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Research Article

Process and Cost Implications of HBIM in Project Management: A Comparative Study of Projects in Türkiye and International Contexts

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Abstract

The documentation, conservation, and sustainable management of cultural heritage buildings are increasingly addressed through digital technologies. In this context, Heritage Building Information Modelling (HBIM) provides a strategic approach that supports not only the geometric representation of historic structures but also the integrated management of project processes in terms of time and cost. This study aims to evaluate HBIM applications from a project management perspective, focusing on their effects on schedule and cost efficiency. The research is based on a comparative analysis of 20 HBIM projects conducted in Türkiye and abroad, examining data acquisition methods, software usage, modelling workflows, and project durations. A qualitative research methodology was adopted, and data were obtained from academic journal articles and postgraduate theses using content analysis and comparative evaluation. The findings indicate that HBIM significantly improves project efficiency by supporting time and cost control while strengthening data integrity and coordination among stakeholders. Accordingly, the study emphasizes that HBIM should be considered not only as a digital documentation method but also as an effective project management tool in cultural heritage projects.

Keywords: Cost Management, Cultural Heritage Buildings, HBIM, Project Management, Time Management.

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INTRODUCTION

HBIM (Heritage Building Information Modelling) has become an increasingly important approach in the documentation, conservation, and management of cultural heritage structures. Unlike traditional methods, it allows historic buildings to be represented with a high level of accuracy while also supporting decision-making processes in restoration projects. By combining technologies such as laser scanning, photogrammetry, and 3D modelling, HBIM makes it possible to capture both the geometric and structural characteristics of heritage buildings in a more comprehensive way.

In addition to its technical advantages, HBIM also contributes to improving project processes. It supports faster planning, reduce potential errors, and enhance coordination among different stakeholders involved in conservation work. This makes it particularly valuable in complex restoration projects where multiple disciplines need to work together.

However, despite these benefits, the application of HBIM is not without challenges. The complex nature of historic structures, limitations in available data, and the relatively high cost of digital technologies can make the process difficult to implement in some cases. For this reason, evaluating HBIM not only as a modelling tool but also as a practical solution within project management becomes essential.

THE AIM OF THE STUDY

The main aim of this study is to examine HBIM applications in cultural heritage projects from a project management perspective, with a particular focus on time and cost efficiency. Within this scope, 20 HBIM projects carried out in Türkiye and in various international contexts were analysed comparatively. Rather than considering HBIM solely as a tool digital documentation, this study also examines how it supports project workflows. By analysing different case studies, it demonstrates how HBIM helps reduce data loss, improve stakeholder communication, and facilitate decision-making during conservation and restoration projects. In this context, the study also aims to highlight the potential of HBIM as a strategic tool that can strengthen both the technical and project-related aspects of cultural heritage projects.

SCOPE AND METHODOLOGY OF THE STUDY

This study is qualitative research that aims to examine the effects of HBIM applications on time and cost management within the scope of project management. This research, 20 HBIM studies identified through a comprehensive literature review from Türkiye and various other countries were comparatively analysed.

The data were obtained through an academic literature review using the key concepts of HBIM (Heritage Building Information Modelling), digital documentation, historic structures, and project management. The selected studies were evaluated according to their relevance to the research focus and their ability to provide comparable project-related data, such as project duration, workflow stages, software use, data collection techniques, and other measurable outputs related to time and cost management. Therefore, the cases were selected not only because they addressed HBIM, but also because they provided sufficiently explicit information for comparative evaluation from a project management perspective.

Since the study aims to provide a balanced comparison between HBIM applications in Türkiye and other countries, the sample was limited to 20 case studies, including 10 from Türkiye and 10 from other countries. This number was considered sufficient to maintain analytical clarity and consistency across the selected cases. A limitation of the study is that accessible and comparable HBIM studies in Türkiye remain relatively limited, as the field is still developing. For this reason, the selection of Turkish cases was shaped by both relevance to the topic and the availability of sufficiently detailed case-based data.

Based on these research questions, the methodological framework followed in the study was developed systematically and is illustrated in Figure 1. For the comparative analysis, evaluation questions were determined during the early stages of the literature review in order to examine the effects of HBIM applications on efficiency, process management, and software. During the literature review process, it was observed that the defined research questions showed similarities with the analytical themes used by Bastem (2021). This finding indicates that the study is theoretically and methodologically grounded in a framework consistent with recent studies in the literature. The information obtained through the literature review was classified under the themes of "data collection method," "software preference," "the contribution of plugins to the project process," and "the relationship between data accuracy, time, and cost." These themes were compared with HBIM process analyses found in the literature, and common evaluation criteria were established for each project. Thus, similarities and differences related to time and cost management in HBIM processes implemented in different countries were identified.

The evaluation questions determined within the scope of the study are as follows:
1.Which techniques have been used as data collection methods in HBIM applications?
2.To what extent are the software tools used suitable in terms of the scale and design requirements of the project?

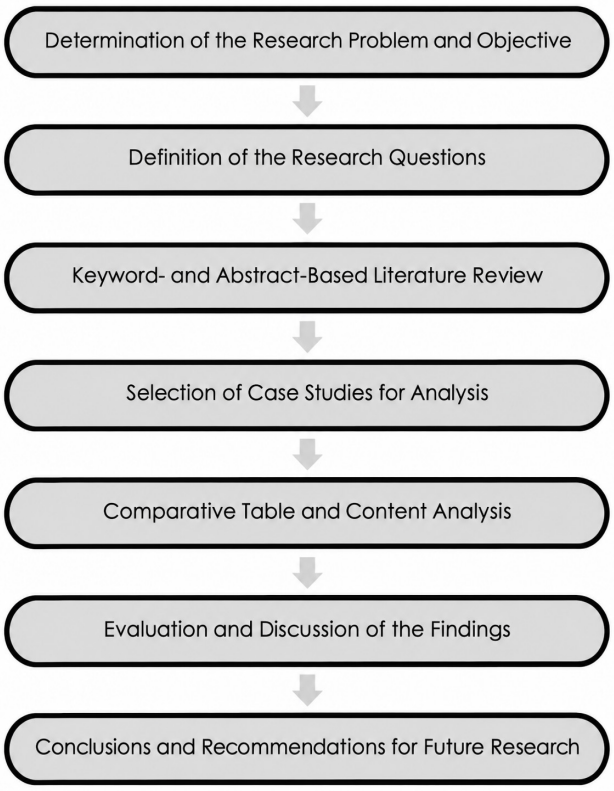


Figure 1. Methodology of the Study (created by the author)

3.Which plugins were used with the software, and what contributions did they make to the project process?
4.What is the impact of the selected data collection method on data accuracy?

CONCEPTUAL FRAMEWORK ON HBIM AND DOCUMENTATION TECHNIQUES

Cultural heritage structures are unique assets that embody the aesthetic, technological, and social values of past civilizations to the present day. The documentation, conservation, and sustainable management of these structures have become major areas of research within the field of heritage conservation since the late twentieth century. As traditional documentation methods proved insufficient for capturing the complexity of historic structures, digital technologies have introduced new possibilities. In this context, the concept of HBIM emerged through the adaptation of Building Information Modelling (BIM) systems to historic buildings. HBIM enables not only the three-dimensional documentation of structures but also the integration of material characteristics, intervention histories, and restoration data into a comprehensive digital environment.

The conceptual framework is organized under four main headings: "The Emergence of the HBIM Concept," "HBIM Dimensions," "HBIM Development Levels," and "Methods and Techniques Used for the Documentation of Cultural Heritage".

