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Conserving the Memory of Hammurabi: A Sustainable Model for Ancient Heritage Management at the Old Babylonian Site of Tell Muhammad, Iraq

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Abstract

An archaeological project requires a complex heritage management approach that includes excavation, scientific research, conservation of unearthed objects, protection of the site's architecture, and, finally, public engagement. Based on these premises, the Baghdad Urban Archaeological Project aims to create a model for Ancient Heritage Management that includes the research, conservation, and public outreach at the Old Babylonian site of Tell Muhammad, located in the southern suburbs of Baghdad (Iraq). In so doing, thanks to the recovery at the site during the mid-19th century of objects with inscriptions related to Hammurabi (1810–1750 BCE), the sixth king of the First Dynasty of Babylon, the project attempts to conserve and promote this fundamental period in the history of ancient Mesopotamia by applying a sustainable model of management of archaeological heritage.

Keywords: Mesopotamia; Hammurabi; adobe architecture; ancient heritage management; Tell Muhammad; architectural conservation; memory

1. Introduction

Hammurabi of Babylon (c. 1810–1750 BCE) is a key figure in the history of mankind, as he created one of the first empires and promulgated the famous Code of Hammurabi, which is widely considered one of the first examples of a structured legal text in human history [1,2]. His figure is also associated with the rise of a powerful empire that briefly controlled Mesopotamia. For all these deeds, he became a point of reference in the history of ancient Mesopotamia, both in antiquity and in modern times.

The Baghdad Urban Archaeological Project (BUAP) launched a long-term initiative in 2022, in collaboration with the Iraqi State Board of Antiquities and Heritage (SBAH), aiming to revisit the memory of this period (i.e., the Old Babylonian period) through the excavation and restoration of adobe vestiges at the site of Tell Muhammad, located along the eastern bank of the Tigris River in the southern suburbs of Baghdad, Iraq (Figure 1). To achieve this goal, the project—thanks to the financial support of the University of Catania, the PNRR "Changes" program, and the Italian Ministry of Foreign Affairs and International Cooperation—sought to establish a sustainable model for Ancient Heritage Management (AHM), to reconstruct a portion of Mesopotamian history in which archaeological research,

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architectural conservation as well as public engagement and outreach are included through a combination of:

- Archaeological excavation at the site of Tell Muhammad, where in the 1850s Captain Felix Jones and Sir Austen Henry Layard discovered copper-alloy mace-heads with inscriptions referring to a possible "palace of Hammurabi" [3];
- Restoration of the adobe architecture uncovered during excavations conducted both in the 1850s and, especially, in the 1970s and 1980s by an Iraqi team from the SBAH [4,5], through a sustainable architectural conservation program carried out in collaboration with an expert in mudbrick architecture (i.e., Claudio Prosperi Porta);
- Planning of an archaeological park at the site of Tell Muhammad, dedicated to the time of Hammurabi, to foster a sense of historical continuity with ancient Mesopotamia for both local and international visitors;
- Public outreach associated with the project's activities through a temporary exhibition at the *Museo dei Saperi e delle Mirabilia Siciliane* of the University of Catania in 2024–2025 [6].

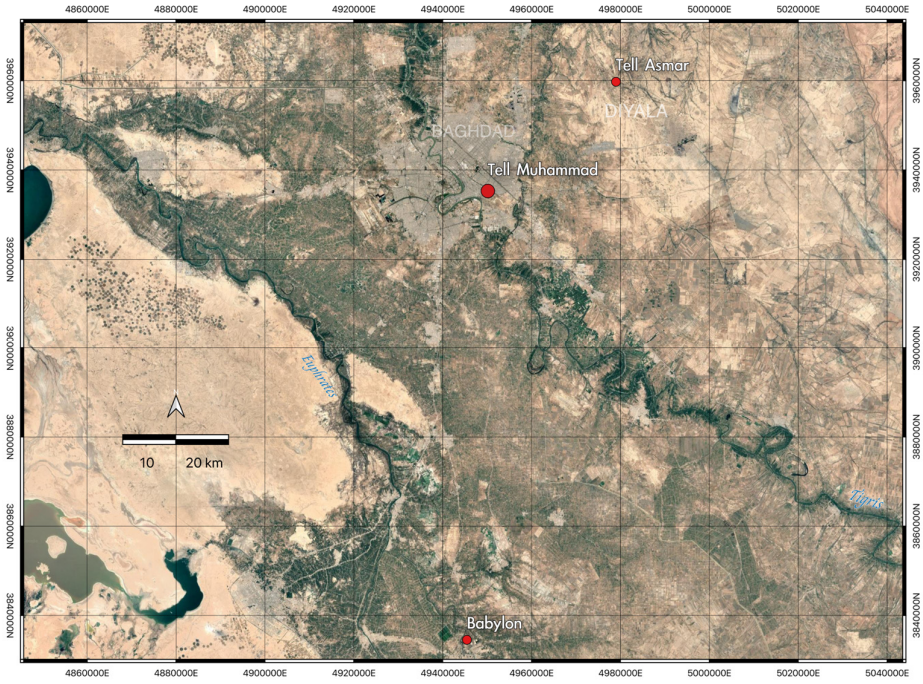


Figure 1. Map of Iraq highlighting the location of Tell Muhammad along the river Tigris (graphic elaboration by A. Borgesi and A. Mendola based on a basic image taken from Google Earth).

Such a model is undoubtedly complex; nevertheless, it has the potential to evolve into an innovative research model that establishes a solid framework, supporting the development of a stronger sense of AHM through the involvement of local stakeholders and the general public. This, in turn, will benefit current and future generations of scholars and students, as well as local communities and the wider public, through the creation of a tourist attraction and a program aimed at re-establishing traditional practices that are gradually disappearing (e.g., mudbrick making).

