The Impact of Water Diplomacy Treaties on the Yarmouk River Basin: Water Variability and Climate Change

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Abstract

The Yarmouk River Basin (YRB), shared by Syria and Jordan, has been subject to multiple treaties since 1953, aiming to regulate water usage between the two countries. However, Syria has violated these agreements by constructing excessive dams and water pumping, leading to a negative change in the hydrological system in the basin and reducing the flow in the Yarmouk River, affecting the regional ecosystems and socio-economic stability. All this leads to a threat to regional cooperation and water-sharing commitments.

This study examines how ambiguous treaty terms contribute to reduced water availability and evaluates land cover changes using Remote Sensing (RS) and Geographic Information Systems (GIS) over the past 50 years with a 10-year time frame. The findings indicate a change in the Jordanian Part, which is 19% of the entire Yarmouk River Basin (YRB) with a total area of 1,405.4 km². This change shows a decline in Jordanian agricultural land from 7.9% in 1972 to 4.3% in 2022, this is equivalent to losing 269 km² of agricultural land, representing 46% of the total agricultural land in 1972. This loss is closely tied to water scarcity, which is exacerbated by unclear water-sharing agreements and governance challenges in the Yarmouk basin. While non-agricultural land expanded from 11.1% to 14.6%. Water bodies showed a slight increase due to artificial reservoirs but remained unchanged. Human activities such as dam construction and urbanization are significant drivers of environmental change, fragmenting ecological corridors and disrupting biodiversity.

The study highlights the urgent need for stronger transboundary water governance by introducing strategies for water management in shared basins for equitable water distribution and regional cooperation. Policy interventions should focus on sustainable water management, conservation strategies, and restoration of ecological connectivity. Policy frameworks by stakeholder engagement to integrate political, infrastructure, and environmental strategy. This multidisciplinary approach aims to inform policy decisions promoting resilience, ecosystem restoration, water scarcity mitigation, and long-term sustainability in the Yarmouk River Basin.

Keywords: Yarmouk River Basin (YRB), Water treaties, Land Use Land Cover (LULC), Remote Sensing (RS), Geographic Information Systems (GIS).

Introduction

The Yarmouk River Basin (YRB), shared by Syria and Jordan, has been regulated by treaties signed in 1953, 1987, 1994, 2001, and 2003 (Climate Diplomacy, 2024). Despite these agreements, Syria has exceeded the treaty limits by constructing 42 dams, far beyond the 25 permitted under the 1987 treaty, drastically reducing water flow to Jordan's territory (Zoubi, 2014). In addition, Syria's use of water pumps has further compounded the issue, severely affecting the river's flow (Zawahri, 2010). Repeated requests by Jordan to dismantle the dams and wells have been ignored, with Syria attributing the reduction in water to decreased rainfall (Grover et al., 2010).

This ongoing depletion has had significant environmental and social consequences, particularly for Jordan, one of the most water-scarce countries in the world. By 2021, Jordan's water consumption had fallen to 61 liters per person per day, with projections indicating a further drop to 35 liters by 2040, according to the National Water Strategy 2023–2040 (MWI, 2023). These violations also pose risks to regional cooperation, as Jordan's ability to meet its water-sharing obligations to Israel under the 1994 treaty is increasingly jeopardized, potentially escalating tensions.

An investigation of how ambiguous terms in the 1953 Bilateral Agreement have contributed to reduced water flow, resulting in significant changes to the microclimate of the Yarmouk Basin. It tracks land cover changes before and after signing these treaties, evaluating their impact on the basin's environmental integrity, water variability, and biodiversity. Additionally, the research explores the relationship between treaty frameworks and cooperative water management amidst shifting environmental conditions, aiming to propose strategies for restoring ecosystem functionality and biodiversity. The study's overarching goal is to document land cover changes and address water resource vulnerabilities resulting from the asymmetric construction of dams on both sides of the basin to mitigate climate change impacts.