The Emergence of HBIM

Building Information Modelling (BIM) emerged in the 1980s as part of the digital transformation in the construction sector and became widely adopted in the 2000s as technology improved (Succar, 2009). The primary objective of BIM is to create an integrated digital data environment that encompasses the entire lifecycle of a building, including design, construction, operation, and maintenance processes Toldo, 2016). However, the irregular geometries, unique material textures, and documentation deficiencies of historic structures fall outside the scope of standard BIM systems. Because of these challenges, the need for a more flexible system became clear, which led to the development of HBIM (Karaoğlu, 2020).

The development of HBIM has accelerated particularly after 2010 due to advancements in laser scanning, 3D photogrammetry, and sensor-based data acquisition technologies. These technologies have eliminated the limited accuracy issues associated with traditional photogrammetry and manual measurement methods, providing the opportunity for highly accurate digital documentation (Yılmaz et al., 2007). In this respect, HBIM has become a data-driven conservation method that enables the comprehensive digital transfer of the physical, historical and material characteristics of historic structures.

Dimensions of HBIM

BIM, as an information system, is not limited to three-dimensional geometric models; rather, it is a multidimensional system enriched with additional layers such as time, cost, energy, sustainability, and management (Jongeling, 2008). In HBIM, these dimensions extend beyond the documentation of cultural heritage and enable data-driven decision-making processes for conservation and intervention strategies.

- 3D (Geometric Model): Represents the physical form of the structure.
- 4D (Time Dimension): Connects project processes with time.
- 5D (Cost): Supports cost estimation and control.
- 6D (Energy Performance): Focuses on energy performance and efficiency.

• 7D (Facility Management): Relates to maintenance and long-term use of the building (Odabaşı, 2022).

Additionally, in cultural heritage–oriented HBIM models, specific dimensions defined by Castellano-Roman and Pinto-Puerto (2019) are also considered:

• 4B (Historical Development): Shows different historical phases of the structure.
• 5B (Identification): Defines the cultural identity of the building.
• 6B (Cultural Context): Includes information about the surrounding environment.
• 7B (Conservation and Intervention): Focuses on restoration and conservation processes.

Levels of Development of HBIM

In HBIM processes, the accuracy and level of detail of the model are critical. The concept of LOD (Level of Detail/Development) is used to describe the amount of information contained in a model and its reliability that information is for different stages of a project (Graham et al., 2018). This concept was developed to manage expectations among project stakeholders and to clarify the level of precision and reliability of the data contained within the model at different stages of the project (Editorial Team, 2026).

Globally accepted LOD standards vary according to regional and institutional approaches. In the system developed by the American Institute of Architects (AIA) and the Associated General Contractors of America (AGC), which is widely adopted in the industry, a numerical scale ranging from LOD 100 to LOD 500 has been adopted (Editorial Team, 2026). According to this classification:

• LOD 100 (Conceptual Design): Represents the basic form, location, and orientation of the structure.
• LOD 200 (Schematic Design): Includes approximate dimensions and general shapes.
• LOD 300 (Design Development): Elements are modelled with more accurate dimensions and positions.
• LOD 350 (Construction Documentation): Connections between building components are defined more clearly.
• LOD 400 (Fabrication and Assembly): Contains detailed information required for production and construction.
• LOD 500 (As-Built Condition): The final model containing the actual data of the structure after construction, used primarily for facility management (Editorial Team, 2026).

In contrast, practices in the United Kingdom adopt a different process-oriented approach. In the UK-based system, development levels are addressed in seven stages covering the entire life cycle of the building: LOD 1 (Brief), LOD 2 (Conceptual), LOD 3 (Developed Design), LOD 4 (Production), LOD 5 (Installation), LOD 6 (As-Built), and LOD 7 (Operation and Maintenance) (Editorial Team, 2026).

The LOD concept is generally classified within ranges such as LOD 100–500 or LOD 0–7 and indicates the level of detail contained in the model. In the context of HBIM, however, these levels have been redefined for existing structures according to the accuracy of available data and the documentation methods employed (Chow et al., 2019):

- LOD 0: Elements may not be modelled; the structure may be represented only through point clouds or historical drawings.
- LOD 1: Shows the general form of the structure without detailed material information.
- LOD 2: Includes basic material and graphical representation.
- LOD 3: Provides more accurate geometry and partial material information.
- LOD 4: The model contains all details, including connections and element dimensions, and is used for areas requiring high accuracy.

These development levels determine the accuracy, reliability, and usability of the model in HBIM applications. Since HBIM studies are conducted based on the existing conditions of historic structures, LOD in this context defines not only the level of geometric detail but also the degree of integration of historical and material information within the model.

Methods and Techniques Used in The Documentation of Cultural Heritage

The conservation of cultural heritage and its transmission to future generations require the accurate identification of the geometric, physical, and material characteristics of structures. The documentation process is a technical activity carried out to determine the current condition of a structure, monitor its historical transformation, and provide a basis for future restoration projects (Aydın, 2024; Korumaz et al., 2011). The methods used in this process have evolved from traditional techniques toward digital and autonomous systems in parallel with technological developments.

Traditional documentation methods: Traditional documentation refers to the method in which the physical characteristics of historic structures are measured using simple hand tools such as measuring tapes, distance meters, plumb lines, and spirit levels, and the obtained data are transferred to hand-drawn sketches. This method represents the oldest and most fundamental approach in the history of architectural documentation (Aydın, 2024). In survey studies conducted using traditional methods, the plans, sections, and elevations of a structure are represented on a two-dimensional plane. However, this approach is insufficient in providing a comprehensive three-dimensional representation of the building (Aydın, 2024). Moreover, because it relies heavily on human intervention, it is prone to measurement errors, the process is highly time-consuming, and difficulties arise in accurately representing complex geometric forms such as muqarnas or highly ornamented surfaces (Aydın, 2024; Korumaz et al., 2011).

Digital documentation techniques: With the advancement of technology, documentation studies have shifted toward digital systems that do not require physical contact with the object and are capable of collecting highly accurate data in a relatively short time (Aydın, 2024). Digital documentation enables the production of simplified yet comprehensive models of cultural heritage assets that include not only their geometry but also texture and color information (Korumaz et al., 2011).

Topographic and geodetic measurements: This method, which can be considered the digitalized form of classical surveying techniques, employs devices such as total stations (electronic tacheometers). These instruments precisely determine the three-dimensional coordinates (X, Y, Z) of specific points on a structure, thereby establishing the infrastructure for digital mapping (Korumaz et al., 2011). It is generally used as a complementary technique in photogrammetric studies to determine the coordinates of ground control points

(GCPs) and to ensure that the model is accurately positioned within a real-world coordinate system (Aydın, 2024).

Photogrammetry: Photogrammetry is a technique that enables the acquisition of reliable metric data from overlapping photographs of objects or terrains taken from different angles (Aydın, 2024; Korumaz et al., 2011). Meaning "measurement through light," photogrammetry is one of the most widely used methods in the documentation of cultural heritage (Aydın, 2024).

Terrestrial Photogrammetry: This method is used in situations where images can be captured from close range, such as building façades or architectural details (Aydın, 2024). Particularly with the use of the "Structure from Motion" (SfM) technique, sequentially captured photographs can be processed to generate three-dimensional point clouds, solid models, and textured models of objects (Aydın, 2024). Compared to laser scanning, this method is more cost-effective and faster, while also offering advantages in visual documentation due to its ability to provide high-resolution texture data (Aydın, 2024).

Aerial Photogrammetry (UAV): This method, carried out using Unmanned Aerial Vehicles (UAVs), is effective for documenting areas that are difficult to access from the ground, such as roofs, domes, or extensive archaeological sites (Aydın, 2024). The data obtained through UAVs can be used to generate Digital Elevation Models (DEM) and large-scale maps (Aydın, 2024).

