

Received: 03 July, 2026

Accepted: 20 September, 2026

Published: 23 September, 2026

The Role of the Khosr River in the Sustainability of the City of Nineveh During the Neo-Assyrian Period (911–612 BC)

Khudher Saleh Ahmed

College of Archaeology, Department of Archaeology, University of Mosul, Mosul, Iraq; khudher.salih@uomosul.edu.iq

Sura Ammar Hamza

College of Archaeology, Department of Ancient Iraqi Languages, University of Mosul, Mosul, Iraq; sura.ammam@uomosul.edu.iq

Noor Faisal Yahya

College of Archaeology, Department of Ancient Iraqi Languages, University of Mosul, Mosul, Iraq; noor.alhayali@uomosul.edu.iq

Farah Imad Ezz El-Din

College of Archaeology, Department of Ancient Iraqi Languages, University of Mosul, Mosul, Iraq; farah.emad@uomosul.edu.iq

Zahraa Mahmoud Mohammed

College of Archaeology, Department of Ancient Iraqi Languages, University of Mosul, Mosul, Iraq; zahraa.mohammad@uomosul.edu.iq

Cite this article:

Ahmed, K. S., Hamza, S. A., Yahya, N. F., Ezz El-Din, F. I., & Mohammed, Z. M. (2026). The Role of the Khosr River in the Sustainability of the City of Nineveh During the Neo-Assyrian Period (911–612 BC). *Revista Cultura Científica*, (24), pp. 1476–1487. <https://doi.org/10.70517/revcc2624122>

Abstract

This study examines the role of the Khosr River in sustaining Nineveh during the Neo-Assyrian period through four interrelated dimensions: water supply, agricultural production, urban development, and defensive security. The analysis draws primarily on Neo-Assyrian royal inscriptions, especially those of Sennacherib, together with archaeological, historical-geographical, and remote-sensing studies of the Nineveh region. The concept of sustainability is used here as a modern analytical lens rather than as a claim that the Assyrians employed the term in its contemporary sense. The evidence indicates that the seasonal character and relatively low natural discharge of the Khosr required deliberate hydraulic intervention. Under Sennacherib, springs and tributary waters were integrated into the river system, canals were excavated, dams and regulating structures were constructed, and

water was redirected toward Nineveh and its surrounding plain. These interventions helped secure a more reliable urban water supply, supported irrigation and gardens, facilitated major construction projects, and contributed to the organization of the city's defensive landscape through canals and moats. The study argues that the significance of the Khosr River lay not simply in the presence of a natural watercourse, but in the Assyrian state's capacity to transform that watercourse into an integrated hydraulic infrastructure. In this sense, the river functioned as a central component of Nineveh's long-term urban, agricultural, economic, environmental, and security resilience.

Keywords: Khosr River, Nineveh, Neo-Assyrian period, Sennacherib, hydraulic engineering, water management, irrigation, urban sustainability, agricultural sustainability, defensive infrastructure

1. INTRODUCTION

Water availability was one of the fundamental conditions governing the location, expansion, and long-term resilience of cities in ancient Mesopotamia. Rivers, springs, seasonal streams, and artificial canals supplied drinking water, sustained agriculture, supported craft and building activities, and influenced the spatial organization and defensibility of settlements. In northern Mesopotamia, these relationships were particularly important because urban development depended not only on the major river systems but also on smaller tributaries and engineered channels capable of redistributing water across uneven terrain. Nineveh provides an especially revealing case because the city occupied a strategic position near the Tigris while the Khosr River crossed the urban area from east to west before joining the larger river system.

The Khosr was important long before the reign of Sennacherib, as Middle Assyrian textual evidence already associates the river with the Nineveh region and with royal landscapes [1]. Its role changed substantially, however, when Sennacherib made Nineveh the principal royal capital of the Neo-Assyrian Empire. The enlarged city, its palaces, gardens, fields, population, and defensive works required a water supply that exceeded what the natural seasonal discharge of the Khosr could reliably provide. Sennacherib's inscriptions repeatedly present the search for new springs, the excavation of canals, the regulation of watercourses, and the transformation of the Nineveh plain as central achievements of his reign [2, 3].

The physical remains of this hydraulic program have attracted sustained archaeological attention. Jacobsen and Lloyd's investigation of the Jerwan aqueduct established the monumental scale and technical sophistication of Assyrian water engineering [4]. Oates subsequently placed the northern waterworks within the broader historical geography of Assyria [5], while Reade reconstructed the phases of Sennacherib's water system and its relationship to Nineveh [6]. More recently, satellite imagery, remote sensing, geoarchaeology, and hydraulic analysis have considerably refined the reconstruction of the canals and their regional connections [7–9].

This scholarship demonstrates that Nineveh's water supply cannot be understood through a single monument or canal. The Khosr formed part of a spatially extensive hydraulic landscape in which natural river channels, springs, dams, aqueducts, and artificial canals interacted. Yet the existing literature has often emphasized particular engineering components, regional canal traces, individual inscriptions, or specific archaeological installations. The present study brings these strands together by placing the Khosr River at the center of an integrated interpretation of Nineveh's water management and by asking how the river's functions extended beyond supply alone to agriculture, urban construction, environmental management, and defense.

