HBIM-GIS Integration for Urban Heritage Visualisation: Al-Tahrir Square and Umma Park in Baghdad, Iraq

Fatimah J. Al-Muqdadi [1]

[1] The Department of Architecture Engineering, College of Engineering, University of Baghdad, Baghdad, Iraq
- Fatimah.j@coeng.uobaghdad.edu.iq

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Abstract

At the intersection of traditional and contemporary heritage in Baghdad, lies Al-Tahrir Square and Umma Park. An urban hub that centrally connects Baghdad’s two sides, Karkh and Rusafah. The site hosts three iconic artworks by Iraqi artists: the Peace March mural by Faeq Hassan, the Mother statue by Khalid Al-Rahal, and Al-Tahrir monument by Jawad Saleem and Rifat Chadirji. Hence, it has served as a symbolic area for national expression since its conception, offering a home for protests, collective memories, and contested urban events. While previous literature often emphasised its political symbolism, limited attention has been paid to the square as a layered piece of urban heritage. This study introduces a methodology that integrates Historic Building Information Modelling (HBIM) with GIS-based spatial analysis to digitally reconstruct and interpret Al-Tahrir Square.

The study combines a philological survey based on historical maps and archives to understand historical events and changes, with a physical survey using photogrammetry and satellite imagery. The result is a multi-scale 3D model that enables layered urban analysis by linking semantic data with historical timelines and contemporary scans. By situating digital reconstruction within a GIS environment, the workflow captures not only the physical configuration of the space but also its social resonance and urban experience. This study forms part of an ongoing project aimed at advancing the study of Iraqi urban heritage and narrating its stories through 3D technologies, with a particular emphasis on re-establishing community access to these spaces by utilising digital technologies to uphold the Iraqi right to the city.

