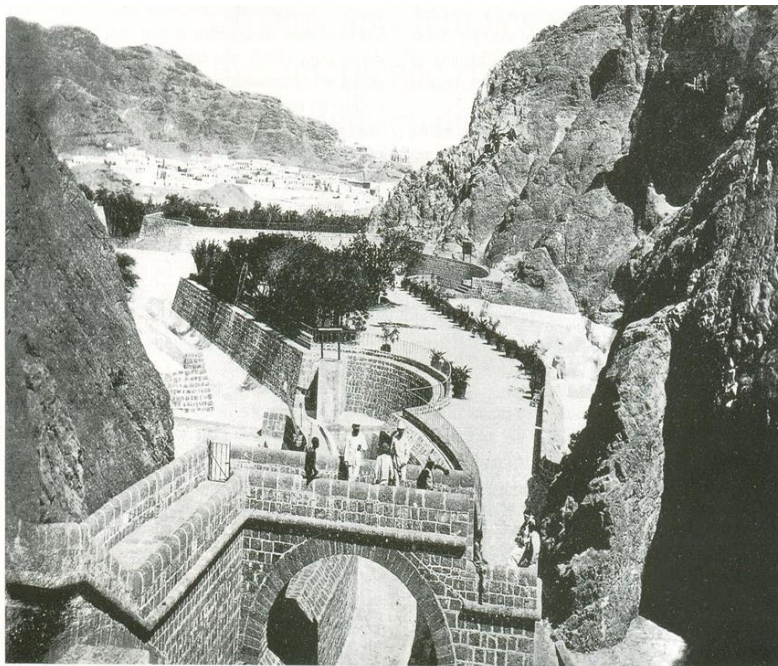
Source: Jean-Baptiste Louis

Traditional irrigation systems offer valuable insights and lessons relevant to contemporary water resource management in agriculture, thus requiring comprehensive understanding across multiple disciplines, including geography, hydrology, hydraulic engineering, water law, institutions, and socio-political dimensions. Specifically, comprehending traditional irrigation systems demands incorporation of intangible heritage embodied in historical practices, localized expertise, and traditional ecological knowledge (Martínez-Sanchis & Viñals, 2015).

Yemen is one of the oldest agricultural civilizations as evidenced by archaeological excavations, remnants of irrigation structures and terraces. The history of irrigation in Yemen is very ancient. Archeological evidence shows that irrigation was practiced in Yemen in 3000 BC and that the cultural and economic prosperity of the area is directly linked with the development of irrigation. There are widespread remains of ancient irrigation installations still to be seen all over the Yemen. Together with the ancient Sabaen engravings - which illustrate surprising agricultural prowess - they stand as evidence of the technical achievement of those days. These works helped to achieve significant agricultural development and transformed the Yemen into green land with rich orchards; at this time it became known to those who lived there as Arabia Felix.

Yemen is a water-scarce country, situated in an arid region with no permanent rivers. Historically, the population depended upon rainfall, springs, hand dug wells and water harvesting in ponds, and behind dikes and dams of various sizes. Maximum well depths didn't exceed few tens of meters and their water was lifted, in small quantities, by muscular, animal or human effort. This water scarcity gave water a prominent role in shaping Yemeni consciousness and civilization throughout history. The Mareb dam is one symbolic example of this vital role of water, another example being the mountain terraces. These terraces, which cover most Yemeni mountains, are in fact water-harvesting structures innovated by Yemeni farmers to retain scarce rainwater along with the precious fertile soil that sweep down the barren mountain-sides. The designing and construction techniques of these terraces are a clear testimony to Yemeni ingenuity.

Yemen's cultivatable lands and rural population have been dependent for generations on scarce and unreliable rainfall. As a result, Yemeni farmers have developed great skills in water harvesting, water storage, and spate irrigation. They also developed techniques to divert the sudden and violent flows of seasonal rains towards cultivated lands, and also to protect their homes and fields from flood damage. They used original methods of conserving water, as it is by the Aden historical tanks. This impressive group of 18 tanks with a total capacity of 90 million l. of water is to be found in the district of Crater city in the middle of a garden in the Al-Taweela wadi. The garden itself is a strip of earth 229 meters long. Archeologists consider that the tanks date back to the first century A.D., and that they were built during the reign of the Hamyar Dynasty. The majority of them were carved out of the solid rock. They were dug into a sloping site and connected to one another by means of channels running along the wadi (Fig. 2). Hand in hand with these skills went an excellent understanding of the ecological imperative of soil and water management for sustainable basic food production.



The Aden tanks in 1888; photograph by the [Austrian] Imperial and Royal Embassy to Siam (Museum für Völkerkunde, Vienna).

Fig. 2. Aden/Crater historic water tanks, Yemen

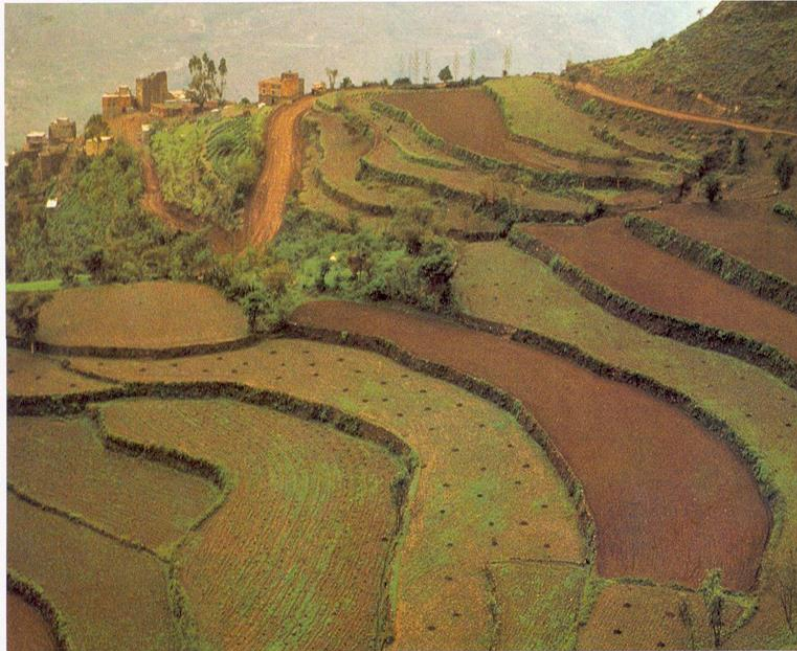
Source: http://alamree.net/aden_39_022.htm