Terrestrial Laser Scanning (TLS based on LiDAR technology): Terrestrial Laser Scanning (TLS) is an active remote sensing method that uses Light Detection and Ranging (LiDAR) technology, in which laser pulses are emitted toward an object and the reflected signals are used to calculate distances (Aydın, 2024). This technology produces a dense and highly accurate three-dimensional representation of a structure, known as a point cloud, by collecting millions of point measurements per second (Aydın, 2024). Laser scanning is considered one of the most reliable methods for documenting complex structures, as it can operate even in low-light conditions and provides geometric data with millimetric accuracy (Aydın, 2024; Korumaz et al., 2011). However, the large volume of data generated and the high hardware requirements for processing constitute significant disadvantages of this technique (Aydın, 2024).

LiDAR, which possesses high-precision measurement capabilities, can generate a complete and highly accurate three-dimensional representation of objects; therefore, it provides highly reliable data for short-range remote sensing and photogrammetric studies (Kalaycık, 2021). Recent technological developments have enabled the integration of LiDAR sensors into mobile devices such as the iPhone 12 Pro. Currently used primarily for design-oriented applications, these mobile sensors are capable of generating three-dimensional models of environments within a range of approximately five meters and allow users to make real-time modifications to these models (Kalaycık, 2021).

Orthophoto: An orthophoto is an image obtained from photogrammetric photographs that have been geometrically corrected to eliminate tilt errors and perspective distortions, resulting in a true orthographic projection. This technique combines the visual richness of photography with the geometric accuracy of mapping (Aydın, 2024). In cultural heritage projects, orthophotos are commonly used as a base layer for façade surveys and for documenting complex surface details such as stone ornaments. Through orthophotos, it becomes possible to perform scaled and precise drawings directly over photographs within CAD-based drawing software (Aydın, 2024).

HBIM APPLICATIONS IN TÜRKİYE AND ABROAD

Today, awareness of BIM is steadily increasing. This situation has accelerated the transition toward the use of BIM technology in historic structures as well. The concept of HBIM continues to evolve and has gained momentum in conservation and documentation studies over the years, leading to a gradual increase in its application. This development reflects the growing interest in digitalization, modelling, and technological innovations. Within this context, documentation studies conducted using HBIM in Türkiye and abroad—particularly in Italy—are discussed.

Italy possesses pioneering applications and a strong academic infrastructure in the field of HBIM and has produced numerous high-quality studies, especially on monumental structures such as churches, cathedrals, and fortifications. In Türkiye, HBIM applications are primarily developing at the academic level; although field implementations remain limited, the approach is gradually gaining wider attention and adoption.

HBIM Applications in Türkiye

HBIM (Heritage Building Information Modelling) applications in Türkiye are predominantly limited to theses, pilot projects, and individual studies conducted mainly at the academic level. However, the increasing awareness of digitalization in the fields of architecture, archaeology, and restoration in recent years has created an important foundation for the integration of HBIM into cultural heritage management processes in Türkiye. Within this framework, HBIM applications have been examined through several case studies located in Türkiye, as well as one example of Turkish origin located in Serbia, as presented in Table 1.

The effect of software on historical building information modelling: Abdal Musa Tomb

This example was evaluated using the data obtained from the study by Coşgun (2022). The research focuses on the Abdal Musa Tomb located in the district of Elmalı (Antalya) and aims to examine the effects of different software tools and modelling techniques on accuracy, time efficiency, and overall productivity within the Heritage Building Information Modelling (HBIM) process. During the data acquisition phase, the structure was documented using the photogrammetry method; hundreds of photographs were captured using drones and high-resolution cameras. These photographs were processed in Agisoft Metashape software to generate a dense point cloud and mesh surface model, which was subsequently cleaned and aligned using Autodesk ReCap (Coşgun, 2022). The processed data were then transferred to the Autodesk Revit environment, where the building components were modelled parametrically. During the modelling stage, the Dynamo plugin was employed to apply algorithmic definitions for parts with irregular geometries. The study indicates that while an inventory at the HBIM model at LOD 300 can be produced within a limited timeframe, the survey, restitution, and restoration processes require significantly more time (Coşgun, 2022).

A proposed approach based on the hbim methodology in the reconstruction process of digital heritage

This example was evaluated using the data obtained from the study by Yörük (2025). Through the case of the Nero Bath in the ancient city of Patara, it aims to develop a holistic approach based on the HBIM methodology in the reconstruction process of digital heritage. During the data collection phase, the structure was documented using LiDAR scanning and UAV (drone)

Table 1. HBIM Projects in Türkiye (created by the author)

Case Study		Comparison Criteria			
Study Name	**Location**	**Data Collection Method**	**Suitability of the Software Used**	**Plugins Used and Their Contribution to the Project**	**Project Scale**
Abdal Musa Tomb (Coşgun, 2022)	Antalya	Photogrammetry drone imagery	Agisoft Metashape, ReCap, Revit, Dynamo	Dynamo: Creation of complex forms through algorithmic modelling when parametric modelling is insufficient	Structure (religious building tomb)
Patara Ancient City (Yörük, 2025)	Antalya	LiDAR scanning, drone photogrammetry	Agisoft Metashape, ReCap Pro, Rhinoceros, Revit, Navisworks	Autodesk Navisworks: Integration of different data sources, clash detection, 4D time planning, visualization of reconstruction scenarios	Structure (archaeological remains)
Ferdane Hanım Mansion (Garip, 2023)	Kocaeli	Laser scanning	ReCap Pro, Revit, Enscape	Enscape: Testing lighting, materials, and spatial perception in a 3D environment	Structure (building)
Afyonkarahisar Ulu Mosque (Tunay, 2022)	Afyon	Manual measurements, laser scanning	Trimble Realworks, ReCap, Faro Scene, Revit, Archicad	—	Structure (religious building – mosque)
Aya Yorgi Church (Günay, 2025)	Isparta	Laser scanning, photogrammetr, archival documents	Faro Scene, ReCap, Revit, Enscape	Enscape: Testing lighting, materials, and spatial perception in a 3D environment	Structure (religious building – church)
Pertev Paşa Mosque (Çelik, 2023)	Kocaeli	Laser scanning	ReCap, Revit	—	Structure (religious building – mosque)
Erythrai (Ildır) Archaeological Site (Sarıcaoğlu, 2021)	İzmir	Laser scanning, photogrammetry (175 min)	BIM environment	ICP (Iterative Closest Point) algorithm used for aligning point clouds	Structure (archaeological remains)
Mehmet Ağa Mansion (Odabaşı, 2022)	Ankara	Laser scanning (13.5 hours)	Faro Scene, ReCap, Revit (point cloud processing: 6 hours)	—	Structure (building)
Mahmud Pasha Bath (Çügen, 2022)	Serbia	Laser scanning, photographs, and videos	WebShare2Go, ReCap, Revit, Rhinoceros	—	Structure (building – bath)
Varna Monument (Aksoy & Kaya, 2025)	Kırklareli	Photogrammetry LiDAR (iPhone 15 Pro)	Agisoft Metashape, Scaniverse (mobile LiDAR capture), SketchUp	—	Structure (monument)

photogrammetry techniques; these data were processed in Agisoft Metashape and Autodesk ReCap Pro software to produce dense point cloud and mesh models. The acquired point cloud data were organized in the Rhinoceros environment and then transferred to the Autodesk Revit environment (Yörük, 2025). In the HBIM modelling process, algorithmic modelling tools were used to parametrically create complex geometries. This model was later transferred to Autodesk Navisworks software; here, the integration of different data sources, the timeline of construction phases (4D simulation), and clash detection of intervention scenarios were carried out. The use of Navisworks enabled the HBIM model to be integrated with multidisciplinary data management and was used as a primary source in reconstruction planning (Yörük, 2025).