The concept of sustainability provides a useful analytical vocabulary for this purpose, provided that it is used carefully. Modern sustainability discourse emphasizes the responsible use and preservation of resources over time [10, p. 375]; environmental sustainability likewise stresses the continued availability and management of natural resources for future needs [11, p. 110]. The Neo-Assyrians did not formulate sustainability in this modern terminology. Accordingly, this study does not attribute a contemporary environmental doctrine to Sennacherib or his administration. Instead, sustainability is used as an analytical lens for evaluating whether hydraulic interventions increased reliability, reduced vulnerability to seasonal variation, supported production, strengthened urban functions, and enhanced the resilience of the capital.

The central research question is therefore: *How did the Assyrian management of the Khosr River contribute to the continuity, expansion, and resilience of Nineveh during the Neo-Assyrian period?* The study addresses this question through four interconnected dimensions: water security, agricultural production, urban development, and defensive security. The principal argument is that the Khosr's historical importance did not result merely from the existence of a natural river. Rather, its significance lay in the Assyrian state's ability to transform a seasonal watercourse into the receiving and distributing component of a much larger hydraulic infrastructure.

The paper proceeds in five stages. It first explains the sources, analytical method, and limitations of the evidence. It then reconstructs the geography, hydrology, and textual identity of the Khosr. The next section examines Sennacherib's hydraulic transformation of the river system. The core analytical section evaluates the river's agricultural, urban, and defensive functions. A final discussion brings these dimensions together and assesses what the Khosr system reveals about long-term urban resource management in the Neo-Assyrian capital.

2. SOURCES, METHOD, AND ANALYTICAL FRAMEWORK

This study adopts a historical-analytical approach based on three principal groups of evidence. First, Neo-Assyrian and Middle Assyrian inscriptions provide direct textual evidence concerning canals, springs, gardens, river regulation, and royal building programs. For Sennacherib, the study uses the classic translation of Luckenbill together with the modern edition of the royal inscriptions by Grayson and Novotny; Middle Assyrian evidence is taken from Grayson's edition [1–3]. These inscriptions are indispensable because they preserve the ruler's own claims regarding water management, although they must also be read as royal commemorative texts rather than neutral engineering reports.

Second, archaeological and historical-geographical studies provide the material and spatial context needed to evaluate the textual evidence. The Jerwan aqueduct, the Kisiri canal, the Khinnis/Bavian works, ancient settlement locations, urban

topography, and the broader canal system have been reconstructed through field survey, excavation, historical geography, and landscape study [4–6, 12]. These studies make it possible to distinguish between rhetorical claims in royal inscriptions and hydraulic features that can be located or reconstructed in the landscape.

Third, modern geographical, geoarchaeological, and remote-sensing studies help clarify the scale and configuration of the Khosr basin and the wider Neo-Assyrian water network [7–9, 13, 14]. Satellite imagery is particularly valuable because long canal segments that are difficult to recognize at ground level can be traced across large areas, allowing separate drainage basins and hydraulic installations to be understood as parts of an integrated regional system.

The evidence is interpreted comparatively. Textual sources are used to reconstruct the intentions, sequence, and ideological presentation of the hydraulic works; archaeological and geographical studies are used to contextualize those claims; and modern imagery is used to visualize topographic relationships. Figures 1, 3, and 4 are present-day Google Earth images and are therefore used for topographic orientation rather than as direct evidence for the exact Neo-Assyrian course of the Khosr. Figures 2 and 5 reproduce or adapt published scholarly reconstructions of the regional hydraulic landscape. Figure 6 illustrates the monumental setting at Khinnis/Bavian in which Sennacherib's hydraulic works were commemorated.

Analytically, the study treats sustainability as a relationship between resource reliability and the continuity of urban functions. Four dimensions are used. *Water sustainability* refers to the capacity to augment, regulate, and distribute water despite seasonal variability. *Agricultural sustainability* concerns the use of managed water to reduce dependence on rainfall and support fields, orchards, gardens, and managed wetland environments. *Urban sustainability* refers to the contribution of water to construction, planted landscapes, palace infrastructure, and the daily needs of the enlarged capital. *Defensive sustainability* concerns the way canals, moats, and wet barriers strengthened the defensive landscape and supported the population during periods of stress. These categories overlap in practice and are used as analytical tools rather than as rigid divisions in the ancient evidence.

3. THE KHOSR RIVER: GEOGRAPHY, HYDROLOGY, AND HISTORICAL CONTEXT

The Khosr is a seasonal river whose natural discharge depends heavily on winter and spring rainfall. Greater precipitation increases water level, discharge, and flow velocity, whereas the dry summer season can produce an extreme decline in flow [13, p. 9]. This hydrological pattern created a structural problem for a large imperial capital. A river that supplied substantial water in wetter months could not, without deliberate intervention, guarantee the continuous flow required by an enlarged population, irrigated fields, royal gardens, construction projects, and defensive waterworks.