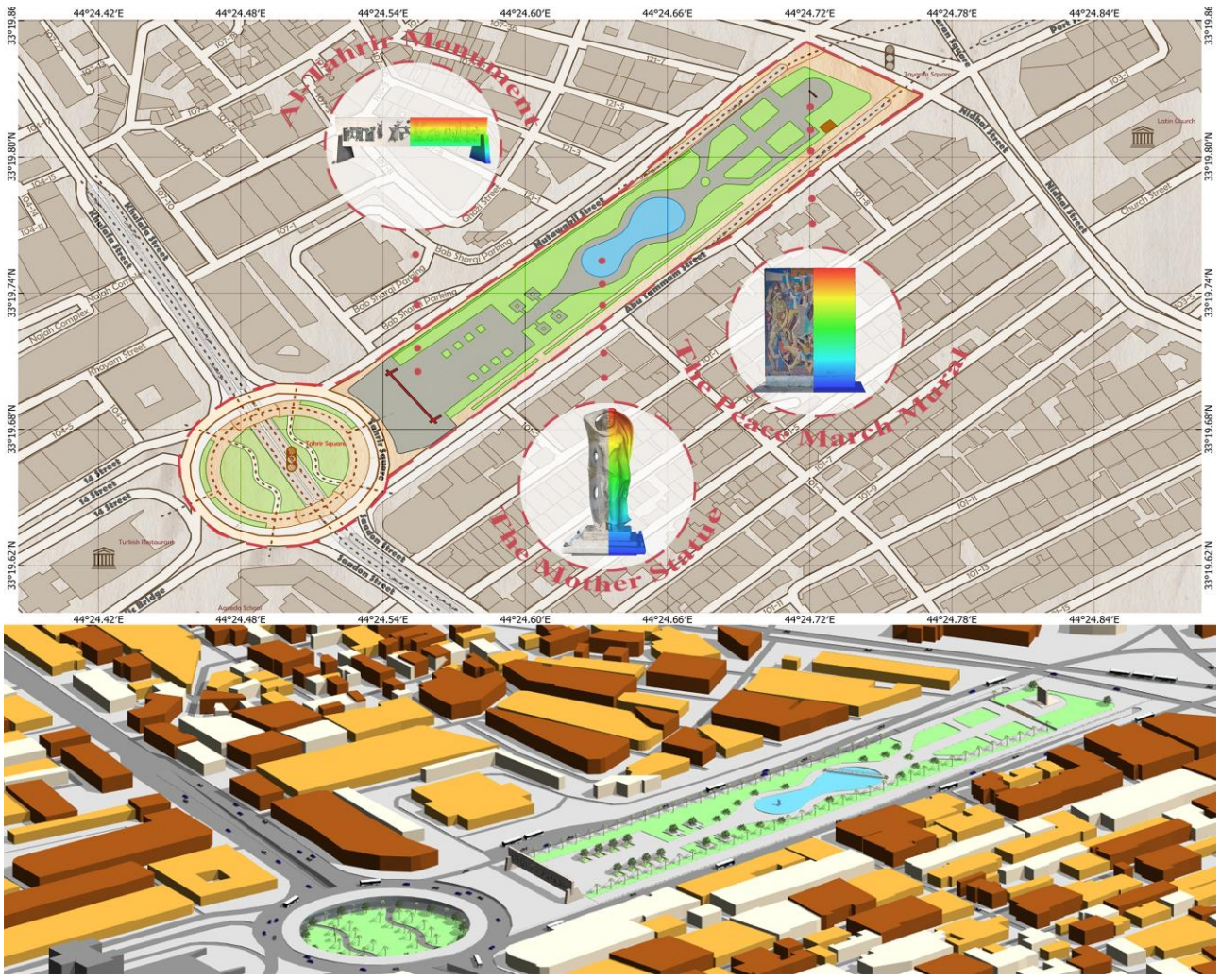

Figure 1. Al-Tahrir Square and Umma Park from GIS to HBIM.

1. Introduction

Al-Tahrir Square and Umma Park, Baghdad’s urban nucleus, played an unparalleled role in shaping Iraq’s sociopolitical, cultural, and urban history. Strategically located between the historic districts of Karkh and Rusafah, this civic nucleus has evolved over the decades from a planned urban plaza into a dynamic space for collective identity, protests, and national memory. The names themselves, Tahrir meaning “liberation” and Umma meaning “nation” in Arabic, reflect the transcendental value inscribed into the physical layout of the site. Since its conception, the square has hosted countless public gatherings and demonstrations, particularly after 2003, when it emerged as the primary site for civilian resistance and social mobilisation in Iraq (Al-Behadili, 2017).

This public space is further anchored by three iconic modernist artworks that embody Iraq’s transition from a monarchy to a republic: Jawad Saleem and Rifat Chadirji’s Tahrir Monument, Khalid Al-Rahal’s Mother Statue, and Faeq Hassan’s Peace March Mural. These monuments are not only artworks but also instruments that visually narrate Iraq’s socio-political trajectory. Literature indicates that people of various generations regard the Tahrir monument as a national symbol for Iraq, allowing them to create deep urban memories associated with the space (Hmoud and Almodhafar, 2022).

Current literature on Baghdad’s urban heritage usually prioritises either transformation and development, planning histories, or understanding current conditions (Aldabbagh and Ismail, 2025; Abbas and Ebraheem, 2024; Al-Bayati and Alobaydi, 2023; Hameed et al., 2023), with few studies exploring the complex and layered nature of urban spaces such as Al-Tahrir Square. Moreover, despite the increasing maturity of digital heritage technologies, their application in Iraq remains limited due to infrastructural constraints, political instability, and limited public funding (Kadhim and Al-Salam, 2024). In this context, the integration of Historic Building Information Modelling (HBIM) with Geographic Information Systems (GIS) could provide a promising methodological intervention that allows for a multiscale, multi-temporal reconstruction of the site, bridging architectural detail with urban narrative.

This research explores the potential of 3D technologies in documenting, visualising, and interpreting Al-Tahrir Square as both a spatial and socio-political phenomenon. The methodology adopts a two-pronged survey approach: a philological survey, which uses historic cartography and archival imagery to reconstruct past spatial logics; and a physical survey, which captures the present condition using terrestrial photogrammetry, satellite imagery, and field documentation. These datasets are then synthesised within an HBIM-GIS framework to enable multi-scale modelling, comparative temporal analysis, and semantic enrichment.

The resulting digital model is not merely a spatial record, but a narrative designed to capture how public space is shaped, inhabited, and transformed by its citizens. Special attention is given to the technical pipeline, including data acquisition, point cloud generation, spatial visualisation using QGIS, and semantic modelling in Autodesk Revit. The study also reflects on the methodological adaptations required to operate in a fragile context such as Iraq, where access to equipment, archival material, and institutional support is often constrained.

Ultimately, this paper seeks to contribute to ongoing efforts to democratize heritage documentation through accessible and reproducible workflows. It positions Al-Tahrir Square not only as a case study in digital reconstruction but as a contested urban heritage site that demands interdisciplinary engagement. Where architecture, memory, and protest intersect. In doing so, it responds to a critical gap in the literature by offering a framework that is both technically rigorous and socially grounded, adaptable to other heritage-rich but resource-constrained settings across the Global South.

2. Historical Context

The story of Al-Tahrir Square and Umma Park reflects Baghdad’s transition from traditional planning to modern urbanism. Based on historical maps of Baghdad, the square occupies the same site as Bab Kilwatha, the eastern gate of medieval Baghdad (Sousa, 1953). Bab Kilwatha (also called Bab Al-sharqi or Bab Al-Basaliyah) was one of the four main gates in Baghdad’s Abbasid historical wall, which was dismantled by the Ottomans in the late 19th century.