The importance of promoting a sustainable program of AHM at Tell Muhammad is aligned with an ongoing debate on heritage management, and especially on how to deal with archaeological contexts marked by the presence of perishable adobe architecture, particularly in politically sensitive and climatically vulnerable contexts such as Iraq.

2. Conceptual Background: Why Doing Archaeology? From Excavation to Public Engagement: Applying an Ancient Heritage Management Model in Context

One of the main questions that arises when starting an archaeological project is: Why are we doing archaeology? This basic question is terrifying if there is not a complete plan that involves not only research questions, but also a model that requires a more complex vision that entangles archaeologists within the broader Cultural Resource Management (CRM) arena [7]. In fact, a twenty-first-century approach to CRM envisions a project involving ancient heritage sites as more of a business than just scientific research [8]. Adopting such a perspective consists of an idea of archaeology and ancient heritage in which the stakeholders involved are not only scientifically oriented but, most importantly, are keen to know about ancient pasts through implementing a coherent model for Ancient Heritage Management (AHM). As recently pointed out by Belford and Wait [9], "doing or practicing archaeology must add to the 'sum of human knowledge' and increasingly in the twenty-first century must also contribute to the well-being and sustainability of (local?) communities and societies today" (p. 27). Viewed through these holistic lenses, and with half a century of worldwide experience in the field of CRM, archaeology is a reasonable path toward a better understanding of how the past can be useful for the present. It can support the societies of the future in a hyper-technological environment [10].

The main objective of this paper is thus to present an AHM model for dealing with a large excavation project in an urban area (i.e., Baghdad) that can be transformed into a sustainable long-term initiative [11]. For a CRM project to be sustainable and fruitful, it requires a solid program that engages all the stakeholders involved (i.e., scholars, the general public, NGOs, etc.) because, as stated by the 1972 World Heritage Convention [12], the fundamental principle behind ancient sites is that they belong to all peoples of the world, not merely to the territories in which they lie, and they serve the purpose of promoting global solidarity and collective responsibility for their preservation. However, there can be no preservation without a shared awareness of their historical value. Thus, research on ancient heritage must aim not only at establishing and validating the scientific reliability of data interpretation, but above all at connecting that "remote past" with our present life. Such an approach will fulfil the objective of preserving this heritage, as it will not rely on a top-down elitist model, but rather on a process of circularity that—similar to the principles of the circular economy—will enrich the lives of local communities inhabiting those territories as well as the general public interested in the topic (Figure 2).

Thus, our AHM model to be successful, sustainable and replicable has to be based on the following foundations:

(1) Rigorous scientific research through archaeological excavation, bibliographic research, publications, data storage, and analyses;
(2) Archaeological and architectural conservation;
(3) Involvement of local stakeholders for recognizing the importance of the site as ancient heritage for the communities as well as for tourism through, for example, the creation of an archaeological park at the site;
(4) Public engagement through the creation of historical reconstruction as well as temporary exhibits useful for promoting the historical importance of the ancient heritage within a broader local as well as international general public.

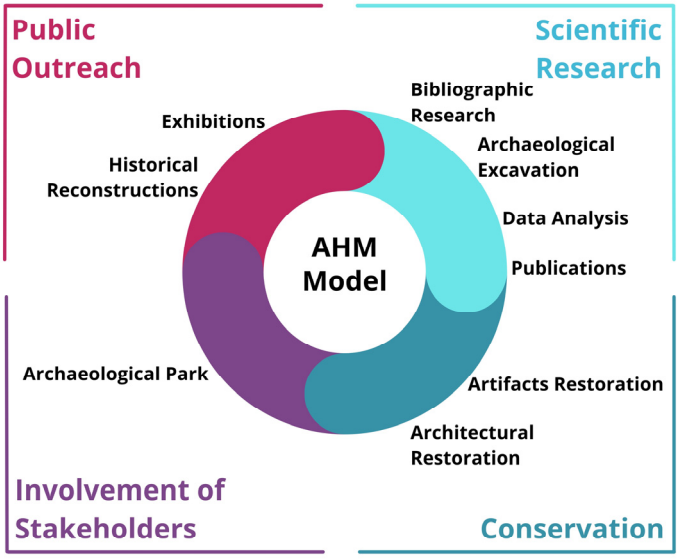


Figure 2. Chart of the Ancient Heritage Management (AHM) model applied by the Baghdad Urban Archaeological Project (BUAP) at Tell Muhammad, Baghdad (Iraq) (graphic elaboration by C. Pappalardo).

3. Materials and Methods: A Sustainable Model for Researching, Preserving, and Promoting Ancient Mesopotamian Heritage

It is with this perspective in mind that we structured the methodological framework of the Baghdad Urban Archaeological Project (BUAP), which is based upon an important ancient Mesopotamian site, i.e., Tell Muhammad, located along the Tigris River in the southern suburbs of the modern capital of Iraq, Baghdad. Today, the site consists of a mounded area of ca. 2.5 hectares, but originally the settlement must have extended to about 24 hectares, making Tell Muhammad a pivotal settlement along the Tigris River during the Old Babylonian period (i.e., ca. 2000–1600 BCE) [13].

After resuming excavation at the site in 2022, the BUAP, together with the SBAH of Iraq, planned a long-term project aiming to preserve the archaeological remains at the site as part of a broader network of archaeological sites in the greater Baghdad area and the Diyala province (including also Tell Harmal and Tell Asmar), to narrate to the general public an important moment in the history of ancient Mesopotamia: the Old Babylonian period marked by King Hammurabi.