The Study Area

The study area Yarmouk River Basin (YRB), which spans over area of approximately 7,386.5 km², is situated in the southwestern region of Syria, encompassing approximately 81% of the total basin area at 5,981.1 km², while the remaining area of the basin is located in the northern part of Jordan, comprising about 19% of the total basin area at 1,405.4 km² (Figure 1).

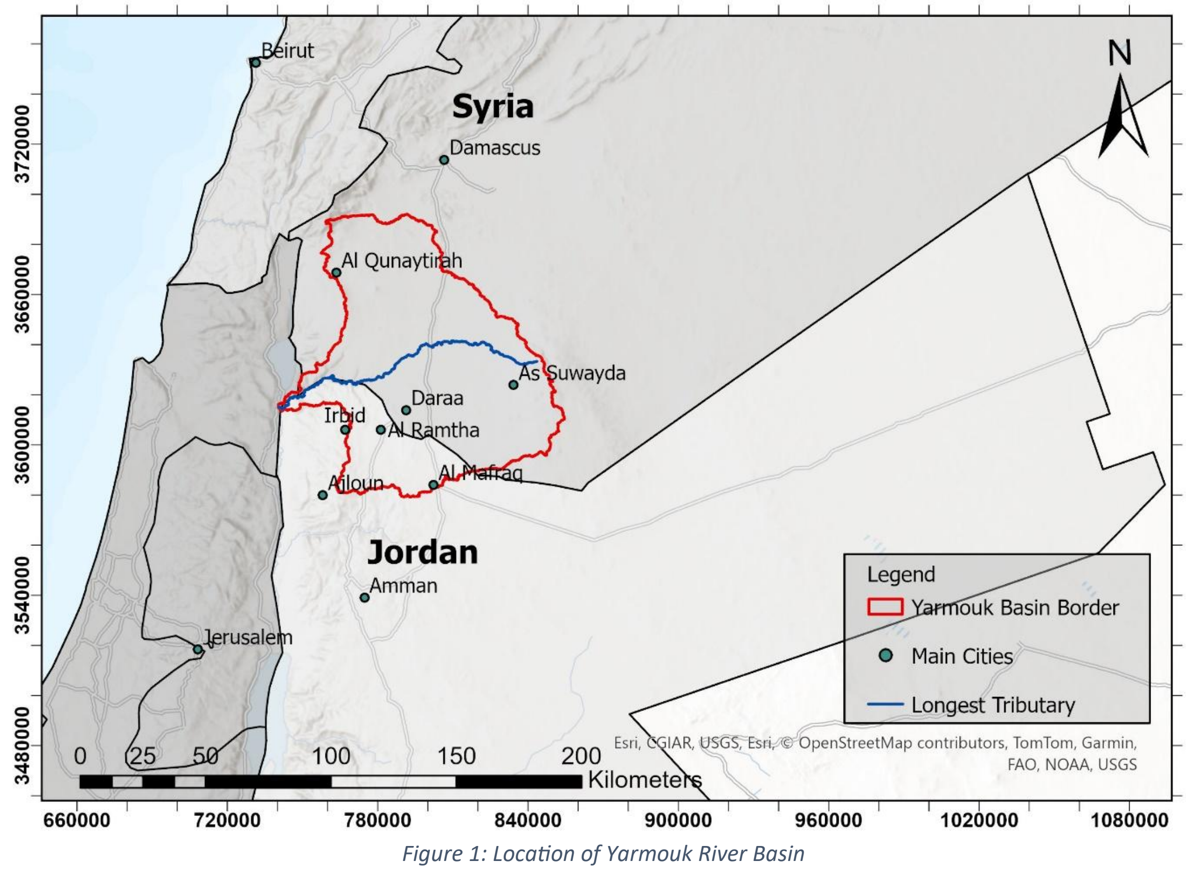

Figure 1: Location of Yarmouk River Basin

The YRB is one of the Middle East's most important transboundary water systems (Zeitoun et al., 2019). The basin extends from the Golan Heights west to the Hauran Plateau in the north of Syria and to the Ajloun Highlands in the south of Jordan. The Yarmouk River is the primary watercourse and the longest tributary of the basin, playing a vital role in the region's water resources (Figure 3).
It is also one of the main tributaries of the Jordan River and a strategic transboundary freshwater source for the entire region (Rosenberg 2006). This region is characterized by diverse terrain, with elevations