The geographical form of the river is illustrated in Figure 1. Its pronounced meandering course east of Nineveh demonstrates that the Khosr was a natural river corridor subsequently incorporated into a much larger managed hydraulic system.



Figure 1. Present-day satellite view of the strongly meandering Khosr River east of Nineveh. The image illustrates the sinuous river corridor and its relationship to the surrounding cultivated and settled landscape. Source: Google Earth.

As Figure 1 makes clear, the channel repeatedly changes direction before reaching the urban area. The image is useful for visualizing the modern river corridor and its relationship to surrounding agricultural zones, although the present landscape should not be projected directly onto the Neo-Assyrian period.

The Khosr basin extends across the uplands northeast of Mosul and receives water from areas associated with Mount

Maqlub, the Gomel highlands [15, p. 18]. Its basin has been estimated at approximately 863.74 km² [13, p. 8]. Figure 2 situates the river within the larger drainage and canal landscape reconstructed for the Nineveh region.

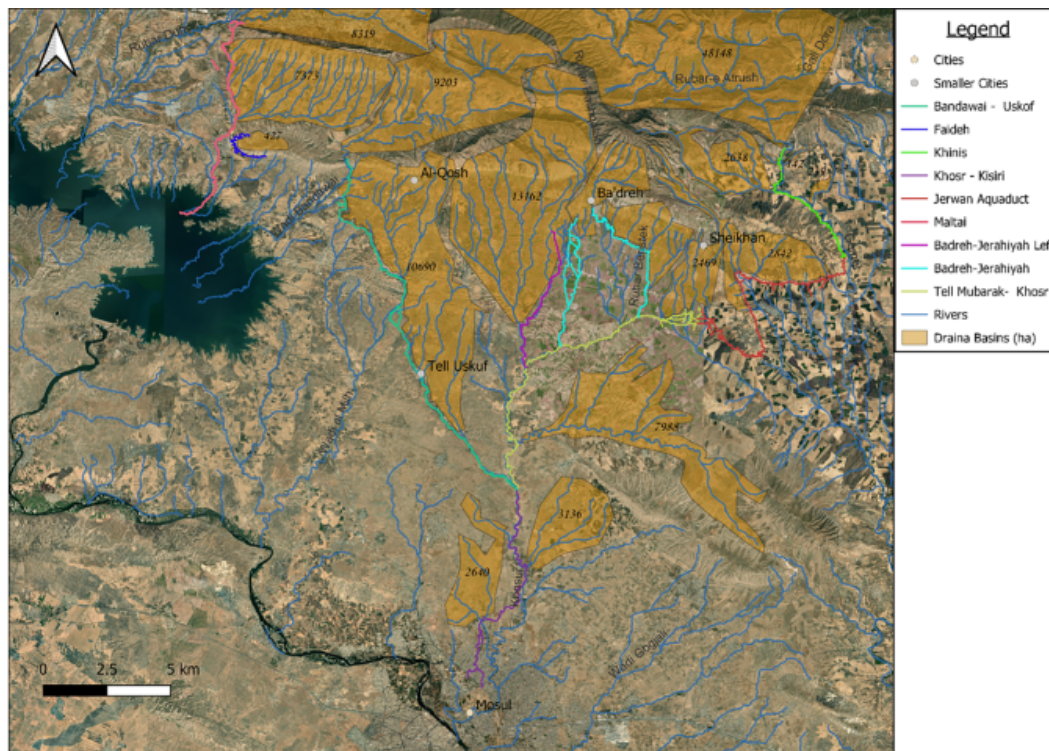


Figure 2. Khosr River basin within the wider Neo-Assyrian hydraulic landscape. The map identifies major canal systems and archaeological localities, including the Khosr/Kisiri system, Khinnis, Faideh, the Jerwan Aqueduct, and areas modeled as potentially irrigable. Source: adapted from Stampoultzidis et al. [9, p. 166].

Figure 2 shows why the Khosr should be interpreted regionally rather than as an isolated urban stream. Canal traces connect the Nineveh plain with water sources and hydraulic installations farther north and northeast. The distribution of Khinnis, Faideh, Jerwan, and other systems illustrates the geographical scale of the infrastructure required to move water across separate drainage zones toward the Assyrian heartland.

From the northeast, the Khosr flows toward Nineveh, enters the ancient city through its eastern side, and continues westward. Within the urban area the river bends around Tell Kuyunjik, one of Nineveh's principal archaeological mounds [16, p. 34]. This spatial relationship is visible in Figure 3.



Figure 3. Present-day satellite image showing the Khosr River bending around the southern and eastern vicinity of Tell Kuyunjik within the urban area of Mosul/Nineveh. The view illustrates the close spatial relationship between the river channel and the principal archaeological mound. Source: Google Earth.