As previously mentioned, the site of Tell Muhammad is located in the suburbs of Baghdad, and the political turmoil that occurred in Iraq during the first decades of the 21st century, as well as climate changes, have affected its condition. The importance of the site has been recognized both by the local authorities (i.e., the SBAH) and UNESCO, considering it together with the nearby site of Tell Harmal as pivotal for future interventions.

At the beginning of the project, the condition of the previously excavated rammed earth structures necessitated their preliminary cleaning and a conservation analysis, which subsequently enabled the development of a conservation plan. Regarding the archaeological excavation, previous field missions in the 1970s and 1980s had highlighted the importance of the sacred area, but had not clarified aspects related to the fortification system and production activities during the Old Babylonian period.

Furthermore, the site's location and its visibility within central Baghdad prompted the local authorities (i.e., the SBAH and the municipality of Baghdad) to undertake a broader intervention that would enhance the historical importance of the archaeological heritage and, consequently, promote it both locally and within tourism programs.

4. Results: Applying an Ancient Heritage Management (AHM) Model at Tell Muhammad, Baghdad (Iraq)

To protect the ancient heritage of Tell Muhammad and propose a sustainable AHM model, the BUAP has planned a long-term project, which will end in 2027, aiming at:

1. Continuing the excavation and research at the ancient site of Tell Muhammad;
2. Conserving the archaeological and adobe architectural remains;
3. Establishing, together with the local authorities, an archaeological park in the city of Baghdad to present the results of the archaeological project to a broader public;
4. Creating a broader framework for public engagement through events.

4.1. The Archaeological Excavation and Scientific Research

The first step of the BUAP was dedicated to resuming archaeological excavations at Tell Muhammad after almost three decades. Between 1977 and 1985, with a final season in 1999, SBAH archaeologists brought to light a sacred area together with the urban layout of Levels II and III on top of the mound [4]. The University of Catania team resumed excavations in 2022 in the north-western section of Tell Muhammad, focusing on the fortification wall and the city gate protruding along a canal (Figure 3) [14].

Figure 3. Aerial view of the site of Tell Muhammad from the north (photo from BUAP archive).

The stratigraphy suggests a major expansion during the nineteenth century BCE (i.e., Level IV), continuity during Level III (i.e., ca. eighteenth–seventeenth century BCE), and a final phase (i.e., Level II, second half of the seventeenth/sixteenth century BCE) during which the site shrank (Figure 4). Level III is characterized by pyrotechnological activities, as demonstrated by the presence of kilns, metal production areas, and a large kitchen facility.

Of great interest is the constant presence of graves—mostly infants—buried beneath building floors. In particular, one room dated to Levels III–IV, located in the corner of a building next to the main city gate, contained five jar burials of infants and one large mudbrick corbel-vaulted cist grave with an adult individual accompanied by two ceramic goblets, which represent standard funerary goods during the Old Babylonian period (Figure 5). In this unique room, an altar with miniature vessels next to it was found, demonstrating the use of specific locales dedicated to the cult of the ancestors, which is also known from ancient Mesopotamian written sources.

Phase	Sub-phase	Chronology	Period	Archaeological evidences
I	-	1600–1200 BCE	Kassite	Scattered pottery, pot burials, cist graves
II	-	1700–1600 BCE	Late old Babylonian	Tannurs, reused walls and roads, pot burials, pottery, figurines
III	IIIa	1800-1700 BCE	Middle Old Babylonian	Metal production areas, tannurs and kilns, reused buildings and fortification wall and gate, burials, pottery, figurines
	IIIb			
	IIIc			
IV	IVa	1900–1800 BCE	Early Old Babylonian	Cemetery buildings, fortification wall and gate, drainage pipe, toilet, stairs, cistern, pottery, figurines
	IVb			

Figure 4. Phasing of the Old Babylonian occupation at Tell Muhammad (graphic elaboration by R. Mammana).

Figure 5. Burial of an adult individual found inside a room dedicated to the cult of the ancestors at Tell Muhammad (photo from BUAP archive).

Moreover, ongoing scientific research on the use of fire, as well as on human, faunal, and botanical remains, will establish a clearer picture of modes of production, paleodiet, and overall societal organization. The presence of written cuneiform tablets from previous

excavations at the site, together with other historical sources from the Old Babylonian period, will further support the outcome of the scientific research.

The occupation at Tell Muhammad is enclosed within a crucial period in the history of ancient Mesopotamia and of mankind, namely the advent of the First Dynasty of Babylon, characterized by its sixth king, Hammurabi. It was during this period that conflicts between Babylon and Eshnunna (located near the Diyala River, about 40 km east of Tell Muhammad) intensified until, in the thirty-eighth year of his reign, Hammurabi destroyed Eshnunna by means of a great flood [2] (p. 52). The area along the Tigris River was a frontier zone, originally under the control and cultural influence of Eshnunna, as evidenced by the Laws of Eshnunna found among the tablets excavated at Tell Harmal (ancient Shaduppum), located only a few hundred meters from Tell Muhammad [15]. This legal text is similar to the Code of Hammurabi and is most probably dated to the kings of Eshnuna, Bilalama and Dadusha, contemporaneous with Hammurabi or slightly earlier [16,17]. Together with the remarkable level of scientific knowledge (especially in mathematics and geometry) evident in the over 1700 tablets found at Tell Harmal, the creation of structured legal texts that would later form the foundation for future developments (as in the case of Biblical and later Roman law) demonstrates the importance of this period in the development of mankind within the broader context of ancient Mesopotamia.

The presentation of scientific results in scientific journals, as well as at international conferences, has increased interest in the Tell Muhammad site, which has led to the organization of a conference dedicated to the Old Babylonian period at the University of Catania in 2024 in collaboration with the Chronoi project of the Free University of Berlin.