Tawila Cisterns, alternatively known as Tawila Reservoirs, stand as the most celebrated historical site in Aden, Yemen. The complex consists of a series of differently-shaped and sized reservoirs interconnected with one another, situated in Wadi Tawila southwest of Crater, Aden's oldest district. Originally housing roughly fifty-three reservoirs, following reconstructions - including British-led interventions in the nineteenth century - only thirteen survive today. Carved out of volcanic rocks native to Wadi Tawila, the reservoirs were lined with a uniquely formulated concrete enriched with volcanic ash, creating durable cement impermeable to water over extended durations. Visitors often express surprise at the

inscription accompanying the Koglan basin reading: "Regarding the original structure, little definitive information exists..." Indeed, credible documentation regarding the origins of these reservoirs remains scarce. One hypothesis posits that Himyarites, pre-Islamic rulers governing parts of Yemen from 115 B.C.E. until 525 C.E., initiated construction in this area, eventually giving rise to the Tawila reservoirs. Known for their use of water-retention systems in other territories under their dominion, the Himyarite connection appears plausible. Following Islam's introduction to Yemen in the seventh century, textual accounts sporadically reference the reservoirs. Al-Hamdani, writing in the tenth century, noted: "Aden contains reservoirs where rainwater is stored". Three hundred years later, Al-Maqdisi similarly documented the presence of wells and cisterns in Aden. By Rasulid Dynasty rule (1229-1454 C.E.), deterioration had set in, though the Rasulids acknowledged the utility of the reservoirs and commenced restoration efforts. Some attribute the reservoirs' establishment to the Rasulids, obscuring their probable deeper historical roots. Post-Rasulid decline saw reservoirs succumb to neglect, flood-induced erosion, and debris buildup. Today, the Tawila Cisterns primarily function as a public park and tourist attraction, having been unfilled for at least fifteen years and contributing no potable water to the city.

Beyond the crescent-like chain of Yemeni mountains and plateaus extending north-to-south from Najran to Hadhramaut lies an expansive plateau. Here, sand dunes alternate with rocky plains, and monsoonal rains occur infrequently and unpredictably, hindered by the mountain ranges farther westward. This area is impossible to cultivate, except in the few places where seasonal wadis and water courses from the mountains come down into the plain. Only nomads dwell there, for ever threatened by famine, constantly fighting over the limited resources of the area. And yet it was there, in a region which is by no means one of the more favourable areas of the Yemen that ancient civilization emerged and developed.

Throughout its history, Yemen has been renowned for relatively plentiful precipitation compared to the rest of the Arabian Peninsula, leading to its ancient appellation as "Arabia Felix" Nonetheless, in light of general geographic conditions, this quantity of rainfall is frequently overestimated. Adequate annual precipitation occurs predominantly on western and southern slopes of the Yemeni mountain range (Rappold, et al., 2003). Topographic energy in the Yemeni highlands is pronounced, except for High Plains, where productive farmlands are sparse. Despite these constraints, it seems not to impede agricultural activities. Pure rain-fed agriculture is feasible only in limited areas. Most agricultural systems rely on supplementary irrigation or alternate methods to compensate for scarcity of rainfall. The aforementioned conditions impose restrictions on agriculture in mountainous regions: high susceptibility to erosion; slope-specific characteristics allow cultivation of small plots demanding substantial maintenance effort; insufficient precipitation for agricultural yield in average years; high variability in rainfall quantities. These limitations give rise to the splendid design of terrace landscapes characteristic of Yemen: terraces providing agricultural fields; terraces acting as erosion prevention systems; terraces functioning as sediment retention systems (Fig. 3).



Terraced fields in the region of Beni Maṭar.

Fig. 3. Terraced fields, Yemen

Source: Al-Ghulaibi, 2004

At the same time the mountainous region of Yemen was quite densely populated. People there based their economy on rain fed agriculture sustained by the higher rainfall of the mountains. In order to profit from rainfall, people had to level their fields so that the precious water drops were retained in the soil, and that the rain did not wash the soil away in the rugged landscape. Where the amount of precipitation required was certain, collector fields were prepared to harvest water for the prepared arable land. In this way, especially in the Himyarite period, a second man-made landscape was shaped. As every farmer in the lowlands knows, the terraces in the highland are the best insurance against disastrous flash floods in their region.

The Sabaeen irrigation of Yemen

Scientific literature illustrating links between irrigation, agricultural intensification, food security, nutrition, rural incomes, employment, and economic growth emerged several decades ago and continues to expand. Irrigation is identified as a catalyst for agricultural transformation in developing nations, particularly in arid and semi-arid climates. Amidst increased climate variability and corresponding fluctuations in water availability, irrigation has assumed greater importance in the present era than ever before. Utilization of irrigation infrastructure in agriculture likely dates back nearly as far as ancient civilizations themselves, with antiquated irrigation systems sustaining local communities through agricultural intensification and diversification, risk dispersion, extended growing seasons, improved dietary intake, and enhanced living standards (Timsina & Weerahewa, 2023).

Irrigation systems employing cascade arrangements of village reservoirs in Sri Lanka exemplify artificial irrigation schemes relying on rainwater capture. Variations of such systems, including small ponds, reservoirs, canals, channels, and farmer-storage units, are prevalent in numerous other countries. Similarly, groundwater-based systems such as qanats, karezes, and falaj systems, along with floodwater-harvesting mechanisms like overflows, depressions, and flooding practices, are extensively employed in Western and Central Asian and African nations. Nevertheless, global climate change occurring over the last half-century, notably intensifying in recent decades, imposes differential impacts on these artificial irrigation systems worldwide (Timsina & Weerahewa, 2023).