ranging from 231 m below sea level near the Jordan Valley to 2,253 m above sea level in surrounding areas such as the Ajloun Mountains in Jordan and the Hauran Plateau in Syria as shown in (Figure 2) as shown in the Digital Elevation Model map (DEM) (Figure 4).

Figure 2: Hauran Plans in the Yarmouk Basin

The climate in the YRB is Mediterranean, influenced by altitude; for example, the temperatures in the highlands are cooler with rainfall reaching 600 mm/year, whereas in the lowlands, temperatures are warmer, with a rainfall of 200 mm/year, which significantly affects the environment and agricultural characteristics of the region (Abdullah et al., 2020). The primary land cover types include vegetation, urban areas, bare soil, rocks, and water bodies. The terrain in the YRB features valleys and proximity to waterways, volcanic terrains in the Hauran Plateau that create fertile soil, and forested areas in the Ajloun Highlands that enhance biodiversity.

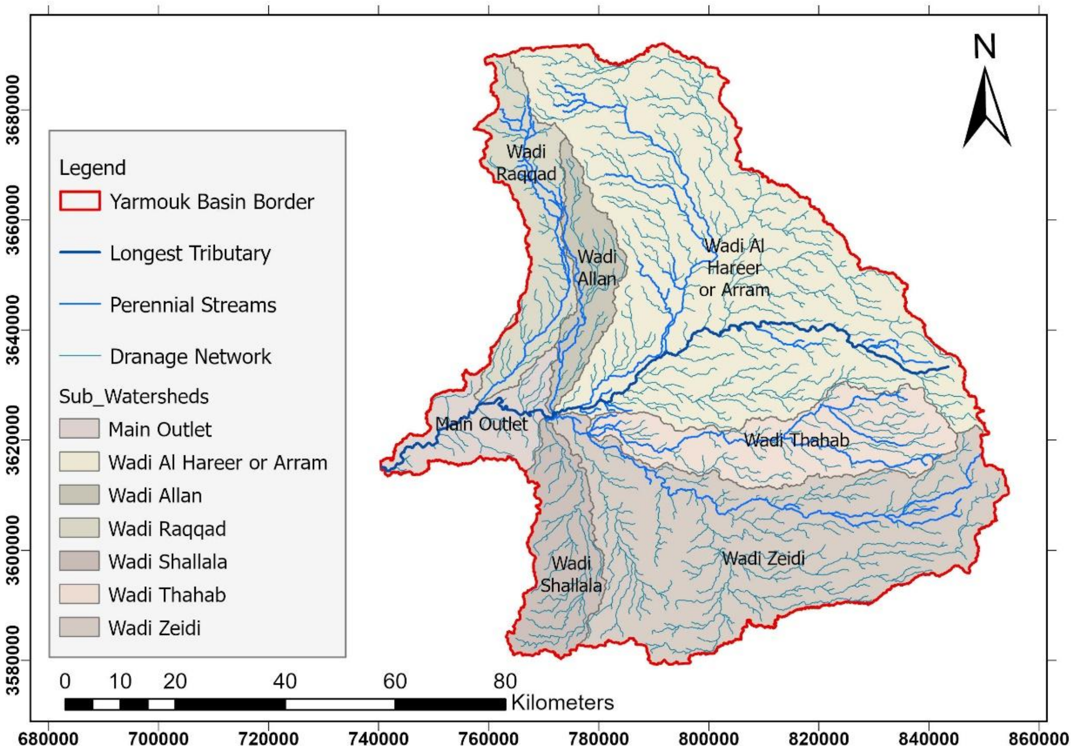

Figure 3: Yarmouk River Basin Sub Watershed and Drainage Network.