Figure 3 is significant because Kuyunjik contained major royal and religious buildings. The river's immediate proximity

provided a water corridor that could be integrated into the urban landscape. The modern image also makes the sharp bend and constrained passage of the channel around the mound visually clear.

West of Kuyunjik, the Khosr continues through the urban area until it joins the Tigris near the Old Bridge. Figure 4 illustrates this confluence and demonstrates the downstream connection between Nineveh's internal river system and the major Tigris channel.



Figure 4. Present-day confluence of the Khosr River with the Tigris near the Old Bridge in Mosul. The Khosr approaches from the east and discharges into the larger Tigris channel, illustrating the downstream connection of Nineveh's internal river system. Source: Google Earth.

The Khosr was therefore both an internal watercourse of Nineveh and a tributary of the Tigris system. This relationship helps explain why water management involved not only increasing the supply entering the city but also controlling the movement and discharge of water through the urban landscape.

The river also had a long textual identity. Middle Assyrian and Neo-Assyrian sources preserve forms of its name. During the reign of Tukulti-apil-Esharra I, the river appears with the river determinative in the form *ID ū-si-ir* [1, pp. 55, 67–68]; Neo-Assyrian sources preserve the closely related form *ID ū-su-ri* [12, p. 161]. These attestations indicate that the Khosr was already embedded in Assyrian geographical and administrative vocabulary before Sennacherib's major hydraulic works.

Later interpretations have sought to explain the etymology of the modern name. One proposal connects *Khawsar* with an Aramaic expression interpreted as “eleven,” possibly referring to a traditional count of water sources [14, p. 373]. Because Akkadian and Aramaic belong to the Semitic language family, later reinterpretation or linguistic continuity is possible [17, p. 160]. The exact derivation nevertheless remains uncertain, and the continuity of the river as a named geographic feature is more secure than any single etymological explanation.

4. SENNACHERIB'S HYDRAULIC TRANSFORMATION OF THE KHOSR SYSTEM

The seasonal limitations of the Khosr made hydraulic augmentation essential. Assyrian engineers therefore sought additional water from springs and neighboring drainage systems. Sennacherib describes an expedition to the Musri Mountains, where springs near the cities of Dur-Ishtar, Shibaniba, and Sulu were enlarged and their waters directed toward the Khosr:

“Near the cities of Dur-Ishtar, Shibaniba, and Sulu, I discovered springs; I expanded them into rivers and channeled their waters into the Khosr River.” [2, pp. 114–115]

The Musri Mountains are generally associated with the Bashiqa region, where several springs are known [7, p. 323]. Historical-geographical research has proposed identifications for the ancient settlements named in the inscription: Dur-Ishtar has been associated with the Bakhzani/Bahzani area, Shibaniba with Tell Billa, and Sulu with a nearby site north of Bahzani [12, pp. 173–189]. These identifications help reconstruct the eastern and northeastern source zone from which additional water could be collected and redirected toward Nineveh.

Sennacherib also records a wider network of channels:

“I excavated eighteen canals to channel water into the Khosr River ... gathering these waters together and directing them toward the great capital—the seat of my kingship.” [2, pp. 149–150]

The water-supply strategy therefore did not depend on a single spring, dam, or canal. It integrated multiple sources and watercourses into a controlled network whose purpose was to increase the dependable flow reaching the capital. This is an important distinction: Sennacherib did not simply improve the Khosr itself; he transformed the river into part of a regional collection and distribution system.

One of the earliest major phases was the Kisiri canal, which drew water from the Khosr upstream of Nineveh and conveyed it toward the plain north of the city. Reade associated the head of this system with the ancient dam or regulating structure at al-Shallalat, while satellite-based reconstruction has traced much of the canal's course [6, p. 64]; [7, pp. 321–324]. The wider hydraulic program developed through successive phases between the early years of Sennacherib's reign and approximately 688 BC. These included the Kisiri works, the enlargement and capture of springs in the Bashiqa/Musri region, and the later incorporation of more distant canal systems into the water supply of the Nineveh plain [7–9].

Figure 5 provides a synoptic view of the regional network and demonstrates the scale of the hydraulic landscape associated with Nineveh.