The 20th-century urban plans, particularly those initiated during Iraq’s monarchical era under British influence, sought to reconfigure the area into a modern civic ensemble. In 1937, the King Ghazi Park and Queen Alia Square (now Umma Park and Al-Tahrir Square) were formally established. By the mid-20th century, Iraq’s newly established republican government initiated a series of artworks to commemorate the 14th of July 1958 Revolution, embedding political iconography into the square’s evolving civic landscape. The square's new spatial configuration, which emphasised axial geometry, open visibility, and monumental public art, reflected an attempt to visually consolidate the new republic’s ideology within the city’s fabric (Hmoud and Almodhafar, 2022).

The last major development during the 20th century was the Tahrir tunnels project in 1972. The work included a vehicle tunnel underneath the square, extending from Al-Khilani Square to Al-Sa'doun Street, and a pedestrian ring tunnel featuring gardens, shops, and other services. In the 21st century, the 2003 invasion of Iraq marked a turning point in the square’s function and meaning. Its strategic location and symbolic artworks made it a natural site for protests and public gatherings. The space became a "living memory arena" of Iraq’s post-2003 sociopolitical climate (Abdulali and AlShamari, 2023).

In 2019, the square hosted the October Revolution, one of the largest youth-led uprisings in Iraq’s history. Protesters occupied the square for months, demanding systemic political reforms and economic opportunities. The square became a canvas for resistance art, with protestors using graffiti, banners, and installations to articulate their grievances and hopes. These acts of expression gave Al-Tahrir Square a new identity, intertwining urban space with political narrative. As a result, the square was heavily militarised, transforming it into a contested and securitised urban zone.

In response to both its deterioration and symbolic prominence, the first major renovation of Al-Tahrir Square and Umma Park was launched in 2022. This initiative involved the restoration of the three artworks, rehabilitation of green spaces, adding contemporary urban features, and partial reinstatement of the original urban language. The project aimed to re-establish the area as an inclusive and accessible urban hub for social activities, reactivating its historical role as a gathering space while responding to contemporary social demands. Currently, the square continues to be the central urban space for national events.

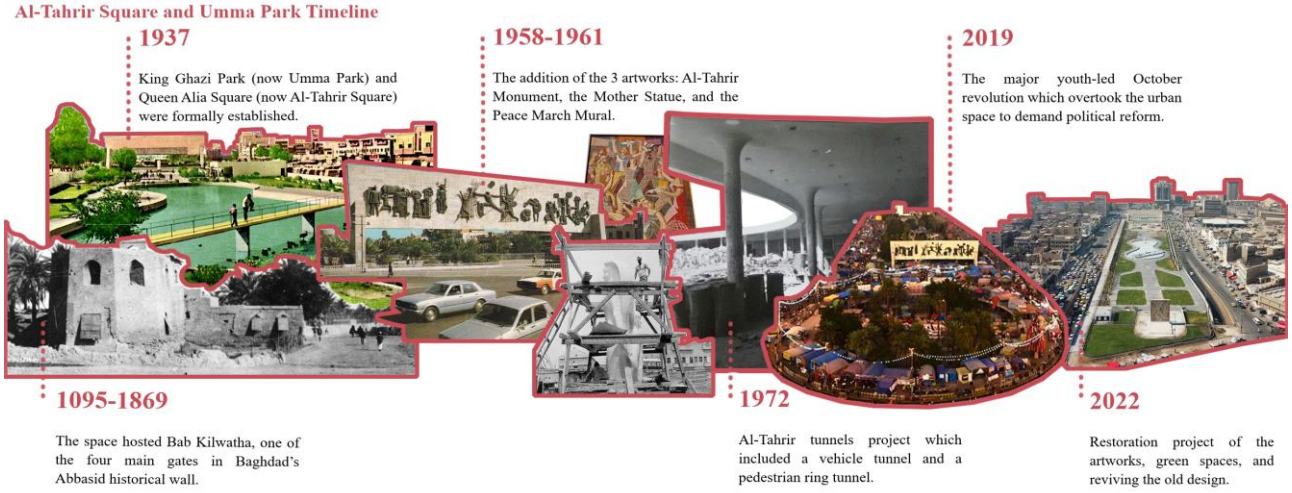

Figure 2. Al-Tahrir Square and Umma Park timeline.

3. Literature Review

Recent years have witnessed the emergence of many digital frameworks that aim to enhance documenting and managing heritage. A prominent concept is Historic Building Information Modelling (HBIM), an evolution of BIM that utilises survey data enriched with historical information to produce a central digital database (Avena et al., 2021). Yet, in the case of documenting urban heritage, the process requires a multi-scale and multi-layer approach to holistically understand the space, its evolution, and metadata (Sammartano et al., 2023). Hence, including geospatial data becomes necessary to understand both the context and the heritage within it. In this case, GIS (Geographic Information System) has established benefits in the modelling, managing, and analysing of geospatial data (Dionizio and Dezen-Kempter, 2024).