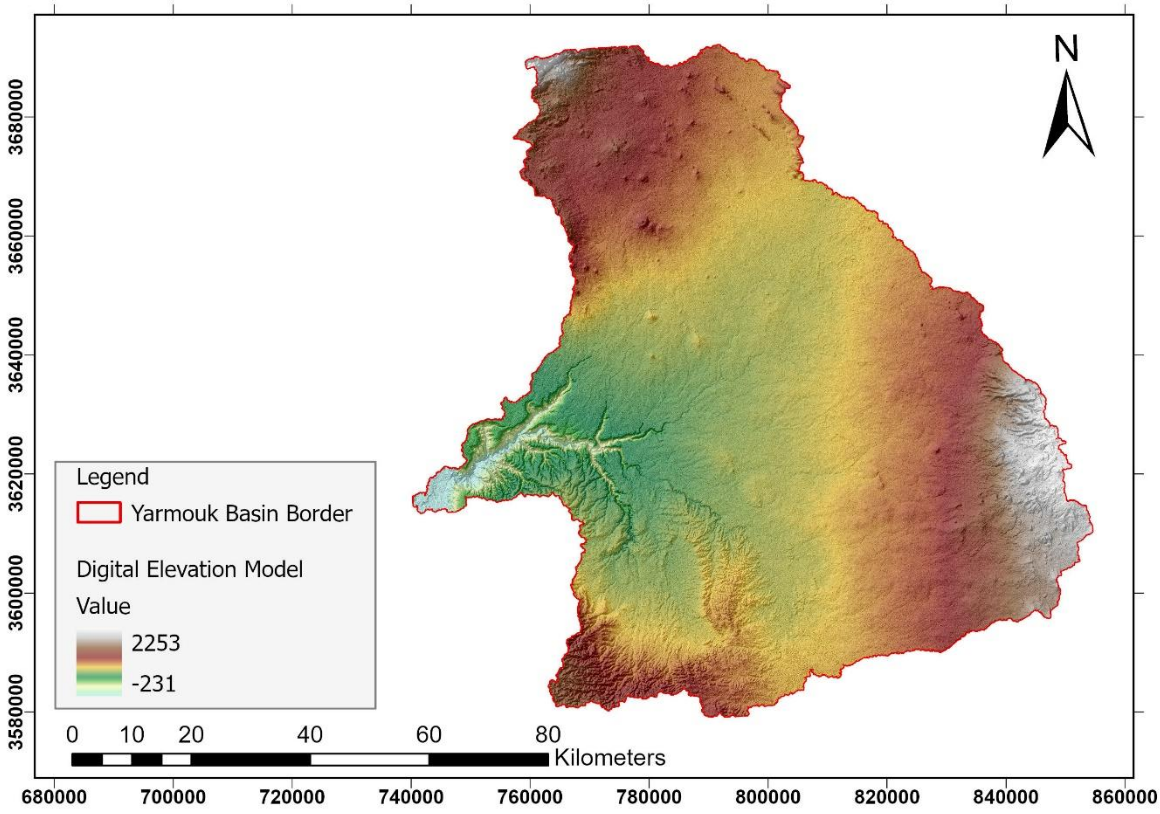

Figure 4: Yarmouk River Basin Digital Elevation Model (DEM)

Methods

This study employs Remote Sensing (RS) techniques and Geographic Information Systems (GIS) to analyze land cover changes in the upstream and downstream regions of the Yarmouk River Basin over a 50-year period. A key method used in this study is the Supervised classification approach, specifically the Support Vector Machine (SVM) algorithm, to classify multi-spectral Landsat satellite image. The land cover classes identified in this study include agriculture, non-agriculture, and water, which are critical to understand the spatial and temporal dynamics of land cover changes. These classified maps are then compared to quantify land cover changes before and after the implementation of water treaties. The analysis provides insights into the spatial extent of land degradation and its correlation with human activities, such as dam construction, agricultural expansion, and urbanization, as well as with climate variability. By explicitly integrating GIS and RS methods, this study highlights the importance of these tools in monitoring and managing environmental changes in the basins.