Association the management process of restoration and conservation projects of historic buildings in Turkey with HBIM technology: A case study

This example was evaluated using the data obtained from the study by Garip (2023). Using the Ferdane Hanım Mansion in İzmit as a case study, a comparative analysis was conducted between traditional documentation methods and HBIM-based digital documentation methods in terms of process, accuracy, and efficiency. In the initial documentation phase, the structure was recorded

through hand measurements, manual drawings, photographs, and on-site observations, and the data were transferred into a digital environment using conventional CAD software. This process took approximately three months (Garip, 2023). In the subsequent HBIM-based phase, the structure was documented through laser scanning, and the resulting point cloud data were processed in Autodesk ReCap and transferred to Autodesk Revit. Enscape was used to enhance three-dimensional visualization and stakeholder communication. In contrast to the traditional method, the HBIM-based process was completed in only 17 days (Garip, 2023). This case demonstrates that HBIM can significantly reduce documentation time while improving data continuity, visualization, and coordination among project stakeholders.

Research on the use of historic building information modelling (HBIM) technique on immovable cultural heritage at Afyonkarahisar Grand Mosque for documentation purposes

This example was evaluated based on the data obtained from the study conducted by Tunay (2022). The research examines the applicability of the Heritage Building Information Modelling (HBIM) method for documentation purposes in immovable cultural heritage assets, using the Afyonkarahisar Ulu Mosque as a case study. In the study, the data collection process was carried out in two stages: first, manual measurements of architectural elements such as windows and doors were conducted using sketches and steel measuring tapes; second, point cloud data were obtained through laser scanning (Tunay, 2022). These data were processed and integrated using various software tools, including Trimble RealWorks, Autodesk ReCap, FARO Scene, Autodesk Revit, and Graphisoft Archicad (Tunay, 2022).

A mesh model was generated from the point cloud data and then transferred into the Revit and Archicad environments to create a digital information model. Revit was used for processing point cloud data and parametric modelling, while Archicad supported the modelling of complex geometries specific to historic structures. Through the HBIM process, geometric data, material textures, photographs, and 2D drawings were integrated into a single digital platform and supported by a virtual tour interface. Compared to traditional documentation methods, this approach minimized data loss, increased measurement accuracy, and facilitated the digital archiving of heritage documentation (Tunay, 2022).

Case studies of restoration processes with the hbim and example of the Church of Isparta Aya Yorgi

This example was analysed based on the data obtained from the study conducted by Günay (2025). The case of the Aya Yorgi Church in Isparta represents an applied research study examining the integration of HBIM technology into the restoration processes of historic structures. During the data collection phase, the structure was scanned using a FARO Focus3D laser scanner, and this process took approximately three days (Günay, 2025). The resulting point cloud data were organized in Autodesk ReCap and subsequently transferred to the Autodesk Revit environment. In the following modelling phase, which lasted five days, the geometry of the structure, material properties, and detailed architectural components were created within Revit. For visualization and the testing of restoration scenarios, the Enscape plugin was utilized, allowing spatial perception, lighting conditions, and material effects to be analysed in a realistic manner (Günay, 2025).

Historical building information modelling (HBIM) application: the case of Pertev Mehmet Paşa Mosque

This example was evaluated using the data obtained from the study by Çelik (2023). Through the case of the Pertev Mehmet Paşa Mosque in Kocaeli, the

study evaluates the applicability of HBIM as a documentation and digital modelling tool for cultural heritage structures. During the data collection process, the structure was documented with the FARO Focus3D laser scanner and this process took approximately three hours (Çelik, 2023). The obtained point cloud data were processed and cleaned in Autodesk ReCap software and then transferred to the Autodesk Revit environment. During the modelling process, the details of the structure were created at the LOD 300 level; however, some complex cultural heritage elements (for example decorations and original stone details) could not be fully modelled in the Revit environment. For this reason, representative models were created for these parts, and since the addition of detailed geometries required manual modelling, the expected level of time saving could not be achieved in the process (Çelik, 2023). Despite this, the HBIM method enabled the documentation of the overall geometry and spatial relationships of the structure with high accuracy and provided an important contribution in terms of digital archiving.

Archaeological heritage information management: HBIM Erythrae (Ildır)

This example was evaluated using the data obtained from the study by Sarıcaoğlu (2021). The study examines how the HBIM approach can be used for archaeological data management and documentation in the Erythrai (Ildır) archaeological heritage site. The aim of the research is to develop an integrated HBIM-based information management methodology that transfers the multilayered data of archaeological remains into the digital environment. During the data collection process, the site was measured using terrestrial laser scanning (TLS) and photogrammetry techniques; for the Heroon structure, high-resolution data were obtained through a total of 24 scanning positions over 175 minutes (Sarıcaoğlu, 2021). Since the obtained point clouds came from different resolutions and sources, they were aligned using the Iterative Closest Point (ICP) algorithm and a single geometric dataset was created. In the data processing and modelling stage, orthophotos were produced from the point cloud, 3D surface models and detailed analyses were carried out; information related to the structure and stone elements was integrated through programs that provide a NURBS infrastructure in the BIM environment (Sarıcaoğlu, 2021). This method increased data accuracy by providing high-precision and reliable representation in structures with complex and irregular geometries such as archaeological heritage sites, while also enabling the development of conservation decisions.

The heritage building information modelling (Heritage BIM) and refunctioning through 3-D documentation of the Mehmet Aga House

This example was evaluated using the data obtained from the study by Odabaşı (2022). It aims to digitally document the historic Mehmet Ağa Mansion located in Ankara and to develop a Heritage Building Information Model (HBIM), with the objective of providing a scientific basis for the future restoration and adaptive reuse processes of the building. During the data collection phase, the mansion was scanned in a total of 44 sessions using a FARO Focus M70 terrestrial laser scanner, and the fieldwork was completed in 13.5 hours; the point cloud data obtained from the scans were combined in FARO Scene software (Odabaşı, 2022). The acquired point clouds were then cleaned and georeferenced in Autodesk ReCap software and converted into ReCap Project (.rcp) format before being transferred to the Autodesk Revit environment. The HBIM model was developed in Revit, and modelling was carried out by referencing the point cloud data to accurately represent complex and deteriorated architectural elements; this process provided higher geometric accuracy and digital integrity compared to traditional documentation methods (Odabaşı, 2022). Special elements such as windows, doors, and the roof dome were modelled separately and later integrated into the model. The three-dimensional model of the building

was used as an effective tool to support future restoration decisions (Odabaşı, 2022).

BIM utilization in restoration projects: Mahmud Pasha Hammam

This example was evaluated using the data obtained from the study by Çügen (2022). The study examines the applicability of the BIM approach within a professional restoration implementation project carried out on the 15th-century Mahmud Pasha Bath in Golubac, Serbia. During the data collection process, the structure was scanned using a Faro Focus LS 120 terrestrial laser scanner, and 8.42 GB of point cloud data were obtained from 83 scan positions. In addition to laser scanning, photographs, videos, and material samples were collected to support the documentation process (Çügen, 2022). The point cloud data were merged in Faro Scene, converted through Autodesk ReCap, and transferred to AutoCAD and Revit environments. Auxiliary tools such as WebShare2Go, Rhinoceros, and SAP2000 were also used for data sharing, flexible modelling, and structural analysis (Çügen, 2022).