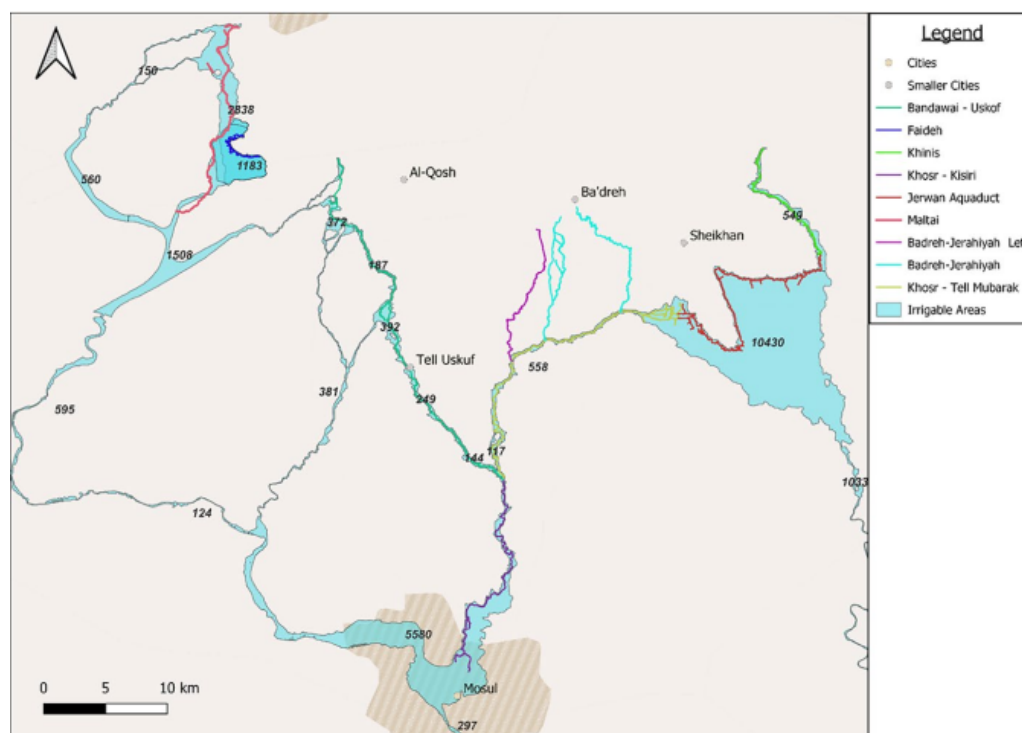


Figure 5. Regional reconstruction of the canal network associated with the water supply of Nineveh. The figure distinguishes major canal segments and hydraulic installations and also indicates modeled irrigable zones, illustrating how water was transferred from northern and northeastern catchments toward the Nineveh region. Source: Stampoulzidis et al. [9, p. 171].

Figure 5 shows that the hydraulic network consisted of several geographically distinct canal groups rather than one continuous artificial channel. Their convergence toward the Nineveh region supports the interpretation of the Khosr as a receiving and distributing component within a broader state-organized water landscape.

The later phases are associated with monuments and inscriptions at Bavian/Khinnis and with canal segments identified archaeologically across the wider Assyrian landscape. Morandi Bonacossi discusses canals that crossed drainage basins and conveyed water through the Bandwaya and Wadi al-Milh systems toward tributaries connected with the Nineveh region [8, p. 91]. Oates had already identified major parts of this northern cross-watershed network, while later remote-sensing work refined the route and relationship of the canal traces [5, pp. 49–52]; [7, pp. 330–335]. The ability to transfer water across drainage boundaries demonstrates the level of planning required to combine natural channels with artificial infrastructure.

The monumental setting at Khinnis/Bavian also reveals the ideological dimension of the hydraulic program. Reliefs and inscriptions were placed in direct association with the canal landscape, transforming water management into a visible statement of royal authority. Figure 6 illustrates this relationship.

The importance of Figure 6 is therefore more than illustrative. The placement of monumental imagery beside the hydraulic system physically connected royal commemoration with engineered water. The broader relief program presents Sennacherib in relation to Assyrian deities and divine symbols, while the Bavian inscription commemorates the waterworks themselves [7, pp. 335–339]; [8, pp. 92–96]. Infrastructure, kingship, religion, and landscape were thus integrated in a single political and visual program.

Taken together, the inscriptions, archaeological remains, and mapped canal systems demonstrate that water security

in Nineveh depended on active management rather than on the natural Khosr alone. The river's seasonal variability was addressed by turning it into the receiving spine of a regional hydraulic system capable of capturing, transferring, regulating, and redistributing water.



Figure 6. Rock relief in the Khinnis/Bavian hydraulic landscape, part of the monumental program associated with Sennacherib's canal works. The reliefs at the site combine royal imagery with divine imagery and inscriptions commemorating the hydraulic project. Source of reproduced image: Abdul Rahman Younis [17, p. 170].

5. THE KHOSR RIVER AND THE MULTIDIMENSIONAL SUSTAINABILITY OF NINEVEH

5.1. AGRICULTURAL SUSTAINABILITY

Reliable water supply had direct consequences for agriculture. Sennacherib's inscriptions describe the agricultural lands around Nineveh as vulnerable because of their dependence on rainfall. One inscription states:

"The agricultural lands of the city of Nineveh lay neglected and barren; its people had no water to irrigate their crops, so they would lift their eyes to the heavens, imploring them for rain." [2, p. 149]

Rainfall remained important to northern Mesopotamian agriculture, but its seasonal and spatial variability limited the reliability of cultivation. Summer crops in particular required a more dependable supply than precipitation alone could provide. The development of canals and regulated watercourses therefore reduced agricultural dependence on seasonal rainfall and allowed water to be directed toward land that would otherwise remain vulnerable to drought.