Results

The results demonstrate significant habitat loss throughout the Yarmouk Basin, particularly in areas most impacted by declining water availability due to upstream water diversions and inequitable water treaties. The reduction in water flow has led to the degradation of riparian vegetation and natural grasslands, which once thrived along the river and supported biodiversity. Key ecological corridors, once vital for wildlife movement, biodiversity conservation and ecosystem connectivity, have been severely fragmented, leaving only isolated patches of natural habitat. The study attributes these changes mainly to human-induced activities, including agricultural intensification, technological advancements, urban sprawl, and infrastructure development. The loss of habitat connectivity has weakened ecological integrity and cultural identity in the region. While local authorities acknowledge these ecological gaps, the proposed mitigation measures have been limited in scope and effectiveness.

The water surface area in the Yarmouk River Basin increased significantly over the study period, rising from 13.7 km2 in 1972 to 98.6 km2 in 2022 as shown in (Figure 5). Agricultural land showed fluctuating trends, with an initial increase from 4,770.7 km2 in 1972 to a peak of 5,055.6 km2 in 1982, reflecting the basin's historical dependence on agriculture. However, agriculture was increasing significantly in the western side of the basin due to the presence of the vast majority of dams (Figure 7), and agriculture began to decline sharply after 1992, declining to 2,624 km^2 in 2022. This decline is caused by the reduction of available water for irrigation, a direct result of the construction of dams upstream in Syria and changing land use priorities. Conversely, non-agricultural land has steadily increased from 2,601.8 km2 in 1972 to 4,663.8 km^2 in 2022. Figure 6 demonstrates the relationship between the agricultural lands and non-agricultural lands in the Yarmouk River Basin. This growth reflects urbanization, infrastructure development, and agricultural land abandonment due to water shortages and low agricultural productivity.

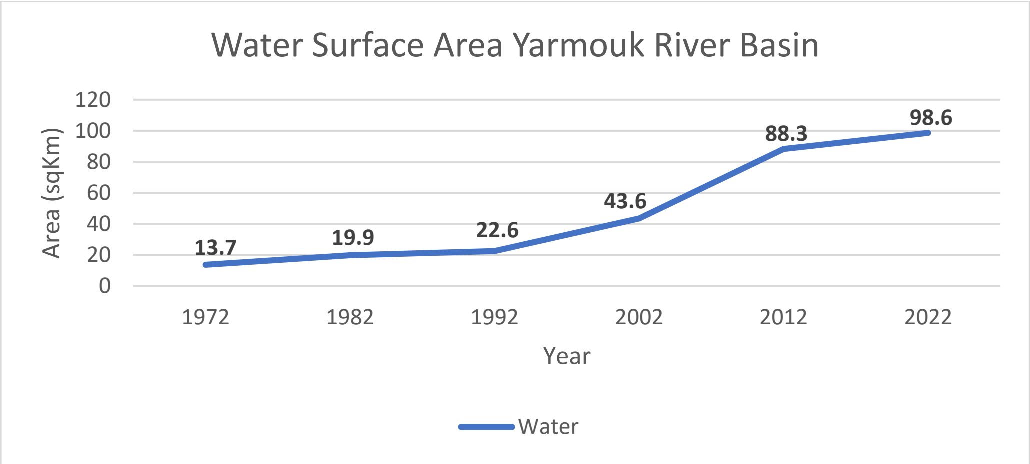

Figure 5 : Water Surface Area Yarmouk River Basin.