The concept of integrating HBIM models in GIS environments appeared to facilitate a comprehensive understanding of urban heritage, starting from the urban scale down to the individual asset. For urban spaces like Baghdad’s Al-Tahrir Square, which serve as cultural and political nexuses, this integration provides a unique opportunity to bridge spatial, historical, and social narratives. The space presents a unique challenge as its heritage value stems from its roles in Iraqi contemporary history, public artworks, urban location, and other factors.

Recent advancements in HBIM-GIS workflows demonstrate their potential in similar contexts. For instance, HBIM has evolved as a cornerstone of digital heritage preservation, enabling the creation of semantically rich 3D models from data such as point clouds and photogrammetry. Triviño Tarradas et al. (2024) highlight the use of HBIM in preserving UNESCO-listed sites through neural radiance fields (NeRFs), showcasing its adaptability to complex urban contexts. While Laohaviraphap and Waroonkun (2024) propose integrating IoT technologies with HBIM to monitor environmental risks for urban heritage, aligning with the need for sustainable documentation practices.

Simultaneously, GIS serves as a cornerstone for analysing and visualising urban heritage, offering tools to layer historical, spatial, and cultural data. The application of GIS in heritage has illustrated benefits in multiple uses. For example, GIS-based visualisations could enhance public engagement by illustrating cultural and spatial narratives (Salimi et al., 2024). Petrulevich and Skovgaard Boeck, (2023) examine GIS-based methodologies for reconstructing pre-modern spatial infrastructures, emphasising their utility in mapping heritage data across temporal scales. This proves to be valuable in cases such as Al-Tahrir Square, which was transformed drastically on multiple occasions. Similarly, Barrile et al. (2024) argue that WebGIS could be a crucial decision support tool that enables risk assessment and sustainable safeguarding of heritage in continuously changing environments. These capabilities align with this study's aim to situate Al-Tahrir Square within its broader urban context, using GIS to map its evolution and relationships with surrounding spaces such as Tayaran Square and Umma Park.

Individually, both concepts prove to be powerful in digitising heritage. Integrating them creates a spatial framework for analysing and managing urban heritage, enabling users to layer historical, cultural, and geographical data (Chen et al., 2023). Data conversion tools facilitate interoperability between HBIM (IFC format) and GIS (GML/CityGML), allowing 3D models to be embedded in broader urban and territorial contexts to support multi-scale analysis and management (Colucci et al., 2020). More recent advancements, such as those by Borgmann et al. (2024), extend this integration to include real-time monitoring and virtual tools that could be adapted to urban heritage management. The project “Main10ance” is used to create a holistic management system for cultural heritage in northern Italy and Switzerland. The project’s case is an example similar to Al-Tahrir Square, where the exterior environment, architecture, and other assets contribute to the overall heritage value (Matrone et al., 2023). These methodologies demonstrate the potential of HBIM-GIS integration to address both micro (building-level) and macro (urban-scale) heritage concerns.

However, challenges remain in achieving seamless interoperability between systems, particularly in regions with limited digital infrastructure, such as this study’s case. Despite its global advancements, the application of HBIM-GIS integration in Middle Eastern and specifically Iraqi urban heritage remains limited. Existing studies, such as Jassim et al. (2025) and Ahmed et al. (2024), touch on the application of GIS and BIM as frameworks for heritage documentation in Iraq. However, they simultaneously highlight the limited technical maturity and practical implementation of such approaches in local heritage projects. This study addresses this gap by applying state-of-the-art HBIM-GIS methodologies to Al-Tahrir Square, combining its socio-political narrative with urban-scale modelling to create an accessible and engaging digital archive.

4. Methodology

This contribution adopted an integrated methodology to spatially document Al-Tahrir Square and Umma Park. The study focused on developing a reproducible workflow that supports the documentation of urban heritage in Iraq and its socio-political narratives. Therefore, the process is structured in four main phases: (1) Data acquisition, (2) GIS development, (3) 3D Modelling (HBIM), and (4) GIS-HBIM Integration.

4.1 Data acquisition

The study employed two phases of surveys: philological and physical surveys. The first is primarily concerned with identifying related historic archives to comprehensively understand the square’s urban transformation since its conception. The second survey documented the present state of Al-Tahrir Square using a blend of satellite imagery and terrestrial photogrammetric scans.