4.2. The Conservation of the Adobe Architecture

After the archaeological excavation and associated scientific research, the second step is to take care of the architecture brought to light throughout the process, as well as the architecture still visible from previous work at the site. Due to the lack of stone, the architecture of ancient Mesopotamia is characterized by the extensive use of earthen structures, primarily built with mudbricks made from a combination of mud and straw [18,19]. This type of architecture is highly perishable and can be easily damaged by external factors (i.e., weathering, animal and human activities, disturbance caused by looting and trashing, as well as climate change and air pollution) that are difficult to prevent or predict [20–22].

At Tell Muhammad, this is particularly evident in the Level II architecture unearthed by the Iraqi team during the last century. In addition, the area around Tell Muhammad was heavily disturbed between 2003 and the subsequent years of political unrest, until about a decade ago, when the SBAH was able to re-fence the area.

Starting in 2024, a detailed conservation program was implemented together with the SBAH. With the support of Mr. Claudio Prosperi Porta, the program aimed at analyzing and documenting the state of degradation of the exposed architecture through autoptic monitoring; observation of degradation patterns through satellite imagery and old photographs taken by the Iraqi team; drone flights to reconstruct architectural models using photogrammetric methods; and analysis of mudbrick samples. A fundamental part of this work was the construction of a robust historical climate database focused on historical climate series (temperature, precipitation, extreme events), variables and indices, and a set of relevant climatological variables such as heavy rainfall, duration of dry events, etc.

Following this program, surveys of degradation phenomena were conducted, producing graphic maps of decay in accordance with the international ICOMOS-ISCS terminology on degradation phenomena and processes [23]. After creating a 3D model of the Sacred Area Temple over the past two years, each façade was drawn using recognizable decay patterns and colors (an example is visible in Figure 6).

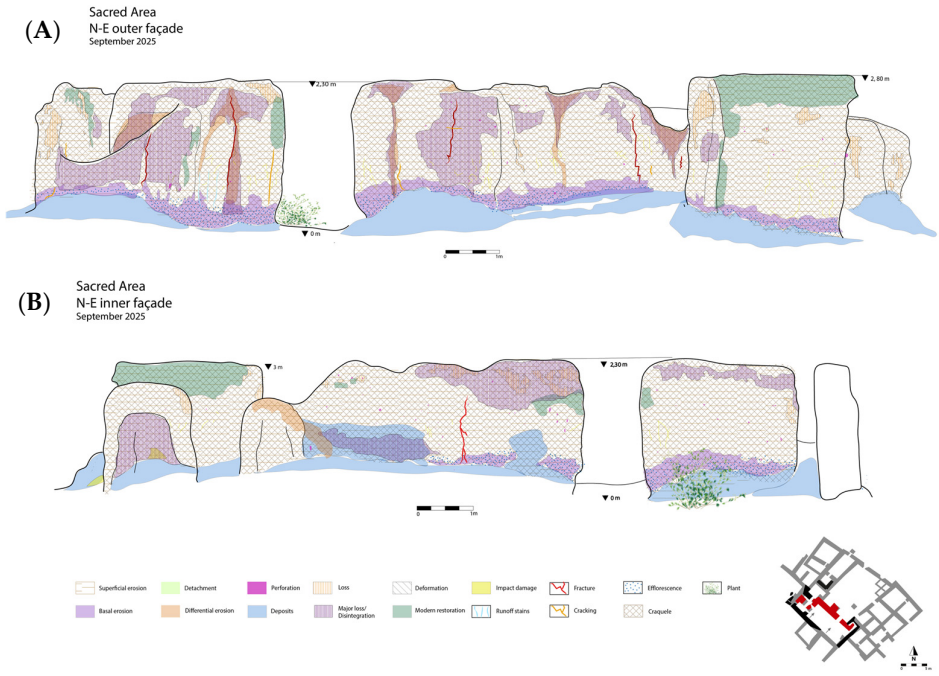


Figure 6. Maps of degradation phenomena affecting the north-east wall of the sacred area: (**A**) outer face; (**B**) inner face (graphic elaboration by R. Mammana).

Overall, the walls show significant damage in terms of surface erosion and extensive craquelure, together with basal erosion affecting almost the entire bottom of every wall. In the comparison between 2024 and 2025, a major loss of earthen material was detected, and impact damage appears significantly exacerbated due to continued animal access to the site (particularly dogs and cows). Additionally, the reduction in the basal portions of wall units constitutes a major hazard and must therefore be considered a priority in the conservation intervention.

Preliminary grain-size characterization (clay-silt-sand ternary diagram) indicates a predominantly silty-clayey fabric with a very low sand fraction (i.e., within the "mud" field). Such a fine-grained microstructure commonly implies an open-porosity system dominated by small pore throats: capillary uptake is primarily controlled by pore-size distribution and connectivity, while permeability/transport rates may remain low. Under wetting-drying cycles, capillary rise and evaporation can promote the redistribution of saline solutions toward the evaporation front, favoring salt accumulation and precipitation.