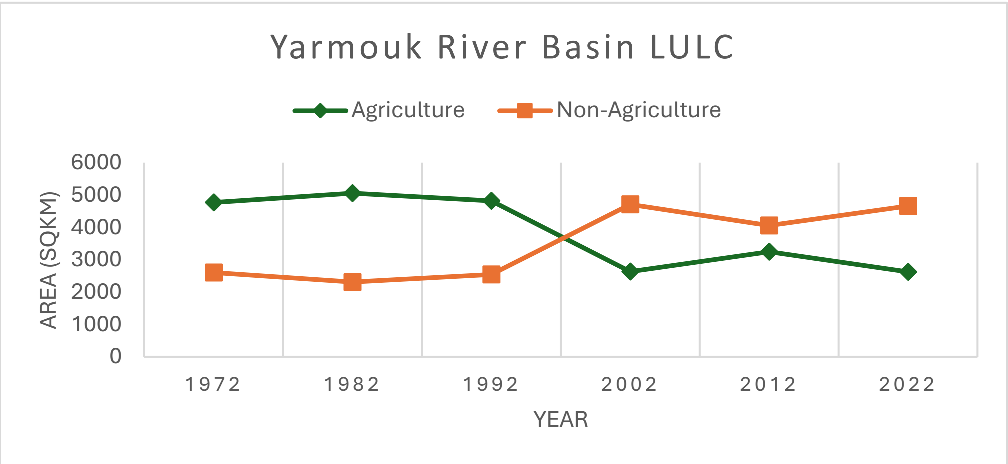

Figure 6: The relationship between the Agricultural Lands and Non-Agriculture Lands in the Yarmouk River Basin.