User-managed irrigation systems constitute the foundation for accessing water resources necessary for agricultural production and other uses in many rural communities worldwide. Throughout millennia, user-governed irrigation systems have sustained agricultural output and livelihoods in rural settings, ensuring reliable water provision allowing extension of cropping seasons, double or triple yields, and cultivation of crops otherwise untenable under rainfed conditions. These systems have been constructed and operated across virtually all climatic and geophysical environments globally. Illustrative examples include floodplain irrigation and qanats in Middle Eastern and Mediterranean deserts; mountainous irrigation systems in European Alps, Himalayas (Asia), Andes (Latin America), Rocky Mountains (North America), and Kili slopes (Africa); lowland valley irrigation (bas-fond and dambos) in Sub-Saharan Africa; tank-based systems in India; and flood control-driven irrigation in fertile deltas of major river systems worldwide (Hoogesteger et al., 2023).

Throughout centuries, agriculture has relied on both natural and man-made bodies of water, such as lakes, reservoirs, ponds, khals (elongated water bodies), and analogous constructions for water accumulation. Coastal zone livelihoods heavily depend on these forms of natural capital. Reservoirs essentially represent small-scale water basins composed of earthen walls designed for collecting and storing water for subsequent utilization. Typical reservoir systems comprise embanked dams or barrages, feeding channels for conveying runoff from adjacent catchment areas, sluice gates for regulating outflow, and distributive canals directing water onto cultivated fields. These ancient irrigation systems played a pivotal role in water conservation to meet varied requirements of rural communities over centuries (Jana & Tamang, 2023). Traditional water-harvesting systems (reservoirs) are intrinsic to agricultural development and sustainability of rural communities. The purpose, benefits, users, and stakeholders of reservoirs vary depending on the region, resulting in differing priorities across various geographical areas (Ratna Reddy et al., 2018).

There has never been a time when, in arid and semiarid zones like Yemen, a civilization could have existed without an efficient irrigation system, and more often than not, the historical development of such a civilization was inextricably linked with the fortunes of the irrigation system that sustained it. The decline of the state could mean the end of the irrigation system, just as a sudden disturbance of the water balance could cause its failure and, consequently, put the whole civilization at risk. In some sophisticated ancient civilization, such as Egypt and Mesopotamia, river flowing all the year round provided an abundant supply of water that could be easily distributed over a large area with the help of an intricate network of supply canals. The inhabitants of Yemen, on the other hand, have always had to rely on the periodical monsoon rainfalls for the water they needed for their existence. Twice a year, as a rule, the water from these copious, but brief downpours had to be collected, and

channeled through an efficient irrigation system. This effort called for a rational concept, a superior degree of planning and co-ordination, and a highly developed technology; and even then success ultimately depended on the strict organization not only of the state, but also of municipal affairs, as in most cases it was the town that played a leading role when such schemes were put into practice.

Mareb was the old capital of Saba, and the area which the Holy Koran refers to as the “Good Country”. The history of the early Yemeni Civilization began in this land. Here the famous old Mareb Dam was built which was a miracle of that civilization. Mareb is situated 175 kilometers east of the Capital City of Sana’a on the Saba plain which overlooks the desert. Mareb is mentioned in many history books, which praise its history and significant events. Mareb was the Capital of Saba for many centuries. History indicates that the civilization of the Saba valley played a major role in proposing the “idea of the dams, and developing the irrigation system in the dry valleys”. Most of the old historical symbols of Yemen are linked with this area (Fig. 4).

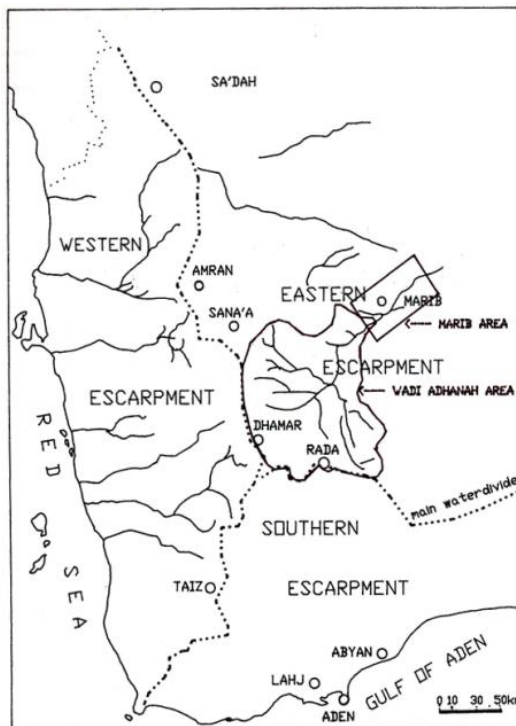


Fig. 4. Location of the Mareb area, Republic of Yemen

Source: Ministry of oil and mineral resources & TNO Institute, 1993

The emblem of Yemen prominently features an image of a dam positioned centrally on the shield (Fig. 5). This representation specifically depicts the Marib Dam accompanied by seven blue wavy stripes beneath it. Complementing the dam illustration is a coffee tree symbol, signifying Yemen's fertile terrain and its association with coffee culture. The ancient city of Marib, once thriving as the capital of the Sabeian Kingdom, owed much of its prosperity to this coffee tradition. Notably, references to the destruction of the Marib Dam

in the sixth century CE are documented within the Holy Qur'an. Water, described metaphorically as Allah's blessing bestowed upon the Sabaeans, enabled them to construct a massive dam amidst the barren Yemeni desert, facilitating the retention of seasonal waters and transforming the region into fertile lands and gardens. This marvel of engineering, however, served as a reminder that prosperity hinges upon adherence to divine laws, as chronicled in the Quranic narrative (Sura Saba', verses 34:15-16).