Hence, the study began with a systematic gathering of historical cartographic and archival materials referencing Al-Tahrir and its surroundings. The search primarily focused on digital resources and physical archives related to Baghdad’s urban development. The process yielded seven maps that cover the site’s urban evolution from 767 to 2003 AD, along with approximately 50 historical images. Ahmed Sousa’s The Atlas of Baghdad (1953) was particularly valuable as it provided an extensive resource that maps Baghdad since its early conception to the modern era. The maps list includes the following:

1. Baghdad, 767-946 (Sousa, 1953).
2. Baghdad, 1055-1258 (Sousa, 1953).
3. Baghdad, 1853-1854 (Sousa, 1053).
4. Baghdad, 1900s (Sousa, 1053).
5. Baghdad, 1944 (Wikimedia Commons, 2025).
6. Baghdad, 1983 (Wikimedia Commons, 2025).
7. Baghdad, 2003 (Wikimedia Commons, 2025).

Prior to the physical scan, an Initial site Assessment was conducted to identify key features, pathways, and areas of interest within the site. As UAV is strictly prohibited in this area, the study utilised high-resolution satellite imagery and terrestrial photogrammetry to conduct the physical scan. Satellite imagery was acquired from Esri’s ArcGIS web mapping service, as it provided the latest scan of the space after the 2022 renovation. Close-range photogrammetry (using DSLR cameras with 35mm lenses) was used to individually scan each of the three artworks and produce high-resolution models.

4.2 GIS Representation

The first part of the digital reconstruction began by establishing the urban foundations of the model in the open-source software QGIS. The site’s contemporary form was mapped using a base layer from OpenStreetMap, as it provided the latest open-source data for Baghdad at the time of this study. Separate layers were created for all urban elements, such as roads, monuments, and plots. Each layer was digitised with attributes that could be used for spatial analysis and translated later as objects' parameters in HBIM environments. For example, the buildings layer contained a *function attribute* to analyse the different land uses. At the same time, monuments, such as main artworks, squares, and landmarks, were also mapped to explore the social context of wayfinding and mind mapping. These steps were intended to illustrate the site’s context and understand the spatial relationships in this vital area.

Historical mapping included georeferencing the seven maps acquired in the data acquisition phase. Using the Georeferencer tool, Ground Control Points (GCPs) were derived from enduring physical landmarks such as bridge intersections and other historical sites in Baghdad. These reference points were used to accurately georeference each map within a consistent spatial framework. Once the maps were projected correctly, each map was digitised using the same spatial organisation of the contemporary map. The resulting spatial database was visualised by creating thematic maps that highlight historical significance, paths, vegetation, and infrastructure layout.