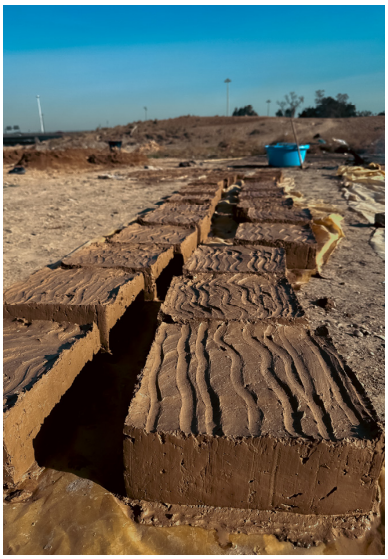
Chemical data from aqueous extracts show consistently alkaline conditions (pH 8.62–8.89) and variable dissolved load (TDS 190–1900 ppm; EC 430–4110 µS/cm). The upper-end EC values (up to 4.11 mS/cm) are in the same order of magnitude as commonly used "salinity" criteria in extract-based classifications, while acknowledging that thresholds depend on the adopted extraction protocol. In conservation terms, these data support a non-negligible presence of soluble salt in several samples to be further constrained by salt speciation/quantification following standardized approaches (e.g., EN 16455 [24] and ion/mineralogical analyses).

Thus, from a conservation perspective, the main risk factor is the crystallization/dissolution cycling of salts [25–27] and, depending on the salt assemblage, hydration/dehydration transitions, which can generate damaging stress in fine-pored earthen materials when crystallization occurs within the pore network. The silty clay texture also makes the system particularly sensitive to moisture gradients: when the evaporation front is located at/near the surface, efflorescence is favored, whereas inward displacement of the evaporation front promotes subflorescence, typically associated with higher material loss.

This study on Old Babylonian architecture and conservation methods is underway and is being carried out by the PhD student Rachele Mammana. In addition to examining bricklaying techniques (including mortar types and the use of fired or semi-fired bricks), mudbrick dimensions (33 cm × 33 cm × 9 cm in the settlement overall; 36 cm × 36 cm × 9 cm in the sacred area), and ancient restoration methods, the research aims to estimate and compare risks where reliable historical data on past interventions and deterioration conditions are lacking, combining condition assessment and machine learning systems.

Based on this preliminary study, the second phase of intervention at the site consists of reshaping mudbricks and preparing plaster to be used for the protection and restoration of the ancient architecture (Figure 7B). In doing so, local knowledge of mudbrick production and the recipes traditionally used by Iraqi teams will be taken into consideration, together with the expertise of scientists and architectural conservators, who will share with local specialists from the SBAH their knowledge and explore sustainable strategies for the long-term protection of earthen adobe.

(**A**)



(**B**)

(**C**)

Figure 7. Restoration activities at Tell Muhammad including the protection of existing adobe architecture (**A**), the actual making of mudbricks (**B**) and the creation of a canal for water collection through the installation of a rainwater collecting pipe (**C**) (all photos from BUAP archive).

The final step will be, in accordance with SBAH experts' requests, the implementation of a roofing system—designed by the Carlo Pianosi Co. (Rome, Italy) architectural firm—to protect the two main areas of adobe architecture at Tell Muhammad from atmospheric agents (i.e., the sacred area excavated by the Iraqi team and the area with the fortifications and western section of the ancient settlement excavated by the University of Catania team between 2022 and 2025).

Together with the roofing of the architecture, a water canalization system has been implemented and planned, using a combination of traditional earthen canals, regular pipes, and specialized agricultural pipes to collect rainfall and prevent water damage to the adobe architecture (Figure 7C). All these elements aim to create the ideal conditions for establishing, in collaboration with the SBAH and local authorities, an archaeological park that will revive the memory of the time of Hammurabi in Baghdad.

4.3. Public Engagement and Involvement of Local Stakeholders: A Plan for the Tell Muhammad Archaeological Park

One fundamental step in the process of protecting ancient heritage is public engagement. As correctly noted recently [9] (p. 27), the general public ranks highly among the stakeholders involved in the CRM arena. Thus, the creation of a stable and sustainable park at the archaeological site of Tell Muhammad—accessible to both locals and tourists—can increase public engagement and raise awareness of the importance of ancient histories within a unique archaeological context.

While museums attract public attention and contribute to establishing a more coherent historical timeline of a place, it is through the creation of an open-air archaeological museum, displaying historical remains in situ, that the memory of a civilization can be truly grounded by creating *lieux de mémoire* for society at large [28].

At Tell Muhammad, the location of the site in a developing area within a southern suburb of Baghdad presents considerable challenges. However, its position underneath the crossroads of two major highways (i.e., Muhammad Ibn Al-Qasim Highway and Doura Expressway) transforms a potential obstacle into an opportunity for visibility, as the archaeological site is observed by thousands of people daily.

Based on these premises, we planned a park centered on the visibility of the two main archaeological areas (i.e., the fortification wall, gate, and annexed neighborhoods—Area D—and the sacred area). In collaboration with the Department of Heritage Protection of the SBAH and the Municipality of Karrada, we planned the re-opening of an old road running between Muhammad Ibn Al-Qasim Highway and the former runway of Al-Rashid military airport, allowing potential visitors to access the site once the visibility of the archaeological remains sparks their curiosity.

From the entrance, a small building reminiscent of the brick production workshops of the 1930s will be transformed into an *antiquarium*, where the history of Babylon and Eshnunna during the time of Hammurabi will be narrated. From here, a pathway will lead visitors to the sacred area and the section with the fortification wall. These two covered areas will feature panels describing the chronological sequence and the functions of the different urban sectors.

Moreover, the archaeological park of Tell Muhammad will be connected to a refurbished version of the already existing archaeological park at the nearby site of Tell Harmal. These two sites—once probably part of a larger settlement—will contribute to illustrating the roots of the Old Babylonian period and the relationship between the First Dynasty of Babylon and the kingdom of Eshnunna.

Since its design, the archaeological park has seen growing interest from the Baghdad municipality, which has increased the cleaning of the site and also from the local communi-

ties, who have been involved in awareness-raising activities on the importance of the site, with the planning of workshops, which will also include Baghdad schools in the future.