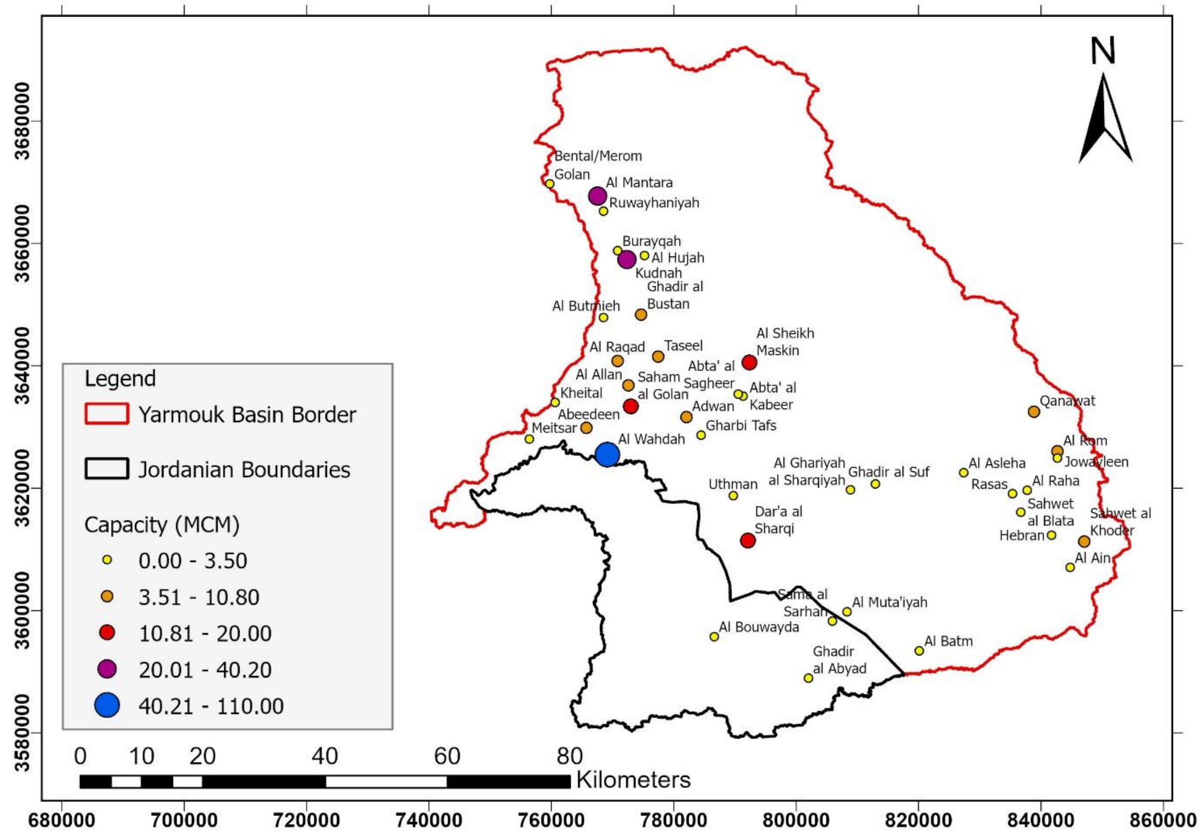

Figure 7: Dams in Yarmouk River Basin

On the Jordanian side of the Yarmouk River Basin, surface water bodies have increased slightly over time, supported by the construction of three dams in the 1960s for agricultural irrigation. This growth became more pronounced after 2012, due to water storage strategies in response to the decline in natural water flow in the basin, which exacerbates the chronic water scarcity problem in the region. There has also been a significant and noticeable change in agricultural land, which was previously dominant in the area due to the construction of dams upstream in Syria, which reduced the availability of irrigation water and thus reduced agricultural land. Despite a temporary recovery of agricultural land in the early 1990s, the long-term trend shows a sharp decline, reflecting the continuing effects of water pressure on the sector. Conversely, non-agricultural land has expanded significantly, driven by urbanization, infrastructure development, and the abandonment of agricultural land as agriculture becomes increasingly unviable and expensive. Unauthorized dam construction on the Syrian side has reduced the flow of the Yarmouk River into the Jordanian side, and a 1987 agreement, which was intended to ensure equitable water distribution, played a crucial role in these shifts. The agreement granted Jordan the right to use most of the river's water; however, unauthorized developments have upset this balance, exacerbating water scarcity and changing land-use patterns in the region.

Discussion

Through a series of workshops with key stakeholders, including representatives from the Ministries of Water, Environment, and Local Administration, the study facilitated discussions on mitigation measures. These workshops encouraged the exchange of critical insights and the generation of viable solutions aimed at addressing regional environmental challenges. A comprehensive content analysis was conducted after these discussions, leading to the development of a policy framework intended to guide future efforts in resilience building, ecosystem restoration, and environmental rehabilitation. This framework integrates key dimensions such as political relations, infrastructure planning, human behavior, and regional water management strategies. It emphasizes the necessity of a multidisciplinary approach to addressing the complex environmental and socio-political dynamics affecting the Yarmouk Basin. Ultimately, the framework serves as a strategic tool for advancing long-term environmental sustainability and resilience in the face of persistent and evolving challenges.

Figure 8 shows the historical images of the Yarmouk River Basin, which provide a stark visual representation of the region's hydrological and ecological evolution. The figure also highlights the early 20th-century infrastructure, such as the 1919 Railway bridge and the 1927-1933 Yarmouk reservoir sluice gates. These structures not only facilitated regional development but also marked the beginning of large-scale water management interventions in the area.

Figure 9 further illustrates the basin's transformation over time. The 1932 aerial photo (Figure 9 A) captures the natural abundance of water in the Yarmouk Basin, contrasting sharply with the arid and degraded environment that characterizes much of the region today. Despite the rugged terrain that limits local residents' access to water, the basin remains a critical source of life for the lower Jordan Valley. The 2022 image of the Alwehdah Dam (Figure 9 B) symbolizes the ongoing hydropolitical dynamics in the region. The dam represents a modern effort to balance water resource management with cross-border cooperation. These images collectively emphasize the need for sustainable and equitable water management strategies that address both ecological and socio-political challenges in the Yarmouk Basin