The applied workflow increased measurement accuracy and reduced data loss by enabling point cloud data to be processed directly within CAD/BIM environments. It also supported the creation of a shared dataset for multi-stakeholder coordination through the WebShare2Go platform. However, the ruinous condition of the bath, organic wall surfaces, and non-standard geometries limited the full representation of the structure in Revit. For this reason, Rhinoceros was used as a complementary tool for modelling irregular forms (Çügen, 2022). Overall, the case demonstrates the contribution of BIM to information sharing, data integrity, technical documentation, cost estimation, and multidisciplinary coordination in restoration projects.

Archiving historical heritage with photogrammetry and lidar: The case of Kırklareli Varna (Karahıdır) monument

This example was evaluated using the data obtained from the study by Aksoy and Kaya (2025). The study, conducted on the Varna (Karahıdır) Monument in Kırklareli, compares mobile LiDAR technology and photogrammetry in terms of accuracy, time, and cost. Three documentation methods were used: photogrammetry, mobile LiDAR, and manual measurement. During the data collection process, 142 photographs were taken for photogrammetric modelling, an iPhone 15 Pro was used for mobile LiDAR scanning, and traditional measuring tools were used for reference measurements. Agisoft Metashape was used to process photogrammetric data, Scaniverse was used for mobile LiDAR data acquisition and processing, and SketchUp was used for architectural analysis. These tools were considered suitable for the geometric and visual modelling of the monument as a medium-scale single structure.

In terms of time and cost efficiency, mobile LiDAR was found to be the most efficient method. The scanning and model generation process with Scaniverse took 2 minutes and 15 seconds, whereas the processing of photogrammetric data, including depth maps and point cloud generation, took approximately 21 minutes (Aksoy & Kaya, 2025). In terms of accuracy, LiDAR measurements were found to be consistent with manual reference measurements and provided the level of precision required for restoration-oriented documentation. Photogrammetry, on the other hand, produced stronger results in visual texture and surface representation, although some geometric deviations were observed. Therefore, the study indicates that mobile LiDAR is more effective for speed and geometric accuracy, while photogrammetry is more suitable for visual presentation and texture mapping. The case demonstrates that the integrated use of mobile LiDAR and photogrammetry can provide a low-cost

and time-efficient documentation strategy, particularly where access to high-cost terrestrial laser scanners is limited.

HBIM Applications Abroad

At the international level, Heritage Building Information Modelling (HBIM) applications were initially developed within the scope of academic studies and pilot projects; however, they have now evolved into advanced practices that strengthen interdisciplinary collaboration in the fields of architecture, archaeology, and cultural heritage conservation. In recent years, the increasing awareness of digital transformation has enabled HBIM to be used as an effective tool in the documentation, analysis, conservation, and restoration processes of historic structures. Within this context, numerous projects have been carried out abroad, and various applications at different scales—particularly in Italy as well as in other countries—have been examined, as summarized in Table 2.

Table 2. HBIM Projects International Context (created by the author)

Case Study		Comparison Criteria			
Study Name	**Location**	**Data Collection Method**	**Suitability of the Software Used**	**Plugins Used and Their Contribution to the Project**	**Project Scale**
Pisa City Walls (Giuliani et al., 2024)	Italy	Photogrammetry (iPhone 11)	Agisoft Metashape, Rhinoceros, Archicad, Grasshopper	Grasshopper: Facilitates the modelling of amorphous structures	Structure (historic city walls)
Colonnade of the Temple of Antas (Bagnolo et al., 2019)	Italy	Photogrammetry, laser scanning	Autodesk Revit, Dynamo	Dynamo: Generates complex forms through algorithmic modelling when parametric modelling is insufficient	Structural element (temple column)
Church of San Nicolo (Banfi, 2022)	Italy	Photogrammetry, laser scanning	AutoCAD, Rhinoceros, Revit	—	Structure (archaeological remains)
A Heritage Building in Massawa (Sewasew & Tesfamariam, 2023)	Eritrea	Photographic data, orthophoto	Photoshop, Revit	—	Structure (civil building)
The Duomo of Molfetta (Nieto-Julian et al., 2024)	Italy	Terrestrial laser scanning, photogrammetry	Archicad, Cyclone	Archicad Teamwork: Used for team collaboration; BIMvision: Used to examine interactions among stakeholders in the HBIM model	Structure (religious building – basilica)
The Castle of Maredolce (Allegra et al., 2024)	Italy	Laser scanning method (3 days)	Cyclone, 3D Reshaper (point cloud software), Revit, Rhinoceros	—	Structure (castle)
Parma Cathedral (Bruno & Roncella, 2018)	Italy	Topographic survey, laser scanning, photogrammetry	Archicad, Cyclone, Rhinoceros, Revit	Revit plugin: Developed to attach orthophotos to the model, produce 2D thematic maps, and automatically transfer this data to the 3D model	Structure (religious building – basilica)
Centre Block, Parliament Hill (Banfi et al., 2018)	Canada	Photogrammetry, laser scanning	ContextCapture, Pointools, Scene, ReCap, Rhinoceros, Revit	Automatic verification system (AVS): A tool that automatically measures and validates deviations between the point cloud and the 3D model	Structure (administrative building)
The Church of St. Francesco at Rocca Calascio (Trizio & Savini, 2020)	Italy	Photogrammetry	Agisoft, Meshlab, Revit, SketchUp	—	Structure (archaeological remains)
Two Arab-Norman Churches (Aricò et al., 2023)	Italy	Laser scanning, photogrammetry, topographic survey	Autodesk ReCap, Agisoft Metashape, CloudCompare, Revit	—	Structure (religious building – church)

A HBIM pipeline for the conservation of large-scale architectural heritage: The city walls of Pisa

This example was evaluated using the data obtained from the study by Giuliani et al. (2024). It focuses on the development of a large-scale HBIM process for the conservation of the Pisa city walls located in the Tuscany region of Italy. The aim of the research is to establish a fast, accurate, and integrated digital method for documenting, analysing, and preserving historical architectural heritage that extends across large areas. During the data collection process, photogrammetry and topographic measurement techniques were used together. The images were processed in Agisoft Metashape software, location data were supported by total station measurements, and the accuracy of the models was ensured (Giuliani et al., 2024). The obtained point clouds were transferred to Rhinoceros software; here, the HBIM model was created in the Graphisoft Archicad environment using the Grasshopper plugin and Archicad. The project was applied to a 405-meter section of the approximately 7 km long city walls and aimed to document both geometric deformations and material deterioration (Giuliani et al., 2024). This method developed a reliable digital data infrastructure that can be used in making planned conservation decisions by providing a low-cost, highly accurate, and time-efficient documentation process in large-scale cultural heritage sites.

HBIM for archaeological sites: From SfM based survey to algorithmic modelling

This example was evaluated using the data obtained from the study by Bagnolo et al. (2019). In the study, the applicability of the HBIM method in the digitalization process of archaeological structures was examined within the scope of research conducted on the architectural elements of the columned front façade (pronaos) of the Temple of Antas located on the island of Sardinia in Italy. The main aim of the research is to evaluate the effectiveness of algorithmic modelling methods in transferring historical structural elements with complex geometries into the BIM environment. During the data collection process, the Structure from Motion (SfM)–based photogrammetry method was used (Bagnolo et al., 2019). The obtained images were processed in Agisoft Photoscan software to generate dense point cloud data, enabling the digital representation of surface geometries with millimetric accuracy. These produced data were transferred to Autodesk Revit software, and the algorithmic modelling process was carried out through the Dynamo plugin (Bagnolo et al., 2019). The mentioned software minimized data loss, preserved model integrity, and provided a high level of accuracy in parametric modelling. The study was conducted at the scale of a single archaeological structure and particularly focused on the parametric and algorithmic modelling processes of columns, capitals, and base elements.