4.4. Public Outreach—On Hammurabi's Path: An Exhibit Dedicated to an Iconic Figure

The pivotal step in defining our strategy for achieving long-term impact was to "bring" the archaeological heritage of Hammurabi—and especially the site of Tell Muhammad—into the research environment in which this project was created, i.e., the University of Catania. This initiative represents an ideal form of public outreach, showing a broader international public the importance of ancient Mesopotamian history and the complexity of archaeological research, which involves multiple scientific figures (i.e., the archaeologist, art historian, philologist, geologist, chemist, physical anthropologist, etc.) in reconstructing ancient pasts.

In 2024, a temporary exhibit on Hammurabi and his period was organized at the *Museo dei Saperi e delle Mirabilia Siciliane* of the University of Catania between 6 December 2024 and 1 April 2025 (Figure 8) [6].

(**A**) (**B**) (**C**)

Figure 8. Original artifacts of the Old Babylonian period loaned from international museums (**A**); reproduction of Hammurabi's linen garment (**B**); 3D reproduction of the Code of Hammurabi (**C**); (Photos by A. Borgesi).

As part of the exhibit dedicated to narrate the importance of the Old Babylonian period in the history of ancient Mesopotamia, the final section of the exhibit was dedicated to Tell Muhammad and displayed objects unearthed by Sir Austen Henry Layard and Comm. James Felix Jones in the mid-nineteenth century [29,30], now preserved at the British Museum, including the copper-alloy mace-heads bearing the inscription "*E.GAL Hammurapi*" (property of the palace/fortress of Hammurabi). Additionally, 3D reconstructions of objects and architectural features uncovered during the past four years of work at Tell Muhammad were presented. For this purpose, the initial phase of a project for the virtual and physical reconstruction of a portion of the defense wall unearthed during the 2022 excavation campaign was initiated in 2024. The project involved a digital and additive manufacturing workflow: the open-source software Blender was used to develop a reconstructive hypothesis of the wall structure based on archaeological data collected in situ (see contributions in [31]).

The reconstruction was based on the excavation documentation of the wall portion found in 2022. Baseline data included plans, sections, and georeferenced photographic surveys of the mudbrick structure [32,33]. This allowed a precise definition of dimensions, orientation, and wall articulation—including the entrance area—of the preserved portion. The elevation was extended by assuming the minimum necessary height (8 m) for stability and through typological comparisons with the defensive walls of Tell Harmal, maintaining the rhythm of niches and buttresses as vertical articulation elements present in entrance zones. The material was simulated with a generic mudbrick texture, prioritizing clarity of form over photorealistic rendering (Figure 9).

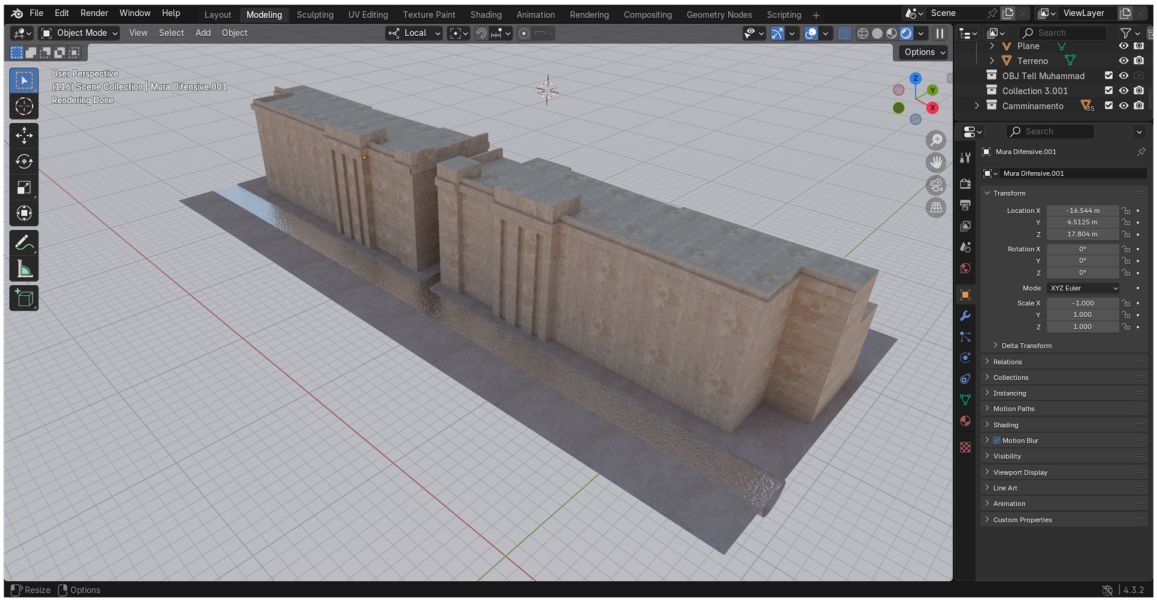


Figure 9. 3D reconstruction using Blender software 4.4 of the fortification wall of the Tell Muhammad site (graphic elaboration by V. Azzaro).

For the 3D printing phase, FDM (Fused Deposition Modeling) technology and PLA (Polylactic Acid) filament were chosen for durability, biodegradability, and ease of post-production integration of separately printed components [33]. A 1:100 scale was selected based on the spatial requirements of the exhibition, with the model placed on a support platform of 80 cm × 80 cm.

Parallel to the reconstruction of the defensive wall, terracotta objects unearthed at Tell Muhammad were digitally reproduced to develop 3D models based on information contained in the database compiled during the study phases of the finds [34]. The project began with sketches and preparatory drawings needed to recreate forms consistent with available measurements. Subsequently, surface modelling was undertaken in Blender.