Sennacherib explicitly connected hydraulic works with the reorganization of the agricultural landscape:

"I divided the flatlands surrounding my capital among the citizens for cultivation." [2, p. 162]

The significance of this passage lies in the relationship between water infrastructure and land use. Irrigation increased the practical value of land surrounding the capital and made it possible to incorporate wider areas into the productive landscape. Agricultural sustainability was therefore not only a matter of increasing water volume; it also involved redistributing water in ways that changed how land could be cultivated and managed.

The expansion of irrigable land was accompanied by the development of gardens around the royal capital. Sennacherib describes planting fruit-bearing and aromatic trees, including species associated with mountainous regions and southern Mesopotamia, and connects their survival with irrigation from the Khosr [2, p. 162]. The hydraulic system consequently supported orchards, royal gardens, specialized vegetation, and landscaped environments in addition to more conventional agricultural production.

The evidence for managed marshland further broadens this interpretation. Water was used to create wet environments planted with reeds and trees and inhabited by animals and birds. Such projects demonstrate that Assyrian hydraulic management could deliberately produce new ecological settings rather than simply irrigate existing fields. From the analytical perspective adopted here, agricultural sustainability therefore included food production, horticulture, landscape creation, and the controlled maintenance of water-dependent environments.

At the same time, the inscriptions present these achievements from the perspective of the king and should not be read as quantitative evidence for crop yields or the total area irrigated. The more defensible conclusion is that Sennacherib's hydraulic works reduced dependence on rainfall and expanded the range of landscapes that could be supplied with managed water.

5.2. URBAN SUSTAINABILITY

Sennacherib's selection of Nineveh as the principal royal capital initiated extensive rebuilding and expansion. The transformation included fortifications, palace construction on Tell Kuyunjik, roads, bridges, canals, and wider modifications to the urban landscape. Nadali emphasizes the enormous quantities of brick required by the building program [18, p. 1]. Such projects required dependable water not only for the population but also for the preparation of mudbrick and mortar, construction activities, labor forces, gardens, and associated services.

The relationship between urban expansion and water management is visible in royal inscriptions that juxtapose the enlargement of Nineveh with previously neglected fields and inadequate irrigation [4, p. 39]. Regulating the Khosr therefore served several urban purposes simultaneously. Water supply could support everyday consumption, construction, planted areas, and the broader reorganization of space associated with the new capital.

The Khosr also supported the royal built environment indirectly through irrigated vegetation. Sennacherib records the use of trees from gardens and marshland vegetation in palace construction:

"I felled mulberry and cypress trees—harvested from the gardens and from vegetation growing in the marshes—and used them in the construction of my royal palace." [2, p. 178]

This passage demonstrates a chain of dependence connecting hydraulic infrastructure, planted environments, raw materials, and monumental architecture. Water management thus contributed to construction not merely through the direct use of water in brickmaking but also by sustaining biological resources that could be harvested for building.

The urban role of the Khosr also had deeper historical roots. A Middle Assyrian inscription attributed to Tukulti-apil-Esharra I describes a canal dug from the Khosr to irrigate a royal garden [1, p. 162]. This evidence suggests that the use of the river for elite urban landscapes preceded Sennacherib, although his reign expanded the scale, regional integration, and political significance of the system.

Reliable water also had consequences for the livability and stability of the enlarged capital. A city containing royal palaces, religious institutions, administrative facilities, military personnel, craft production, and a substantial population required continuity of supply beyond a single season. By augmenting and regulating the Khosr, the Neo-Assyrian state reduced one of the major environmental constraints on metropolitan growth.

Urban sustainability in Nineveh can therefore be understood as a combination of supply, construction, landscape management, and spatial integration. The Khosr supported the city not through one isolated function but by linking water, materials, vegetation, infrastructure, and the everyday requirements of an imperial capital.

5.3. DEFENSIVE AND SECURITY SUSTAINABILITY

Watercourses could also be incorporated into defensive planning. In Mesopotamia, rivers, canals, wetlands, and moats could slow attacking forces, constrain movement, and create additional obstacles before city walls [19, pp. 321–322]. At Nineveh, the Khosr and associated channels formed part of this defensive landscape rather than serving exclusively as sources of domestic or agricultural water.

Sennacherib's modifications to the river system strengthened this potential. Ur's reconstruction of the Kisiri canal shows the channel approaching the northern corner of Nineveh and suggests that its water could have circulated around the northeastern and northwestern sides of the city through a moat visible in twentieth-century aerial imagery [7, pp. 322–324]. Al-Karawi likewise reconstructs channels connected with the Khosr that ran parallel to sections of the city walls and ultimately discharged either back into the river or toward the Tigris [14, p. 381].

The defensive significance of these channels should be stated carefully. Water barriers alone could not make Nineveh invulnerable, and the fall of the city in 612 BC demonstrates the limits of any single defensive system. Their value lay instead in shaping the terrain around the fortifications, restricting convenient approaches, and adding successive obstacles that an attacking force had to negotiate.