Fig. 5. The coat of arms of Yemen (left) and a shield depicting Marib Dam (right)

Source: https://commons.wikimedia.org/wiki/File:Emblem_of_Yemen.svg

The great Sabaean creations of religious architecture and masterpieces of sculpture bear witness to a highly developed culture; numerous inscriptions tell us of their intellectual and spiritual life, and inform us about the way the state and its legal system were organized; and still other historical sources bear clear evidence of the political and economic importance of the country. Legendary city of the Queen of Saba, metropolis of the kingdom, Mareb, in a short space of time, had grown from an early settlement into a capital with a world wide reputation, acclaimed by Greek and Roman geographers and historians, such as Strabo, Pliny, etc. People everywhere heard about the city's affluence, a fact that repeatedly exposed it to enemy attacks. In 24 B.C. the Emperor Augustus decided to incorporate Mareb into the Roman Empire, and ordered his general Aelius Gallus to take the city; but the campaign was a failure, the Roman troops were forced to retreat. Saba stood firm against the Romans, and Mareb proved unassailable.

The enormous revenues accruing from the control of the trading routes and making the kingdom both rich and powerful, were not sufficient to create a living space for the country and its capital. What was needed was an ecological base, to be brought about by an agriculture that, in its turn, had to rely on irrigation system which, in the course of their development, reached almost unequalled perfection. Nearly the fourth part of the total of precipitations in the Yemeni highlands was transformed into a whole network of dams and irrigation plants, consistent and, down to the last detail, carefully planned. Sabaean society thus created a technology that found its expression in installations of such perfection that only our highly mechanized century has been able to produce structural devices which are roughly comparable in ingenuity.

First historical sources, dating from the 8th/7th centuries B.C., mention the construction of an irrigation plant. The famous Mareb dam, and the sluices which were part of it, still extant today, were built in the 6th century B.C., and, for the duration of a millennium, the increasingly complex system of installations was in operation. The beginnings, however, of water conservation and distribution go back much further. The oldest extant proof of the existence of a firmly established and technically already very advanced irrigation plant are

some massive dams and sluices, built in the 3rd and 2nd millennium B.C. The topographical character of the area, its natural geomorphologic conditions, must have suggested such a scheme. The purpose of the dam was not to store water for a long time, but to divert the flash floods course for irrigation. If the dam were built for holding water over a long period of time, its storage capacity would have decreased gradually due to the accumulation of silt, stones and deadwood. The amount of matter carried by flashfloods every year is estimated at 2.5 million cubic meters (Fig. 6).

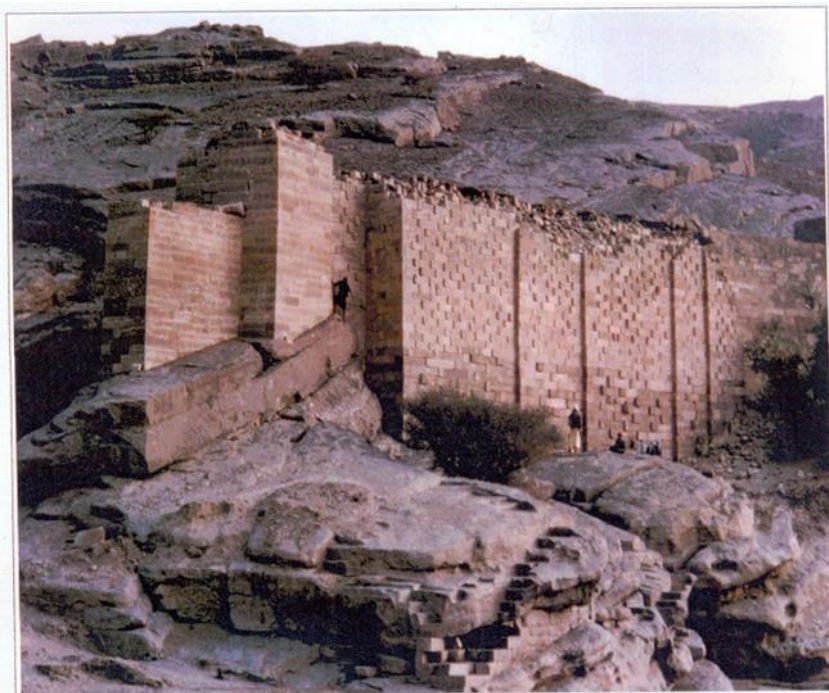


Fig. 6. The sluice gates of the ancient Mareb Dam, Yemen

These natural conditions, right from the start, encouraged irrigation farming in the area around Mareb, and facilitated the construction of huge water inlets on natural rock formation and lava rocks, which could be used as dams. As cultivation under rain was an obvious non-starter, farmers had to rely on the water flowing down the wadis, from the hills to the desert plain of the Rub al-khali. The catchments basin of the Wadi Adhanah, which has its outlet near Mareb, measures about 10,000 km² and is easily the largest in the Yemen highlands. To the west it stretches as far as the watershed east of Sana'a and Dhamar and is fed by countless small, even minute wadis, which flow into larger wadis that, in their turn, join the main course of the Wadi Adhanah. Where the Wadi Adhanah narrows, between the mountain ranges of Gabal Balaq al-Ausat and Gabal Balaq al-Qibli, and enters the eastern lowlands of Ramlat as-Sabatayn, the strip of land merging into the Rub al-Khali, huge turbidity currents caused a problem that early hydraulic engineering was unable to solve (Fig. 7).

The earliest agriculture practice was to sow the seeds directly in the wadi bed, as soon as the sayl-flood had drained away, may be safely assumed, even though we are still lacking the archeological evidence to prove it. The next step must have been to regulate the irrigation of cultivable land by diverting part of the sayl-flood with the help of primitive barriers

consisting of earth piled up in the wadi course, and by distributing the water over the flood plain of the wadi. This, too, we have to conjecture from examples of recent practice still followed in wadi valley today (Fig. 8). The earliest archeological material of any use to us in this context are several constructions, made of ashlar, on the periphery and in the middle of the wadi. Lack of expertise in hydraulic engineering at first ruled out the possibility of closing the wadi at its narrowest point and building a barrier across the watercourse. Avoiding the danger zones in the gorge of the valley, builders opted for erecting barrages and regulating sluices further downstream, in an area where the water was already flowing more calmly.



Fig. 7. Spate irrigation satellite image in Mareb area, Yemen

Source: Voogt, et al., 2007; Pelgrum, et al., 2009

The solid structure, the high standard of workmanship, and the extremely clever choice of the sites indicate that, even at that early stage, there existed a highly sophisticated system of water conservation and distribution probably preceded by a long tradition; and, indeed, sedimentary deposits prove that the history of irrigation must have started as early as the 3rd millennium B.C.