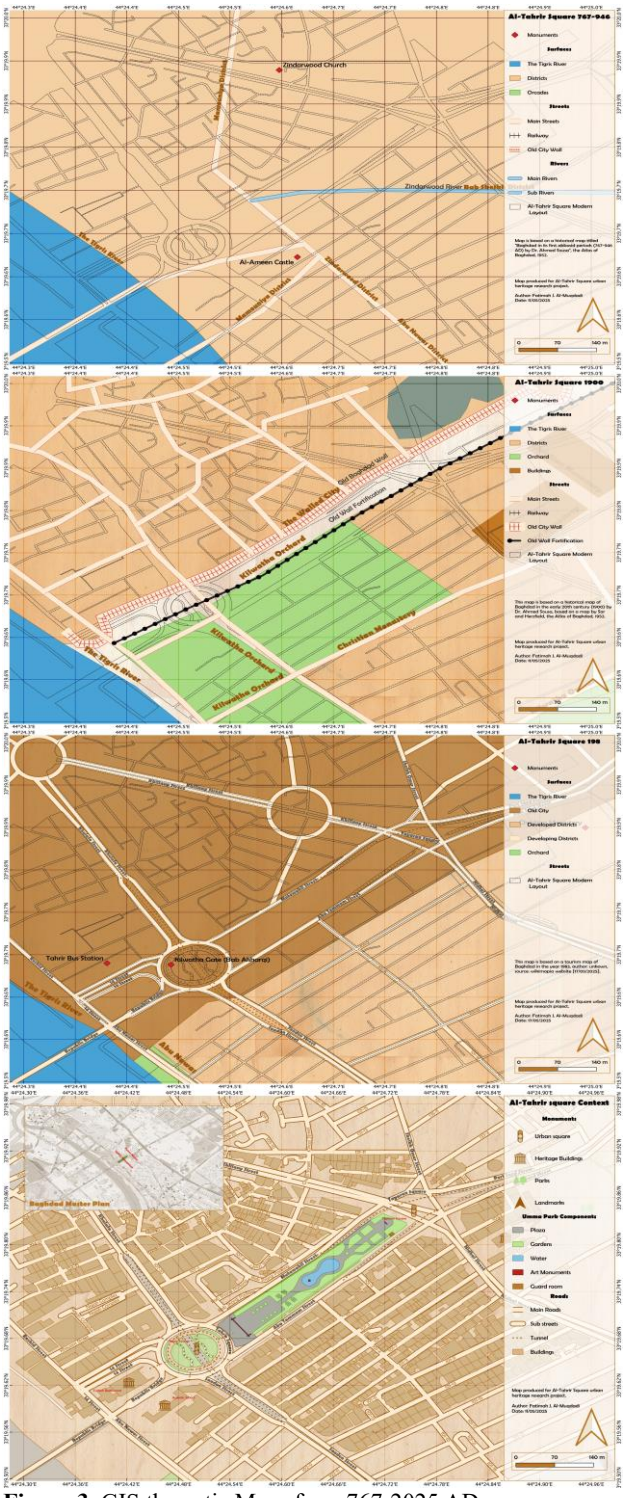

Figure 3. GIS thematic Maps from 767-2025 AD.

https://doi.org/10.5194/isprs-archives-XLVIII-M-9-2025-25-2025

4.3 3D Modelling (HBIM)

The photogrammetric data was processed in Agisoft® Metashape to generate 3D models of the three artworks. The process included aligning images to create dense point clouds, creating 3D meshes, Mapping texture, Model validation, and exporting. The data included 424 images of the Al-Tahrir monument, 171 images of the Mother sculpture, and 261 images of the Peace March Mural.

Figure 4. Point clouds and models for the three artworks.

The models were imported into BIM environments to be developed as urban features using metadata extracted from archival drawings and field surveys. For this purpose, Autodesk® Revit was used as it allows the exportation of data in IFC standard format, compatible with a wide variety of other digital environments. The modelling adhered to a multiscale Level of Detail (LoD) schema, ranging from LoD1 for the urban massing of surrounding blocks, LoD2 for Al-Tahrir square and Umma Park, and LoD3 for monument-specific details.

The model’s parametric elements were associated with various types of information related to the artworks employing ‘shared parameters’ and ‘system families’ to ensure a higher level of semantic details as well. Custom metadata fields were developed for each sculptural and architectural element, such as: *Designer, Construction_Year, Material_Type, Symbolic_Theme, Restoration_Status, and Event_Association (e.g., 14 July 1958, 2019 protests).* These parameters enable multidimensional queries and support future integration with heritage databases. Subsequently, the model was assigned a geographic position using the survey point and Base point tools. Al-Tahrir Square’s central coordinates were established in the model and verified against GIS base layers exported from QGIS to further enrich the model with the spatial position of monuments.

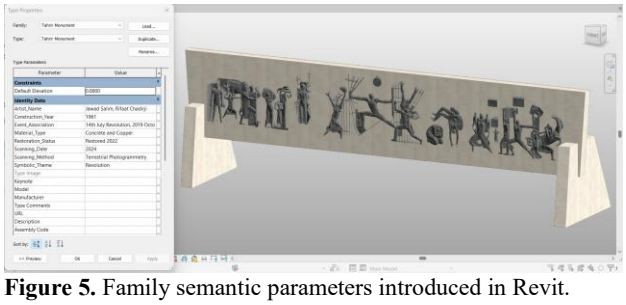

Figure 5. Family semantic parameters introduced in Revit.