Security sustainability also included the capacity to maintain essential urban functions during periods of stress. A managed water system that supplied the city, gardens, and productive areas could contribute indirectly to resilience during mobilization or siege by reducing dependence on a single uncontrolled source. This function is difficult to quantify from the surviving evidence, but it reinforces the broader point that hydraulic infrastructure had strategic as well as economic and environmental significance.

The Khosr's security contribution was therefore dual. It helped sustain the urban population and productive landscape

while also forming part of a deliberately modified terrain of channels, moats, and wet barriers surrounding portions of the capital. Its defensive role should thus be interpreted as one component of an integrated urban system rather than as an independent military installation.

6. DISCUSSION

The evidence examined in this study suggests that the Khosr River should not be understood merely as a natural stream passing through Nineveh. Its historical significance resulted from the interaction between environmental setting, state organization, and hydraulic engineering. The natural river provided a foundation, but the resilience of the enlarged Neo-Assyrian capital depended on the ability to overcome its seasonal limitations through infrastructure.

The system operated through a sequence of interconnected interventions. Springs and tributaries increased the volume entering the network; canals moved water across the landscape; dams and regulating structures controlled flow; irrigated fields and gardens converted water into agricultural and ecological productivity; and urban channels linked supply with the built environment. The same landscape could also acquire defensive value where channels and moats shaped approaches to the fortifications.

This integrated interpretation also clarifies the central role of the Khosr within the wider canal system. Recent regional studies rightly emphasize that Sennacherib's waterworks extended far beyond the river itself [7–9]. Yet the Khosr remained crucial because it connected the wider hydraulic landscape to Nineveh. It functioned as both a natural watercourse and a managed infrastructural corridor through which additional water could be received, distributed, and eventually discharged toward the Tigris.

The royal inscriptions add a political dimension to this material landscape. Sennacherib repeatedly presented the discovery of water, excavation of canals, planting of gardens, reclamation of land, and rebuilding of Nineveh as achievements of kingship [2, 3]. The Khinnis/Bavian reliefs demonstrate that these claims were not confined to written texts: monumental imagery was placed directly within the hydraulic landscape. Water management therefore became part of the visual and ideological representation of royal power.

At the same time, the evidence has limits. Royal inscriptions emphasize achievement and rarely record failure, maintenance costs, labor burdens, or conflicts over access to water. Modern satellite imagery documents present topography and archaeological traces but cannot reproduce the ancient landscape in every detail. The sustainability interpretation offered here must therefore remain analytical rather than literal. It identifies long-term functional relationships without assuming that Assyrian planners employed modern concepts of sustainability or that the surviving evidence permits precise quantitative reconstruction of every hydraulic effect.

Within these limits, Nineveh provides a strong example of integrated urban resource management in a seasonally constrained environment. The effectiveness of the capital depended on coordinated management of water, land, food production, construction resources, landscape, and security. The Khosr system demonstrates that resilience was produced not by natural resources alone but by the institutional capacity to organize, redistribute, and maintain them.

7. CONCLUSIONS

The Khosr River was a central element of the environmental and infrastructural system that sustained Nineveh during the Neo-Assyrian period. Its importance did not derive from natural flow alone. Seasonal variability created a constraint that the Assyrian state addressed through a large hydraulic program incorporating springs, canals, dams, regulating structures, and cross-watershed water transfer.

These works strengthened water security by increasing and regulating the supply reaching the capital. They supported agriculture by reducing dependence on rainfall and by extending managed water to fields, gardens, orchards, and wetland environments. They contributed to urban sustainability by supporting construction, planted landscapes, raw-material production, and the everyday needs of an enlarged imperial capital. They also shaped parts of the defensive landscape through canals, moats, and wet barriers.

The principal contribution of this study is therefore to interpret the Khosr as an integrative element within the wider Nineveh hydraulic system. The river linked regional water collection with urban distribution and connected environmental resources to agricultural, architectural, political, and military functions. This integrated role explains why the Khosr cannot be reduced to a local tributary of the Tigris.

Seen through the carefully qualified analytical lens of sustainability, Sennacherib's hydraulic program illustrates how long-term urban resilience could depend on the systematic management of a variable natural resource. Nineveh's development was supported not simply by access to water, but by the capacity of the Neo-Assyrian state to reorganize the landscape so that water could be captured, transferred, controlled, and used across multiple sectors of urban life.

Future research can develop this interpretation through more detailed hydraulic modeling, archaeological investigation of canal chronologies and maintenance phases, analysis of agricultural catchments, and comparison with other Neo-

Assyrian capitals. Such work would help determine more precisely how the Nineveh system changed over time and how far its different branches functioned simultaneously.

AUTHOR CONTRIBUTIONS

All authors contributed to the conception and development of the study, reviewed the manuscript critically, approved the final version, and agreed to be accountable for all aspects of the work.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

FUNDING

This research received no external funding.