HBIM, 3D drawing and virtual reality for archaeological sites and ancient ruins

This example was evaluated using the data obtained from the study by Banfi (2020). The research was conducted on the San Nicolò Church and the surrounding archaeological remains located in the village of Bajardo in the Liguria region of Italy. During the data collection process, photogrammetry and terrestrial laser scanning (TLS) methods were used together, and the obtained high-resolution data were processed through NURBS-based modelling using Rhinoceros, AutoCAD, and Autodesk Revit software (Banfi, 2020). This software chain (Rhinoceros–Revit) minimized data loss and ensured high geometric accuracy and multi-layered information transfer (Banfi, 2020). Although the project was carried out at the scale of a single structure, it covered the ruined church of a historic village and the surrounding archaeological remains, thereby presenting an exemplary model for the digital documentation and virtual reconstruction of cultural heritage.

Historic building information modelling using image: example of port city Massawa, Eritrea

This example was evaluated using the data obtained from the study by Sewasew and Tesfamariam (2023). The study aims to develop a low-cost, image-based HBIM method for documenting and preserving cultural heritage structures with limited accessibility in the port city of Massawa in Eritrea. The main objective of the research is to create parametric HBIM models of historic structures using only photographic data in cases where access to modern surveying equipment (such as LiDAR or TLS) is not available, thereby addressing the documentation gap in developing countries (Sewasew & Tesfamariam, 2023). During the data collection process, available visual sources such as individual façade photographs, Google Earth images, maps, and archival documents were used; these images were corrected in Adobe Photoshop to produce scaled façade drawings. Subsequently, the model was created using Autodesk Revit 2022 software. GIS-based location data and historical architectural drawings were integrated into the process. The accuracy of the method was tested by comparing the results with architectural drawings dated 1927, and it was determined that measurement differences were generally minimal, indicating a high level of geometric accuracy (Sewasew & Tesfamariam, 2023). The study was implemented at the scale of a single structure and façade. By enabling the production of HBIM models solely from photographic data without the use of modern scanning technologies, the method offers a sustainable, low-cost, and accuracy-based solution for the digital documentation and conservation of heritage sites with limited accessibility.

An efficient process for the management of the deterioration and conservation of architectural heritage: The HBIM project of the Duomo of Molfetta (Italy)

This example was evaluated using the data obtained from the study by Nieto-Julián et al. (2024). The research was conducted on the Duomo di Molfetta Cathedral located in the Puglia region of Italy and aims to develop an effective HBIM methodology to optimize the management of deterioration and conservation processes of the historic structure. In the study, the data collection process was carried out through the combined application of terrestrial laser scanning (TLS) and photogrammetric techniques. The obtained point clouds were processed using Cyclone software. The photogrammetric data produced with Agisoft Metashape were integrated into the Archicad 27 environment. The resulting datasets were semantically separated according to structural elements (such as columns, vaults, and walls) and subsequently exported in IFC format (Nieto-Julián et al., 2024). Accuracy assessments were conducted through comparisons between the point cloud and the parametric model (Nieto-Julián et al., 2024). The high accuracy of the method enabled the millimetric detection of column deformations and wall cracks. Collaboration was supported through Archicad Teamwork, allowing real-time and up-to-date data sharing among the project stakeholders involved in the study (Nieto-Julián et al., 2024).

Scan-to-BIM for The Management of Heritage Buildings: The Case Study of The Castle of Maredolce (Palermo, Italy)

This example was evaluated using the data obtained from the study by Allegra et al. (2020). The research was conducted on the Maredolce (Favara) Castle from the Arab–Norman period located in Palermo, Italy, and examines the applicability of the Scan-to-BIM process for the documentation, conservation, and management of historic structures. The main aim of the study is to develop a usable digital data infrastructure for conservation and restoration planning by generating a highly accurate HBIM model of a historic structure with complex geometries from laser scanning data. The data collection process was carried out using Leica RTC360 and FARO Focus 3D laser scanners (Allegra et al., 2020).

The data were registered and aligned in Leica Cyclone software and organized through filtering in the 3D Reshaper program. The point cloud data were transferred to the Autodesk Revit environment, where both parametric and non-parametric modelling strategies were applied; custom models were created for elements with complex geometries, and unique forms were modelled in Rhinoceros software and integrated into Revit. An HBIM model at the LOD 2–3 level was produced (Allegra et al., 2020). The resulting model integrated the geometric, material, and functional data of the structure within a single digital platform, enabling the digital management of restoration, maintenance, and conservation processes.

A restoration oriented HBIM system for cultural heritage documentation: The case study of Parma Cathedral

This example was evaluated using the data obtained from the study by Bruno and Roncella (2018). The research was conducted on the Parma Cathedral located in Parma, Italy, and aims to develop a restoration-oriented HBIM system specifically designed for the documentation, maintenance, and restoration of historic structures. The main objective of the study is to create a flexible, accurate, and user-friendly digital system capable of managing complex geometries, irregular forms, and multi-layered data specific to historic buildings. During the data collection process, topographic surveying, laser scanning, and photogrammetry were used together to document both the interior and exterior spaces of the structure in three dimensions. The photogrammetric processing was carried out in Agisoft Photoscan software, while the laser scanning data were registered and aligned in Leica Cyclone software to ensure accuracy (Bruno & Roncella, 2018). Rhinoceros software was used to accurately model elements with complex geometries. The HBIM model was created in the Autodesk Revit environment. In addition, a custom-developed plugin for Revit enabled the automatic transfer of 2D deterioration and material maps derived from orthophotos into the 3D model, thereby integrating the thematic mapping process for restoration planning directly into the BIM environment (Bruno & Roncella, 2018).

Building information modelling for cultural heritage: The management of generative process for complex historical buildings

This example was evaluated using the data obtained from the study by Banfi et al. (2018). The research addresses the "advanced modelling techniques" process developed for the digitalization of complex historic structures, through the case of Confederation Hall located within the Centre Block of the Parliament Building in Ottawa, Canada. The main objective of the study is to create accurate, parametric digital models compatible with structural analysis for historic structures with highly complex geometries. During the data collection process, point cloud data obtained from three different 3D laser scanners were integrated with photogrammetry, archival drawings, historical photographs, and CAD data (Banfi et al., 2018). The acquired scanning data were cleaned and optimized using Context Capture, Pointools, Scene, and Autodesk ReCap software. In the modelling stage, free-form surfaces were created in Rhinoceros software and subsequently transferred to Autodesk Revit and Graphisoft Archicad environments. The project was conducted at the scale of a single interior architectural space (Confederation Hall), and a highly detailed model at the LOD 300–500 level was produced (Banfi et al., 2018).

Archaeology of buildings and hbim methodology: İntegrated tools for documentation and knowledge management of architectural heritage

This example was analysed using the data obtained from the study by Trizio and Savini (2020). The research was conducted on the San Francesco Church located

in Rocca Calascio in the L'Aquila region of Italy and proposes a multidisciplinary method for integrating data obtained through archaeological analyses into the HBIM environment. During the data collection phase, the photogrammetry method was used; the images were processed in Agisoft Photoscan software and subsequently merged in Meshlab software (Trizio & Savini, 2020). In this way, the resulting photorealistic 3D model was validated through geometric and color verification, and high-resolution 2D orthophotos and plan sections were also produced.