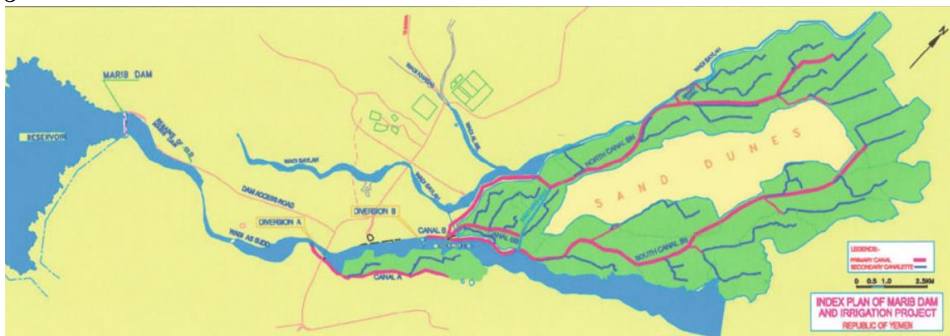


Fig. 8. Marib Dam and irrigation project. Plan of the Marib irrigation scheme, showing location of the main dam, diversion structures A and B, and main canals A, B, BN, BB, and BS

Source: Chakraborty, 2012

In the area between Gabal Balaq al-Qibli and Mareb we only find silt deposits not containing any rock particles, a clear indication that irrigation was functioning perfectly smoothly. Although massive deposits allow the archeologist to spot only isolated instances of prehistoric and early irrigation practice, not a coherent picture, it is obvious that the specimens dating from the 3rd millennium B.C. and from the following centuries are part of a system which had already outgrown the early stages of irrigation by water deflection, and become a system of its own, conceived on a large scale. Approximately 1900 m south-east of the big Mareb dam, at the foot of Gabal Balaq al-Ausat, there is a large complex of early constructions, which occupies an area measuring 200x200m, and which, in the 3rd millennium B.C., drew off the water of the Wadi Adhanah and diverted it on to the area south of the wadi, the so-called southern oasis. Flanked by two bastions that are rounded on the waterside, there are two outlet constructions one of which served to divert the water intended for irrigation, whilst the purpose of the other was to lead any surplus water, which might otherwise have caused flood damages, back into the wadi bed. The water rushing down from the highlands contained suspended matter, which was deposited on the irrigated land and accumulated comparatively quickly on the surface of the arable area. Each new flooding therefore, caused the irrigation level of the oases to rise still further. However, the steady accumulation of irrigation sediments could not be halted, and so there had to come a point when all these installations were no longer operable and a new concept had to take their place. Technical expertise had grown in the course of a long evolution, and each new generation had benefited from the experience of the previous one. This meant that it was, at last, possible to close the Wadi Adhanah at its narrowest point and to construct, across the stream, a 680m long dam. When it was finished, it turned out to be 18m high, and at each end, built on the rocky mountain faces, there were sluices and regulating constructions which drew off the flood water and directed it on the oases. With the bursting of the dam, in 575 A.D., came the final catastrophe; the damages proved impossible to repair, and irrigation came to a halt. Yet scientific research has shown that the demise of this glorious era of ancient technology was ultimately not caused by technical failure or faultier construction. The irrigation systems could easily have functioned for another 200 years, thus keeping full-scale agricultural production going.

The causes of the deathblow to Sabaeen irrigation economy must be sought elsewhere. Political upheavals, like the Ethiopian hegemony, had weakened the social fabric of the country and, together with the emigration of certain sections of the population, may have been detrimental to the upkeep of the irrigation system. The occupation of Yemen by the Persians, in 575 A.D., was the final blow which effectively brought Sabaeen civilization to an end. Already under the Abyssinian general Abraha, Saba had irretrievably lost its autonomy. Polity and central power had been weakened, and as a consequence the control and maintenance of public institutions serving the common good were neglected. It was this inner weakness that accounted for the visible decay. Now, Mareb has harsh weather, with dust and moving sands, and Yemenis are building a new Mareb, keeping in mind that, they are the descendants of those who built a great ancient capital, the lovely Mareb.

Tourism in Yemen: Status and Development Prospects

Tourism is commonly perceived as a revenue source for developing countries because, as labor-intensive industry, it generates income and creates job opportunities. Cultural and historical heritage constitutes a pivotal factor in attracting tourists to various destinations

and therefore represents a foundational resource for both current and future tourist influx. However, ongoing global conflicts, particularly in the Middle East, jeopardize cultural heritage, thereby undermining the future economic potential of affected regions. International tourism exhibits acute sensitivity to terrorism, conflict, and political violence. Since travelers prefer safe destinations, any perception of injury, fatality, or stress-inducing circumstances will deter them from selecting such locales (Groizard & Santana Gallego, 2018).

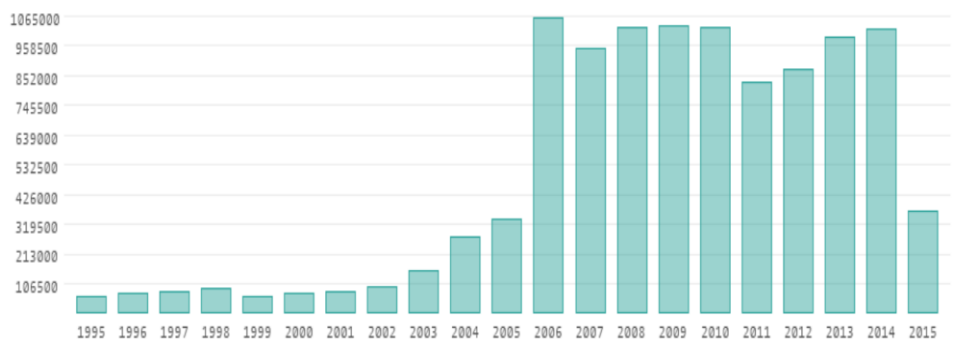


Fig. 9. Number of tourist arrivals recorded in Yemen

Source: Yearbook of Tourism Statistics, Compendium of Tourism Statistics and data files, UN Tourism

Fig. 9 illustrates annual recorded tourist arrivals in Yemen. Prior to 2005, individuals who spent at least one night but no longer than twelve months in the country were classified as tourists. Starting from 2006, same-day visitors from neighboring countries were additionally incorporated into the count. Since trip purpose was surveyed, business travel and non-touristic visit motives were already excluded. Individuals transiting through the country within a single day, such as ship crews or airline personnel, are generally not counted as tourists in most countries. If a person enters and exits multiple times within a year, each entry is separately accounted for. Note the sharp increase between 2005 and 2006 attributable to altered calculation methodology, now inclusive of day-trippers. Adjustments for expenditure calculations had already been made earlier.