DATA AVAILABILITY

No new empirical dataset was generated for this historical study. The analysis is based on the textual, archaeological, geographical, and published sources cited in the manuscript.

DECLARATION OF GENERATIVE AI AND AI-ASSISTED TECHNOLOGIES IN THE WRITING PROCESS

During the preparation of this manuscript, the authors used ChatGPT to assist with English-language editing, readability, and the organization of the manuscript. After using this tool, the authors reviewed and revised the text, verified the scholarly content and references, and take full responsibility for the final content of the manuscript.

REFERENCES

- [1] Grayson, A. Kirk. *Assyrian Rulers of the Early First Millennium BC I (1114–859 BC)*. The Royal Inscriptions of Mesopotamia: Assyrian Periods, vol. 2, University of Toronto Press, 1991.
- [2] Luckenbill, Daniel David. *Ancient Records of Assyria and Babylonia. Vol. II: Historical Records of Assyria from Sargon to the End*. University of Chicago Press, 1927.
- [3] Grayson, A. Kirk, and Jamie Novotny. *The Royal Inscriptions of Sennacherib, King of Assyria (704–681 BC), Part 1*. Royal Inscriptions of the Neo-Assyrian Period, vol. 3/1, Eisenbrauns, 2012.
- [4] Jacobsen, Thorkild, and Seton Lloyd. *Sennacherib's Aqueduct at Jerwan*. Oriental Institute Publications, vol. 24, University of Chicago Press, 1935.
- [5] Oates, David. *Studies in the Ancient History of Northern Iraq*. Published for the British Academy by Oxford University Press, 1968.
- [6] Reade, Julian E. "Studies in Assyrian Geography, Part I: Sennacherib and the Waters of Nineveh." *Revue d'Assyriologie et d'Archéologie Orientale*, vol. 72, no. 1, 1978, pp. 47–72.
- [7] Ur, Jason A. "Sennacherib's Northern Assyrian Canals: New Insights from Satellite Imagery and Aerial Photography." *Iraq*, vol. 67, no. 1, 2005, pp. 317–345.
- [8] Morandi Bonacossi, Daniele. "Water for Nineveh: The Nineveh Irrigation System in the Regional Context of the 'Assyrian Triangle': A First Geoarchaeological Assessment." *Water for Assyria*, edited by Hartmut Kühne, Studia Chaburensia, vol. 7, Harrassowitz Verlag, 2018, pp. 77–116.
- [9] Stampoultzidis, A., et al. "The Fluidity of Empire: Hydraulics of Neo-Assyrian Canal Systems in Relation to Their Possible Uses." *Water History*, vol. 16, 2024, pp. 165–185.
- [10] Abu Al-Nasr, Medhat Mohamed Mahmoud. "Social Sustainability: Definition, Aims, Dimensions, Principles and Indicators." *Arab Journal of Arts and Humanities*, vol. 8, no. 30, 2024, pp. 373–392.
- [11] Senousy, Warda Ali. "Environmental Sustainability and Sustainable Development." *Scientific Journal of Social Work–Aswan*, vol. 6, no. 2, 2025, pp. 108–121.

-
- [12] Hanoun, Nael. *Ancient Cities and Archaeological Sites: A Study in the Historical Geography of Northern Iraq during the Assyrian Periods*. Dar Al-Zaman for Printing and Publishing, 2009.
 - [13] Al-Hussein, Asaad A. Muqdad, Mohammed Ali Mohammed Sulaiman, and Noor Talal Al-Tae. "Morphometric Characteristics of Al-Khoser River Basin by Using GIS / Mosul-Iraq." *Kirkuk University Journal for Scientific Studies*, vol. 17, no. 3, 2022, pp. 7–16.
 - [14] Al-Karawi, Ru'a Zuhair Zaidan. "The Khosr River in Nineveh in Light of Remote Sensing Technology." *Journal of Arab Scientific Heritage*, no. 1, 2016, pp. 371–402.
 - [15] Al-Hamdani, Mahmoud Shawqi. *Glimpses of the Development of Irrigation in Iraq: Ancient and Modern*. Al-Saadoun Press, 1984.
 - [16] Madhloom, Tariq Abdul-Wahab, and Ali M. Mahdi. *Nineveh*. Historical Monuments in Iraq, vol. 4, Republic of Iraq, Ministry of Information, Directorate General of Antiquities, 1976.
 - [17] Abdul Rahman Younis Abdul Rahman. "Al-Khawser River in Cuneiform Sources." *Athar Al-Rafidain*, vol. 1, no. 1, 2012, pp. 158–176.
 - [18] Nadali, Davide. "Bricks in Nineveh." *Encyclopaedia of the History of Science, Technology, and Medicine in Non-Western Cultures*, edited by Helaine Selin, Springer, 2014, pp. 1–4.
 - [19] Al-Khatib, Abdul Rahman Younis Abdul Rahman. *Water in the Civilization of Mesopotamia*. 1st ed., Bayt Al-Hikma, 2014.