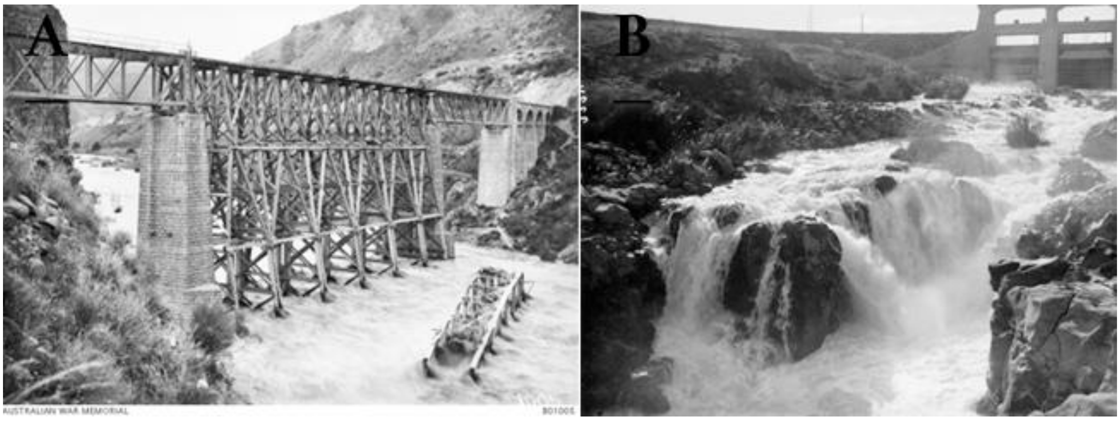

Figure 8 A: 1919 Railway bridge over the Yarmouk River. B: 1927-1933 Yarmouk reservoir sluice gates. The Palestine Electric Corporation power plant.

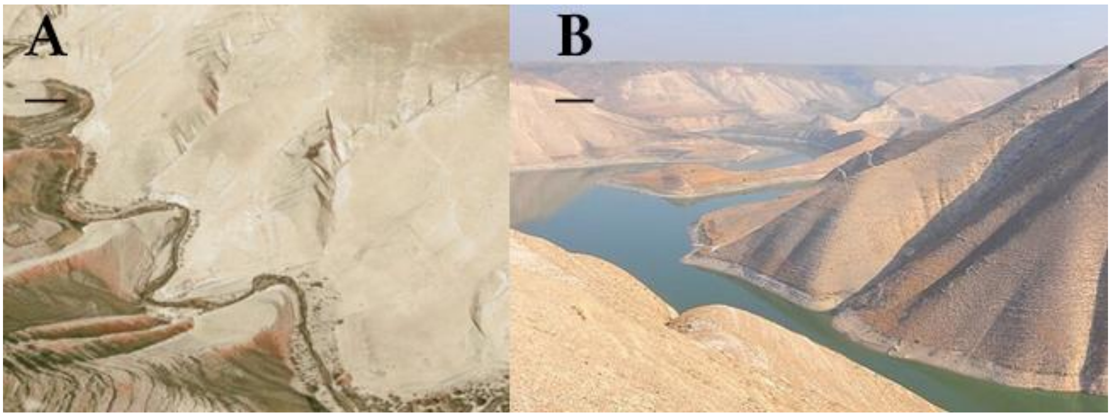

Figure 9 A: An aerial photo from 1932. B: Alwehdah Dam 2022.

Conclusions

The YRB stands at a critical stage, facing significant challenges because of water scarcity, ecological degradation, and transboundary tensions exacerbated by ambiguous water-sharing agreements and unsustainable water management practices. This study highlights the dramatic decline in agricultural land, the fragmentation of ecological corridors, and the socio-economic impacts of reduced water availability, particularly for Jordan. The findings emphasize the urgent need for robust transboundary water governance, equitable water distribution, and integrated strategies to restore ecological connectivity and biodiversity. Implementing these measures, supported by international collaboration and stakeholder engagement, can pave the way for long-term resilience, ecosystem restoration, and socio-economic stability in the YRB. The path forward requires a multidisciplinary approach, balancing political, environmental, and infrastructural priorities to ensure the basin's sustainability for future generations.

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