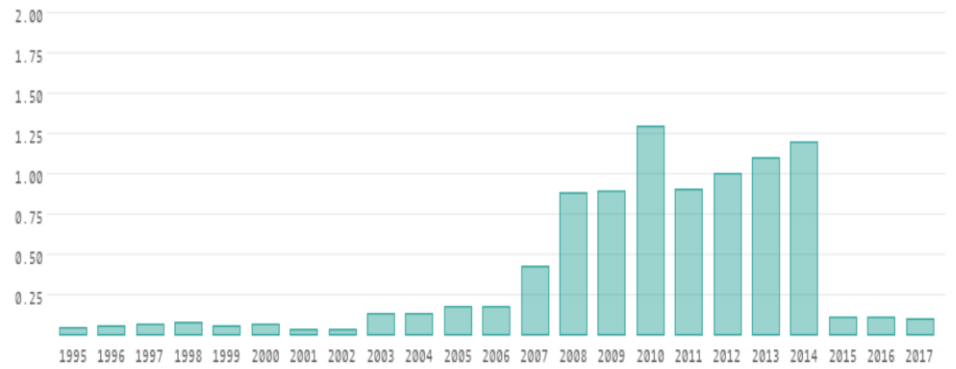


Fig. 10. Tourism revenue in Yemen, US\$ million

Source: Yearbook of Tourism Statistics, Compendium of Tourism Statistics and data files, UN Tourism

In 1995, tourism revenues stood at USD 50 million, equivalent to approximately 1.2% of GDP (gross domestic product). Over the ensuing 22-year period, the nation's reliance on tourism diminished considerably. Preceding the onset of the COVID-19 pandemic, sales volumes reached USD 100 million, accounting for 0.37% of GDP. Unfortunately, obtaining data for Yemen proves challenging. The latest figures on international tourist arrivals date back to 2015 (Fig. 10), while the final available record for tourism-derived income corresponds to 2017. As of October 2025, according to World Bank statistics, the total number of incoming international tourists to Yemen amounts to 398,000.

Yemen boasts a rich cultural heritage comprising customs, traditions, dances, and traditional markets offering unique products reflective of its cultural patrimony, distinguishing it from other nations worldwide. With an extensive coastline, stretching over 2,500 kilometers along the Arabian Sea and Red Sea, Yemen is renowned for its coral reefs, colorful fish species, and soft sandy beaches ideal for diving and relaxation. The country also hosts expansive desert expanses suitable for various forms of sand-based tourism. Characterized by towering mountain heights, Yemen accommodates diverse outdoor pursuits such as hiking, rock climbing, and paragliding, showcased by Prophet Shu'aib Peak—the highest point in Yemen and the Arabian Peninsula at 3,666 meters above sea level. Yemen harbors numerous distinctive tourist attractions catering to varying preferences, rendering it an attractive destination for global travelers. On December 3rd, 1997, the World Tourism Organization designated Yemen as a tourist state, further describing it as a hospitable country brimming with cultural uniqueness, civilizational heritage, diverse landscapes, and myriad tourist attractions. Types of Tourism Activities Yemen emerges as one of the premier international tourist destinations, hosting a wide array of tourism activities including natural, religious, historical, social, sports-oriented, cultural, educational, entertainment-focused, shopping-centric, and other categories. Current Reality of Tourism Industry Presently, Yemen's tourism industry grapples with severe and multifaceted crises, evidenced by near stagnation in domestic and international tourism levels exacerbated by prolonged political and socio-economic challenges (Alnajjar & Ishwara, 2018).

Yemen is considered a “tourist state” owing to its abundance of unique and exclusive tourist attributes, appealing natural scenery, and ecologically diverse ecosystems scarcely found elsewhere globally. Additionally, it houses an ancient historical and cultural heritage, prompting historians and archaeologists to regard it as a vast open-air museum of history. Throughout its protracted history, Yemen has been distinguished by an impressive repertoire of architectural monuments, edifices, strategic citadels, and historical castles dispersed across various provinces. Cultural heritage bolsters resilience through fostering social cohesion, wellbeing, crisis mitigation, and economic support. Further interdisciplinary investigations into heritage, resilience, and multilayered hazards are warranted (Fontanella et al., 2025). Yemen, as one of the most traditional regions within the Islamic world, presents excellent opportunities for studying the integration of conventional leisure modalities with the impact of Western excursion-based tourism (Kopp, 1989).

Conclusion

Cultural heritage sites and cultural heritage as a whole play a pivotal role in shaping the tourism industry and serve as a prerequisite for the development of cultural tourism in Yemen. They function as powerful tools for attracting tourists and can generate a favorable territorial image through branding of historical and cultural heritage, ultimately enhancing