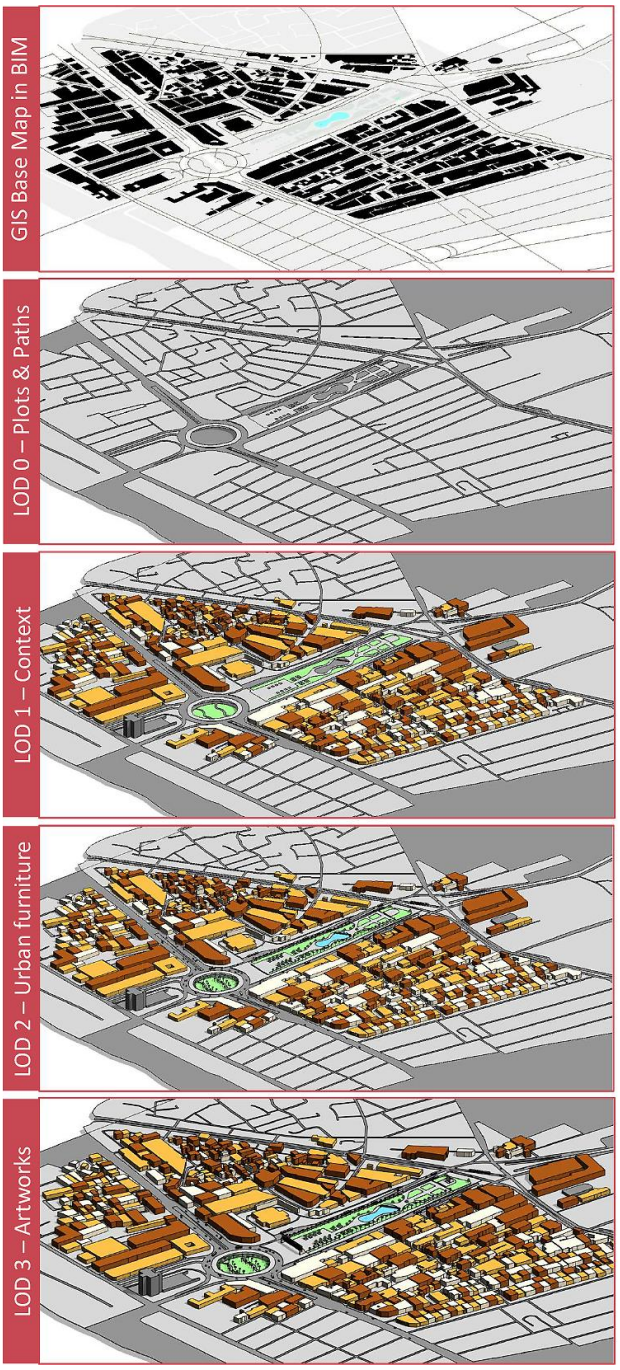

Figure 6. The LoD scheme adopted in developing the HBIM.

4.4 GIS-HBIM Integration

Finally, the monuments models are exported as IFC format with preserved GUIDs and transformed using the FME (Feature Manipulation Engine) to QGIS. The focus was on ensuring Feature-level metadata preservation for object types, categories, and historical associations. Alternatively, DWG export with custom layers was used for 2D urban footprint data, aiding faster GIS overlay without semantically enriched geometry. In the final database, feature attributes were structured relationally, enabling powerful spatial queries and analysis such as, highlighting 2019 protest zones. The integration also enabled semantic filtering, users could isolate monuments by restoration phase, symbolic theme, or political context.