In Blender, visual references can be uploaded as background elements and positioned in orthographic views (front, side, and top), providing three-dimensional guidance during modelling. On this basis, the initial mesh is constructed using polygonal modelling techniques, involving linear extrusion and topological control of vertices to define the structure, profile, and general geometry of the artefact. Once the base model is established, detailed modelling is undertaken: through digital sculpting tools, reliefs, engravings, and other distinctive features can be created.

A further crucial step concerns UV mapping, which enables textures to be applied to the three-dimensional model. During UV unwrapping, the mesh is projected onto a two-dimensional surface to ensure correct texture distribution. This procedure is essential for integrating visual elements—such as colors, materials, and micro-reliefs—that enhance

the model's final appearance and allow key characteristics of the artefact to be reproduced more accurately (Figure 10).

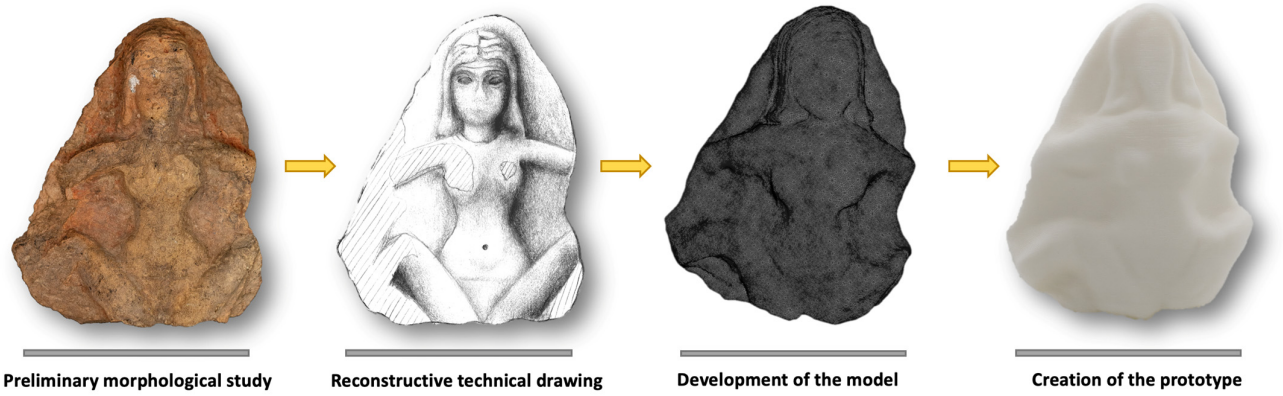


Figure 10. Steps from the original artifact to its 3D representation (graphic elaboration by A. Borgesi).

The digital reconstruction process allowed the production of 3D-printable models that constitute geometrically accurate and metrically verifiable reproductions of the finds, suitable for both archaeological analysis and museum contexts. These replicas were incorporated into the educational laboratory of the exhibition *From Babylon to Baghdad. On Hammurabi's Path*, where collaboration between archaeologists, geologists, and heritage specialists contributed to a more nuanced narrative highlighting the role of georesources in understanding the past. In fact, clay, ubiquitous in Mesopotamian material culture, represents a primary resource whose mineralogical and chemical composition allows provenance and procurement strategies of raw materials to be traced.

These aspects formed the core of the educational workshops, designed to illustrate the sustainable use of natural resources and the evolution of production technologies over time. Practical activities enabled participants to explore the relationship between geology and archaeology through direct manipulation of clay and other geomaterials. This multisensory approach, based on tactile and visual experience, made scientific communication more accessible and fostered greater scientific literacy among non-specialist audiences. The integration of geological and archaeological data also offered a holistic perspective on Mesopotamian material culture, facilitating an emotional connection with cultural heritage. In their contemporary role, museums function as dynamic cultural centers that encourage dialogue and curiosity through interactive and inclusive experiences. Full scientific accessibility requires the active involvement of groups often excluded from traditional museum strategies, particularly younger audiences. This approach represents a case study demonstrating how the integration of geomaterials and 3D reconstruction technologies in museum education can transform learning, making it more engaging, inclusive, and methodologically rigorous.

Overall, the exhibit welcomed nearly 20,000 visitors, becoming by far the most visited history exhibition at the University of Catania. Its success was accompanied by increasing interest in ancient Mesopotamia and Hammurabi, with some groups even travelling to Iraq to visit the places where this story originated.

5. Discussion: Hammurabi and His Time, the Past for the Future

The Baghdad Urban Archaeological Project is attempting to implement a framework based on a combination of elements (i.e., archaeological excavation and scientific research, conservation of adobe architecture, public engagement, and outreach) that can further support a long-lasting and scientifically solid pathway for narrating ancient histories to the general public. The results obtained from such a holistic and circular perspective aim

to create a solid mnemonic reference for ancient heritage that can be enduring, while also stimulating public interest.

5.1. Envisioning a Model for AHM in Iraq

First, archaeological excavation at the site produces new data that—also thanks to innovative techniques—can feed new historical perspectives on ancient Mesopotamia (e.g., on the role played by Hammurabi and other Old Babylonian rulers in military strategies against the kingdom of Eshnunna, and vice versa). Second, a thorough study of the condition of adobe architecture and the identification of best practices for preserving it after years of chemical interventions that have damaged mudbrick architecture may offer important contributions to architectural conservation, especially within the context of politically sensitive [35] and climatically vulnerable [36]. Finally, the creation of permanent (i.e., archaeological parks at Tell Muhammad and Tell Harmal) as well as temporary (e.g., the Hammurabi exhibit at the University of Catania) venues for public outreach is fundamental for fulfilling a key principle of archaeology: reaching the general public.