the region's visibility in the tourism arena. Furthermore, the presence of cultural heritage enables the proliferation of diverse tourism forms and potentially prolongs the duration of the tourist season within the region. Yemen preserves the largest concentration of cultural and historical monuments among all Middle Eastern states. Many structures have survived intact, some possessing global significance and listed as UNESCO World Heritage Sites. Human-built hydrotechnical installations over thousands of years have left a profound imprint on the histories and cultures of various peoples. Among these structures, Yemen's unique hydrotechnical complexes occupy a special place, forming a distinctive type of water management and urban environment. Prominent examples include the famed Ma'rib Dam, the reservoir system in Aden, and numerous canals ensuring stable water supply in the harsh semi-desert climate. The historical significance of Yemen's hydrotechnical structures cannot be overestimated. The earliest ones originated during the reign of the kingdom of Sheba (7th–5th centuries BCE). One of the most remarkable testaments to human ingenuity is the Ma'rib Dam, erected in ancient times and serving as a reliable water source. This extraordinary structure allowed residents to develop intensive agriculture, cultivating prosperous farmland in Yemen's arid lands. Such achievements impressed contemporaries and resonated in religious texts, myths, and folklore. Beyond practical functionality, hydrotechnical works fulfilled important cultural roles. Their construction symbolized power and prestige for ruling dynasties, functioning as focal points of community life, meeting spots, and trading hubs. Unsurprisingly, most waterways and reservoirs are situated close to settlements and temples, forming coherent urban ensembles. Yemen preserves the largest concentration of cultural and historical monuments among all Middle Eastern states. Many structures have survived intact, some possessing global significance and listed as UNESCO World Heritage Sites. Human-built hydrotechnical installations over thousands of years have left a profound imprint on the histories and cultures of various peoples. Among these structures, Yemen's unique hydrotechnical complexes occupy a special place, forming a distinctive type of water management and urban environment. Prominent examples include the famed Ma'rib Dam, the reservoir system in Aden, and numerous canals ensuring stable water supply in the harsh semi-desert climate.

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Beyond practical functionality, hydrotechnical works fulfilled important cultural roles. Their construction symbolized power and prestige for ruling dynasties, functioning as focal points of community life, meeting spots, and trading hubs. Unsurprisingly, most waterways and reservoirs are situated close to settlements and temples, forming coherent urban ensembles. Today, Yemen's hydrotechnical structures assume renewed relevance as cultural heritage and a significant driver of tourism. The region appeals to enthusiasts of history and architecture, offering glimpses into the enduring skills of ancient engineers and exposing unique technological advancements of yesteryear. This trend becomes increasingly pertinent amid rising demand for authentic vacations and exploration of historical sites. However, safeguarding this heritage poses serious challenges. Numerous structures are in poor condition, requiring rehabilitation and reconstruction. Challenges stemming from natural

disasters, political instability, and insufficient funding for monument protection compound these issues. Addressing these concerns is imperative given the enormous scientific and cultural worth of these structures. To effectively promote such tourism, improving visitor comfort is paramount. Essential measures include upgrading infrastructure - roads, hotels, cafés, tour agencies - and optimizing transport services and service quality. Raising awareness among potential tourists about the existence and uniqueness of this heritage, coupled with advertising campaigns and educational programs, is equally important. Developing academic tourism targeting technical explorations of ancient constructs would engage professionals and students alike. Interactive museum displays, virtual tours, and multimedia resources could render the process engaging and accessible to broader audiences. Additionally, there is considerable scope for thematic events such as craft festivals, product fairs utilizing traditional farming methods, scholarly symposiums, and workshops. All these steps promise to significantly increase tourist inflows and stimulate regional economic growth. Ultimately, Yemen's hydrotechnical structures represent a singular cultural legacy of immense importance to global heritage and tourism development. Efforts toward their restoration and advocacy could make significant contributions to the country's economy and reinforce international collaboration in cultural exchange. Preserving this invaluable element of cultural heritage ensures its safeguarding for posterity and opens new vistas for regional progress.

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References

- Al-Ghulaibi, N.M.A. (2004). *Traditional water harvesting on the mountain terraces of Yemen*. Study Report submitted to United Nations University, Tokyo, Japan
- Bergmann, N. (2024). The Yellowstone as the longest undammed river in the contiguous United States: An environmental historical geography of a mythic landscape. *Journal of Historical Geography*, 86, 311-325. <https://doi.org/10.1016/j.jhg.2024.10.011>
- Chakraborty, R. (2012). Marib Dam and irrigation project. In: Bengtsson, L., Herschy, R.W., Fairbridge, R.W. (Eds) *Encyclopedia of Lakes and Reservoirs*. Encyclopedia of Earth Sciences Series. Springer, Dordrecht. https://doi.org/10.1007/978-1-4020-4410-6_125
- Da-Silva-Branco, C., de Brito, A. G., & Castro Seixas, P. (2026). A comprehensive review of traditional irrigation systems: Sustainability and future prospects. *Agricultural Systems*, 231, Article 104481. <https://doi.org/10.1016/j.agsy.2025.104481>
- Fontanella Pisa, P., Romagnoli, F., & Shanko, A. (2025). Framing Resilience: The Role of Cultural Heritage in Community Responses to Multi-Hazard Risks. *International Journal of Disaster Risk Reduction*, 130, Article 105876. <https://doi.org/10.1016/j.ijdrr.2025.105876>