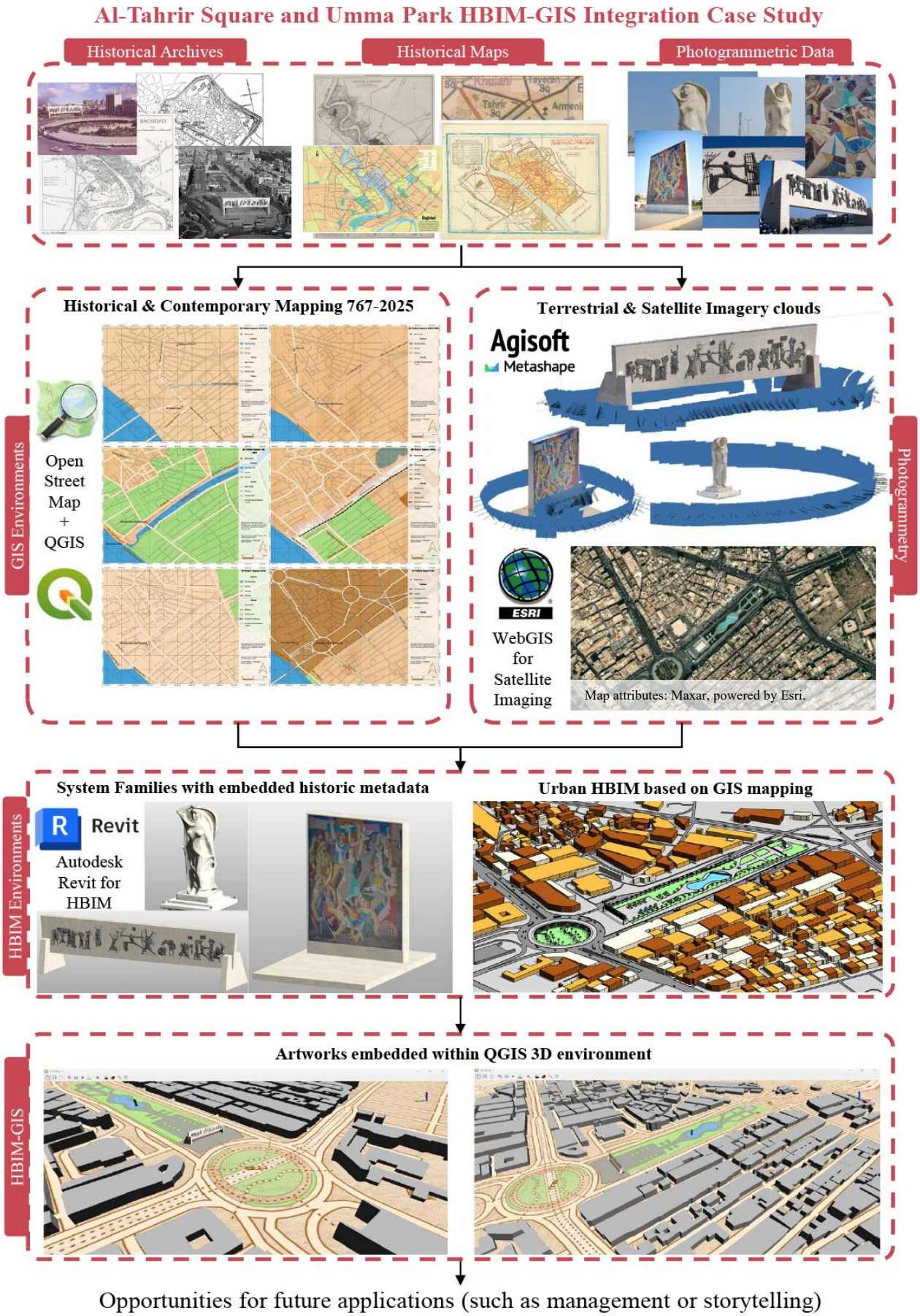

Figure 7. Al-Tahrir Square and Umma Park HBIM-GIS comprehensive Methodology Diagram.

5. Results And Discussions

This study attempted to create a comprehensive spatial documentation of Al-Tahrir Square and Umma Park. The resulting model captures various historical phases that illustrate not only the development of Al-Tahrir Square but also Baghdad's urban transformation. Nevertheless, the project faced multiple challenges, including technical constraints and context challenges specific to the Iraqi environment.

5.1 Technical Constraint

The resulting HBIM combined both geometrical elements generated by photogrammetry and metadata from archival references and GIS maps. The LoD scheme was particularly useful in clarifying the modelling goals for each urban element. The spatial mapping in GIS was truly the highlight of the project, as it illustrated the ability to trace rapid urban changes faced in a city such as Baghdad. From a walled medieval city to an urban contemporary capital, the spatial analysis of this urban space illustrated the many lives a city and its public spaces can live. Yet, several technical constraints should be highlighted:

- **Interoperability:** HBIM documentations often require various tools to produce a comprehensive model. In this case, the lack of direct exportation methods that retained data across platforms was the primary issue. For example, Revit's IFC format contains the models, while equally important semantic attributes were often partially preserved or lost. This required manually adding the data back after each exportation.

- **Lack of established workflows:** while individual-level HBIM is fairly established in the literature, urban-level HBIM still requires further standardisation. This is illustrated in Revit's lack of native support for geospatial standards, which necessitates using other methods such as DWG imports and plugins. Similarly, QGIS needs custom scripting to replicate HBIM standards, such as element class and metadata transfer.

5.2 Contextual Challenges

In addition to technical limitations, challenges relating to the Iraqi context also shaped this study's methods and outcomes.

- **Limited archives:** Access to high-quality archive materials remains a pressing challenge for heritage research in Iraq. For this project, only seven maps from 767-2003 AD were identified and used. All maps required manual digitisation or sourcing from informal sources such as Wikimedia Commons. The lack of central historical databases often delays similar efforts and reduces model accuracy.

- **Lack of institutional support:** The past political instability has continuously affected the quality of digital heritage research in Iraq. For instance, this site could only be scanned during a constrained time window with limited equipment, which naturally affected the LoD consistency across objects. Moreover, the local context offers little institutional capacity and funding frameworks needed to produce state-of-the-art documentation. This study adopted open-source software or manual workarounds to achieve its aims, which reflects a broader systematic issue of funding in similar contexts.

6. Conclusions And Future Prospects

HBIM-GIS integration was explored in this study within the context of Al-Tahrir Square and Umma Park in Baghdad. Through utilising historical cartography, photogrammetry, and HBIM modelling, the research created a multiscale representation of this vital urban space in Iraq's capital. The results illustrate how accessible digital technologies can produce meaningful documentation of urban heritage, even in challenging environments. Beyond the limitations, the project demonstrates how spatial memory, social narratives, and political shifts intersect with urban heritage. The inclusion of metadata and social memories can add a social dimension to digital technologies.

The research also highlighted limitations in both technical and contextual aspects. Looking forward, the methodology adopted here could be replicated for other urban sites across Iraq. Future work could expand to include interactive, web-based applications that enhance public engagement and participatory experiences through storytelling. Furthermore, the possibility of integrating Artificial Intelligence (AI) with resulting models for real-time monitoring could also be explored to improve urban heritage management.

Ultimately, this research positions HBIM-GIS not only as a digital process but also as a means to reclaim urban memory in Iraq. The future for urban heritage in Baghdad may rely not only on documentation but also on contextual technological frameworks that reconnect communities with their public spaces and ultimately, their city.

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