During the modelling process, the Stratigraphic Wall Units identified on the wall surfaces were classified chronologically through archaeological analyses, and this information was integrated into the HBIM model. Parametric modelling was tested through two different methods: the first directly within Autodesk Revit software, and the second by transferring models created using SketchUp (2019 version) into Revit. This method increased model accuracy by integrating photogrammetry and archaeological databases; metric verification was carried out in the Revit environment, resulting in a geometrically consistent and information-rich HBIM model. The project was implemented at the scale of a single structure, and a highly accurate digital twin was developed in which archaeological, structural, and historical data were integrated within the same digital model.

A scan-to-BIM approach for the management of two Arab-Norman churches in Palermo (Italy)

This example was evaluated using the data obtained from the study by Aricò et al. (2023). The study focuses on the Scan-to-BIM–based HBIM application carried out on the St. John the Baptist of the Lepers and St. John the Evangelist of the Hermits churches in Palermo. The aim of the research is to examine the effectiveness of digital technologies in the documentation, analysis, and conservation management processes of these two medieval structures from the Arab–Norman period. During the data collection phase, terrestrial laser scanning (TLS), drone photogrammetry (UAV), and topographic surveying methods were used for the first structure; however, due to legal restrictions, only TLS scanning was applied for the second structure (Aricò et al., 2023). The scanning operations took several days. The data were processed using Autodesk ReCap, Agisoft Metashape, and CloudCompare software, and subsequently an HBIM model was created in the Autodesk Revit environment (Aricò et al., 2023). During the modelling stage, programs allowing more flexible work were required for complex geometries. All special elements were additionally modelled and added to the Revit library, which required additional time. The deviations from the reference points obtained through laser scanning were evaluated, and the accuracy of the method was confirmed (Aricò et al., 2023).

DISCUSSION

In the field of HBIM (Heritage Building Information Modelling), the international literature has developed rapidly in recent years; particularly in Europe-based projects, comprehensive case studies have been published focusing on process management, data integrity, cost optimization, and software integration. In contrast, the number of academic studies on HBIM in Türkiye remains limited, and the existing body of knowledge is largely based on academic theses. At the implementation level, the number of comprehensive and multidisciplinary HBIM projects is quite low. This situation leads to limitations in both methodological comparisons and the production of comprehensive data related to process and cost management. Large-scale studies published abroad, supported by advanced hardware–software infrastructures, archival resources, and expert

teams, provide more concrete outputs regarding how HBIM processes can be optimized.

Discussion of Time Management

In HBIM projects conducted abroad, processes are generally completed in a shorter time due to the effective use of advanced hardware and software infrastructures, the availability of institutional digital archives, and the presence of interdisciplinary teams specialized in HBIM. The integrated use of software such as Autodesk Revit, Graphisoft Archicad, and Rhinoceros facilitates smoother transitions between data collection, modelling, and analysis stages, thereby improving workflow efficiency.

In contrast, HBIM applications in Türkiye generally require longer processing times. This is largely due to the lack of institutional digital archives, limited numbers of specialists experienced in HBIM workflows, and restrictions in access to licensed software. Nevertheless, case studies such as the Ferdane Hanım Mansion demonstrate that HBIM-based documentation can significantly reduce project durations compared to traditional methods.

Discussion of Cost Management

When evaluated in terms of cost management, it is observed that in HBIM projects conducted abroad, although high investments are made in hardware and licensed software at the initial stage, the total project cost can be optimized in the long term. The main reason for this is the significant reduction in labor and time costs as HBIM processes are completed in a shorter period. In particular, the use of data collection methods with high initial investment costs, such as laser scanning (LiDAR/TLS), together with or as an alternative to photogrammetry techniques, enables the establishment of a balance between cost and accuracy. In international case studies, it has been observed that integrating high-resolution laser scanning data with lower-cost photogrammetric data within the same model shortens the fieldwork duration while maintaining acceptable levels of accuracy.

In Türkiye, HBIM applications tend to rely on more limited technical equipment and alternative software in order to reduce initial investment costs. While this approach lowers short-term expenses, it may increase manual modelling efforts and extend project duration. Despite these limitations, HBIM still offers significant long-term economic benefits through improved data management, digital archiving, and more efficient maintenance and restoration processes.

Discussion of the Data Collection Process

In HBIM projects conducted abroad, the data collection process is generally based on a hybrid approach combining laser scanning (LiDAR, TLS) and photogrammetry. High-precision devices such as Leica RTC360, FARO Focus 3D, and Nikon NPL 350 are frequently used, as their ability to produce dense point clouds allows the current condition of structures to be represented with millimetric accuracy. While laser scanning improves geometric reliability, particularly for structures with complex geometries and deformations, photogrammetry provides complementary data for surface textures and visual details. The combined use of these two methods ensures that both geometric accuracy and visual information are comprehensively transferred to the model, thereby increasing the accuracy and reliability of the HBIM model (Aksoy & Kaya, 2025).

In Türkiye, although similar data collection methods are used, drone-based photogrammetry is more frequently preferred to reduce hardware costs. While this approach decreases fieldwork time and initial investment costs, it may result

in lower geometric accuracy compared to laser scanning. In cases involving irregular surfaces, interior spaces, or detailed architectural elements, reliance solely on photogrammetry can limit model accuracy. Therefore, the balance between cost efficiency and model accuracy remains a key factor influencing the quality of HBIM processes in Türkiye.

Discussion of the Software Used in the Data Processing and Modelling Process

In the data processing and integration stage, combining laser scanning and photogrammetry data from different sources within a single coordinate system is essential. In the examined HBIM projects, software such as Agisoft Metashape, Autodesk ReCap Pro, and Cyclone Register 360 are widely used for aligning heterogeneous datasets, removing noise, and improving coordinate accuracy. Cyclone Register 360 is particularly effective in the automatic alignment of laser scanning data, while Agisoft Metashape is commonly used for generating photogrammetric data and transferring texture information into models. Autodesk ReCap Pro functions as an intermediary platform for transferring point cloud data into BIM environments.

During the modelling stage, Autodesk Revit, Graphisoft Archicad, and Rhinoceros emerge as key tools within HBIM workflows. While Revit and Archicad support information-based modelling through parametric BIM infrastructures, Rhinoceros is frequently used for modelling complex and irregular cultural heritage geometries. Visual programming plugins such as Dynamo and Grasshopper further support algorithmic modelling, enabling the efficient creation of repetitive or complex elements. Additionally, Autodesk Navisworks facilitates model integration, 4D time simulations, clash detection, and schedule control, supporting overall project management processes.

HBIM technology contributes significantly to reducing project duration and improving cost management. The integration of photogrammetry and laser scanning data within the same model can considerably shorten fieldwork time. Although HBIM applications are gradually increasing in Türkiye, limitations such as restricted digital archives, software licensing costs, and a lack of specialized experts still hinder the full realization of these advantages (Garip, 2023). Nevertheless, existing studies demonstrate that HBIM provides substantial time savings and cost reductions compared to traditional documentation methods.

CONCLUSION

This study aimed to evaluate the Heritage Building Information Modelling (HBIM) approach in the documentation and sustainable management of cultural heritage structures not only as a documentation tool but also as a decision-support system from the perspective of time and cost management. For this purpose, the research was conducted within the framework of a qualitative research method; in line with the research questions defined by the author, a total of 20 HBIM projects selected from Türkiye (10 cases) and international context (10 cases) were comparatively analysed. As a result of the comparative analyses, the following key findings regarding the effects of HBIM processes on project management were identified:

- HBIM as a Tool for Process Efficiency and Management: In the examined cases, HBIM was found to improve project efficiency by integrating geometric data, material information, documentation records, and visual outputs within a single digital environment. This integration reduces data fragmentation, supports more coordinated decision-making, and strengthens communication among project stakeholders. Therefore, HBIM functions not only as a modelling

system but also as a management platform that can guide documentation, restoration, maintenance, and conservation processes.