These results should be regularly monitored through control systems capable of providing objective feedback. The entanglement between different practices (i.e., archaeological research, heritage restoration and protection, public engagement) can yield results that—if visualized on a chart—would resemble a large "blob" embedded between scientific research and economic returns. Implementing a plan such as the one presented here involves high risks; however, if the objective is to envision heritage significance beyond purely scientific research or economic profit, the outcome can be highly successful.

The immediate interest shown in BUAP activities by various stakeholders (e.g., the SBAH, the Municipality of Baghdad, the Italian Ministry of Foreign Affairs, and the academic world), as well as by local communities (as demonstrated, for example, by a decrease in garbage dumping at and around the site), has strengthened our determination to expand the working plan. Our aim is to establish by 2027 a strong awareness among local communities of the importance of Hammurabi's and Mesopotamian heritage, so that Iraq's heritage can gradually become a social and economic asset for future generations.

5.2. How to Control the Results

Assessing the outcome of this type of project—which does not have a clearly defined scientific or economic output—is a challenging task. We therefore aim to establish a clear agenda that can guide both other researchers and us in the implementation of future sustainable projects in the field of Ancient Heritage Management.

In doing so, we believe that our experience has shown that results can be verified through a series of key milestones, such as:

1. Annual monitoring of the stability of preserved adobe architecture through a GIS that—thanks to the application of machine learning processes, whether ontology-based or Artificial Intelligence-based—can help scientists adjust practices in response, for example, to weather conditions or political instabilities [37];
2. Measuring increases in the number of visitors (especially school groups) to the site, as well as requests from schools in Iraq or Italy for scholarly involvement in explaining the importance of the Old Babylonian period in human history;
3. Tracking increases in internet searches related to specific keywords (e.g., Hammurabi, Baghdad heritage, Tell Muhammad, Babylon, etc.) or the number of views of videos or online content dedicated to these topics [38].

These suggestions may help scholars conceive research not only as an activity validated by academic parameters, but also as part of a broader context in which archaeological heritage serves the interests of local communities as well as the general public.

5.3. The Future Outcome of the AHM Model Applied at Tell Muhammad

As stated by numerous scholars, dealing with ancient heritage is a complex task, especially when done in a "foreign" environment [39]. Political instability, climate change, and pollution associated with an increasing population can create difficult pathways. However, it is the duty of scholars to develop a cultural heritage management policy consistent with the dictates of UNESCO, on the one hand, and with contemporary political realities, on the other.

Pitfalls, mistakes, and misunderstandings may occur along the way, but these risks must be overcome in order to research and protect ancient heritage. As stated by former UNESCO Director-General Irina Bokova in 2013 [40], "protecting heritage is inseparable from protecting populations, because heritage enshrines a people's values and identities." Thus, to reach this objective, it is necessary to implement a holistic approach to ancient heritage that aims to research, protect, and promote it—especially in Middle Eastern countries that during recent decades have been widely affected by destruction and looting [41,42].

In this perspective, it should be mandatory to involve local stakeholders (e.g., Directorates of antiquity as well as NGOs, associations, etc.) to pursue an approach that supports archaeological and historical research, protects cultural heritage, and promotes economic and social enhancement for the country as a whole.

All these elements have been taken into consideration in planning and implementing an AHM through the Baghdad Urban Archaeological Project at Tell Muhammad, which aims to research, conserve, and promote this extraordinary Old Babylonian site in the southern suburbs of Baghdad. Thanks to the discovery of important elements of material culture as well as written sources associated with Babylon at the time of Hammurabi, the site can become a driving force for promoting cultural tourism in Iraq.

The challenges of managing a sustainable project related to archaeological heritage, particularly in a context like Baghdad, Iraq, are numerous and necessarily rely on the authorities and local communities validating its importance. This aspect also becomes crucial for imagining the possibility of replicating the model in other similar contexts. Therefore, it is by making the importance of such projects visible that the possibility of making them sustainable arises. Creating workshops for a younger audience (school-age children) that engage them in learning about their history and ancient construction techniques, such as raw earth, an easily workable and environmentally friendly raw material, is therefore a priority for the model's success.

6. Conclusions

Recently, ownership of ancient pasts as well as the intertwining relationship between archaeological research and Cultural Resource Management have been hotly debated [43,44]. Thus, it is of great importance to work towards the creation of sustainable proposals that can integrate the scientific research with the public outreach when dealing with ancient archaeological heritage, especially when this can be done in a country such as Iraq, which needs support in conserving and promoting its own ancient heritage. The site of Tell Muhammad, its location within the capital of Iraq (Baghdad), as well as the presence of written sources related to one of the most important kings of ancient Mesopotamia, Hammurabi, makes the Baghdad Urban Archaeological Project and its AHM model a great opportunity for creating a sustainable project for conserving and promoting the memory of one of the most emblematic figures of humanity's shared cultural heritage. His memory and deeds have often been condensed into the creation of his Code of Laws as one of the earliest in human history; yet they are also part of a wider network that has radiated into the modern world, transforming him into an iconic figure and one of the first emperors and legislators.

Preserving, conserving, and promoting this legacy, therefore, represents a critical cultural and ethical responsibility that must rely on an integrated system of practices, including research, heritage conservation, and engagement with the general public. Due to its proximity to an important capital such as Baghdad, the site of Tell Muhammad can become the center of this network, weaving a connection between ancient Mesopotamia and the modern world—between Iraq and the rest of the globe. Through strategic conservation and inclusive dissemination, Iraq's heritage can be a resilient foundation for intercultural understanding and a catalyst for long-term social and economic regeneration, reinforcing its role as a cornerstone of global historical consciousness.

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