- Giulia-Mair, A., Keall, E., Stock, S., & Shugar, A. (2000). Copper-based implements of a newly identified culture in Yemen. *Journal of Cultural Heritage*, 1(1), 37-43. [https://doi.org/10.1016/S1296-2074\(99\)00116-8](https://doi.org/10.1016/S1296-2074(99)00116-8)
- Groizard, L. J., & Santana Gallego, M. (2018). The destruction of cultural heritage and international tourism: The case of the Arab countries. *Journal of Cultural Heritage*, 33, 285-292. <https://doi.org/10.1016/j.culher.2018.06.005>
- Hoogesteger, J., Bolding, A., Sanchis-Ibor, C., Veldwisch, G. J., & Venot, J-P., Vos, J., & Boelens, R. (2023). Communalism in farmer managed irrigation systems: Insights from Spain, Ecuador, Cambodia and Mozambique. *Agricultural Systems*, 204, Article 103552. <https://doi.org/10.1016/j.agsy.2022.103552>
- Jana, K. S., & Tamang, P. (2023). Prospects of rehabilitation of ancient irrigation systems in India—A case study from coastal saline zone of West Bengal. *Agricultural Systems*, 207, Article 103638. <https://doi.org/10.1016/j.agsy.2023.103638>
- Joseph, K., & Maluka, S.O. (2025). Moving out from the river banks: some areas of contestation between traditional irrigation practices and formal water institutions in Tanzania. *African Geographical Review*, 44(7), 634-648. <https://doi.org/10.1080/19376812.2025.2476497>
- Kopp, H. (1989). Tourism and Recreation in Northern Yemen. *Tourism Recreation Research*, 14(2), 11-15. <https://doi.org/10.1080/02508281.1989.11014547>
- Legg, S., Ding, Y., Ferretti, F., Morin, K., & Novaes, A. R. (2025). Historical geographies: Translating times and spaces. *Journal of Historical Geography*, 88, 5-6. <https://doi.org/10.1016/j.jhg.2025.05.016>
- Leibundgut, C. & Kohn, I. (2014). European Traditional Irrigation in Transition Part I: Irrigation in Times Past - A historic land use practice across Europe. *Irrigation and Drainage*, 63. <https://doi.org/10.1002/ird.1826>
- Liao, Z., Pang, Q., & Xiao, H. (2025). Glocalization: Cross-cultural communication of tourism research. *Tourism Management*, 108, Article 105129. <https://doi.org/10.1016/j.tourman.2024.105129>
- Liu, Y., Wang, Y., Dupre, K. & McIlwaine, C. (2022). The impacts of world cultural heritage site designation and heritage tourism on community livelihoods: A Chinese case study. *Tourism Management Perspectives*, 43, Article 100994. <https://doi.org/10.1016/j.tmp.2022.100994>
- Liu, Y., Wang, J., Huang, K., Li, Y., & Wan, L. (2025). The sustainable paradox of community tourism in world cultural heritage villages: The case of Xidi and Hong. *Annals of Tourism Research*, 115, Article 104020. <https://doi.org/10.1016/j.annals.2025.104020>
- Lukoseviciute, G., Henriques, C., Panagopoulos, T. & Perreira, L. (2024). Participatory development and management of eco-cultural trails in sustainable tourism destinations. *Journal of Outdoor Recreation and Tourism*, 47, Article 100779. <https://doi.org/10.1016/j.jort.2024.100779>
- Martínez-Sanchis, Imma & Viñals, Maria. (2015). Enhancing the traditional Mediterranean irrigation agroecosystems: a case study of the rivers Túrria and Júcar (Valencia, Spain). *Ecology and the Environment*, 192, 45-54. <https://doi.org/10.2495/ECO150051>
- Maw, T., & Seo, D. (2024). Historical geographies of grid city development: Mandalay from Burma to Myanmar. *Journal of Historical Geography*, 86, Article 133-148. <https://doi.org/10.1016/j.jhg.2024.07.005>
- Ministry of oil and mineral resources & TNO Institute. (1993). Report WRAY 23, Water Resources Wadi Adhanah and Mareb area, Republic of Yemen

- Mosleh, A., & Ishwara. P. (2018). A Study on Potentiality of Tourism Industry in Yemen. *Tourism Innovations*, 8(2), 126-133.
- Nautiyal, R., Albrecht, J. & Carr, A. (2025). Spiritual practice as tourism experience: An application of cultural transmission theory. *Annals of Tourism Research*, 110, Article 103866. <https://doi.org/10.1016/j.annals.2024.103866>
- Pelgrum, H., Bastiaanssen, W., Voogt, M., & Berghege, M. (2009). Satellite Imagery for Cropping and Irrigated Area Monitoring; Ministry of Agriculture and Irrigation of Republic of Yemen and World Bank: Sana'a, Yemen.
- Rappold, G., Ergenzinger, P. J., Gerke, H., & Scholz, F. (2003). Hydrological Analysis of Terraced Catchments: A Case Study of the Tacizz Region, Yemen. In F. Pelat & A. Al-Hakimi (Eds.), *Savoirs locaux et agriculture durable au Yémen*. Sanaa: Centre français de recherche de la péninsule Arabique. <https://doi.org/10.4000/books.cefas.2889>
- Ratna Reddy, V., Srinivasa Reddy, M., & Palanisami, K. (2018). Tank Rehabilitation in India: Review of Experiences and Strategies. *Agricultural Water Management*, 209, 32-43. <https://doi.org/10.1016/j.agwat.2018.07.013>
- Tang, Ch., Yang, Y., Liu, Y., & Xiao, X. (2023). Comprehensive evaluation of the cultural inheritance level of tourism-oriented traditional villages: The example of Beijing. *Tourism Management Perspectives*, 48, Article 101166. <https://doi.org/10.1016/j.tmp.2023.101166>
- Timsina, J., & Weerahewa, J. (2023). Restoring ancient irrigation systems for sustainable agro-ecosystems development: Reflections on the special issue. *Agricultural Systems*, 209, 103668. <https://doi.org/10.1016/j.agsy.2023.103668>
- Voogt, M., Soppe, R., & Noordman, E. (2007). Satellite Imagery for Cropping Pattern and Irrigated Area Monitoring Interim Report; WaterWatch: Sana'a, Yemen, 27
- Weerahewa, J., Timsina, J., Wickramasinghe, M.R.C.P., Jayasekara, S., Dayananda, D., & Puspakumara, G. (2023). Ancient irrigation systems in Asia and Africa: Typologies, degradation and ecosystem services. *Agricultural Systems*, 205, Article 103580. <https://doi.org/10.1016/j.agsy.2022.103580>
- Wu, P., Goh, H., & Hussin, H. (2025). Stakeholders' perspectives of intangible cultural heritage tourism: A systematic review. *Journal of Hospitality and Tourism Management*, 64, Article 101303. <https://doi.org/10.1016/j.jhtm.2025.101303>
- Zheng, F., Tang, Y., & Jin, H. (2025). The Dual Threshold Effects of Rural Cultural Tourism Industry Ecology and Green Finance Support: Based on the Moderating Effect of Regional Cultural Tourism Development. *International Review of Economics & Finance*, 103, Article 104538. <https://doi.org/10.1016/j.iref.2025.104538>
- Zheng, Y., Han, X., Wu (Snow), J., & Xiao, L. (2025). Transformative value in cultural tourism: Scale development and its impact on tourist eudaimonic well-being. *Tourism Management Perspectives*, 56, Article 101346. <https://doi.org/10.1016/j.tmp.2025.101346>