- Time and Cost Efficiency through Integrated Workflows: The findings indicate that the contribution of HBIM to time and cost management depends on the relationship between data acquisition methods, software environments, and modelling strategies. Laser scanning and LiDAR-based methods generally support faster and more accurate data acquisition, while photogrammetry provides advantages in visual documentation and texture mapping. Hybrid workflows combining these methods offer a more balanced approach in terms of accuracy, time, and cost.
- Software Integration and Process Coordination: The use of BIM-based software and complementary tools such as Revit, Archicad, Rhinoceros, Dynamo, Grasshopper, Navisworks, and visualization platforms contributes to more coordinated and information-rich project processes. These tools support different stages of HBIM workflows, including point cloud processing, parametric modelling, algorithmic form generation, visualization, clash detection, and process planning. In this respect, software interoperability is a critical factor in transforming HBIM from a documentation method into a project management tool.
- Comparative Findings between Türkiye and International Contexts: The comparison between Türkiye and international examples reveals a clear difference in terms of project management maturity. International HBIM applications generally demonstrate more integrated workflows supported by advanced hardware, specialized teams, institutional archives, and software interoperability. In contrast, HBIM applications in Türkiye are still developing mainly through academic studies, pilot projects, and individual research initiatives. Although limitations related to software access, digital archives, technical expertise, and project budgets affect the continuity of HBIM-based workflows, the Turkish cases also show that HBIM can provide significant advantages over traditional documentation methods, particularly in reducing data loss, shortening documentation time, and improving stakeholder coordination.

As a result, the comparative evaluation shows that HBIM applications international context generally demonstrate a more advanced structure in terms of process management, cost efficiency, software integration, and data accuracy, whereas HBIM practices in Türkiye are still in a developmental stage. However, the cases examined in Türkiye indicate that growing academic interest, university-based research, and the increasing use of digital tools provide an important basis for the future integration of HBIM into cultural heritage management. In this context, HBIM should not be addressed only as a technical documentation method, but as a multidimensional project management approach that supports decision-making, conservation planning, maintenance strategies, and long-term data management.

This study contributes to the literature by examining HBIM from a project management perspective and by comparing its time and cost implications in Türkiye and international contexts. The findings indicate that the systematic use of HBIM can support more efficient documentation, reduce data loss, improve stakeholder coordination, and strengthen decision-making in cultural heritage projects. Future studies should focus on developing national HBIM standards, expanding practice-based training models, creating institutional digital archives, and testing HBIM workflows through field-based applications.

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REFERENCES

Advenser. (2023, September 28). Understanding BIM LOD levels and LOI: Navigating the depths of building information modelling. https://www.advenser.com/2023/09/28/understanding-bim-lod-levels-and-loi-navigating-the-depths-of-building-information-modelling/

Aksoy, T., & Kaya, S. (2025). Tarihi mirasın fotogrametri ve LiDAR ile arşivlenmesi: Kırklareli Varna (Karahıdır) anıtı örneği. *Kırklareli University Journal of the Faculty of Architecture (E-Scala), 4*(2), 73–91.

Allegra, V., Di Paola, F., Brutto, M. L., & Vinci, C. (2020). Scan-to-BIM for the management of heritage buildings: The case study of the Castle of Maredolce (Palermo, Italy). The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. https://doi.org/10.5194/isprs-archives-XLIII-B2-2020-1355-2020

Aricò, M., Brutto, M. L., & Maltese, A. (2023). A scan-to-BIM approach for the management of two Arab-Norman churches in Palermo (Italy). *Heritage*. https://doi.org/10.3390/heritage6020087

Aydın, E. (2024). *Kültürel Mirasın 3 Boyutlu Belgelenmesinde Dijital İkiz Teknolojisinin Kullanımı.* (Tez No: 886111) [Yüksek Lisans Tezi, İstanbul Teknik Üniversitesi]. YÖK Ulusal Tez Merkezi.

Bagnolo, V., Argiolas, R., & Cuccu, A. (2019). HBIM for archaeological sites: From SfM-based survey to algorithmic modelling. The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. https://doi.org/10.5194/isprs-archives-XLII-2-W9-57-2019

Banfi, F. (2020). HBIM, 3D drawing and virtual reality for archaeological sites and ancient ruins. *Virtual Archaeology Review*. https://doi.org/10.4995/var.2020.12416

Banfi, F., Chow, L., Ortiz, M. R., Ouimet, C., & Fai, S. (2018). Building information modelling for cultural heritage: The management of generative process for complex historical buildings. In Springer International Publishing. https://doi.

org/10.1007/978-3-319-75826-8_10

Bastem, S. S. (2021). *Tarihi Yapılarda Yapı Bilgi Modeli Uygulamalarının Sistematik Literatür Tarama Yöntemiyle Değerlendirilmesi*. (Tez No: 688805) [Yüksek Lisans Tezi, İstanbul Teknik Üniversitesi]. YÖK Ulusal Tez Merkezi.

Bruno, N., & Roncella, R. (2018). A restoration-oriented HBIM system for cultural heritage documentation: The case study of Parma Cathedral. The International Archives of the Photogrammetry, *Remote Sensing and Spatial Information Sciences*. https://doi.org/10.5194/isprs-archives-XLII-2-171-2018

Castellano-Román, M., & Pinto-Puerto, F. (2019). Dimensions and levels of knowledge in heritage building information modelling, HBIM: The model of the Charterhouse of Jerez (Cadiz, Spain). Digital Applications in Archaeology and Cultural Heritage, 14, e00110. https://doi.org/10.1016/j.daach.2019.e00110

Chow, L., Graham, K., Grunt, T., Gallant, M., Rafeiro, J., & Fai, S. (2019). The evolution of modelling practices on Canada's Parliament Hill: An analysis of three significant heritage building information models (HBIM). The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, 42(2), 419–426. https://doi.org/10.5194/isprs-archives-XLII-2-W11-419-2019

Coşgun, N. T. (2022). *Tarihi Yapı Bilgi Modellemesinde Yazılımların Etkisi: Abdal Musa Türbesi.* [Yüksek Lisans Tezi, Gazi Üniversitesi]. AVESİS Açık Erişim Koleksiyonu

Çelik, E. (2023). *Tarihi Yapı Bilgi Modellemesi (Tybm) Uygulaması: Pertev Mehmet Paşa Camii Örneği.* (Tez No: 826510) [Yüksek Lisans Tezi, Kocaeli Üniversitesi]. YÖK Ulusal Tez Merkezi.

Çügen, H. F. (2022). *BIM Utilization in Restoration Projects: Mahmud Pasha Hammam*. (Tez No: 726701) [Yüksek Lisans Tezi, Gazi Üniversitesi]. YÖK Ulusal Tez Merkezi.

Editorial Team. (2026, June 3). *Understanding LOD and LOIN in BIM: Definitions and applications.* BibLus. Retrieved June 2026, from https://biblus.accasoftware.com/en/what-are-lod-and-loin-in-bim-and-what-are-they-for/

Evrim Ağacı. (2021, March 3). LIDAR Teknolojisi Nedir? Nasıl Çalışır? Nerelerde Kullanılır? Retrieved January 2025, from https://evrimagaci.org/lidar-teknolojisi-nedir-nasil-calisir-nerelerde-kullanilir-10214

Garip, D. (2023). *Türkiye'deki Tarihi Yapıların Restorasyon ve Koruma Projelerinin Yönetim Sürecinin HBIM Teknolojisiyle İlişkilendirilmesi: Bir Vaka Çalışması.* (Tez No: 790537) [Yüksek Lisans Tezi, Mimar Sinan Güzel Sanatlar Üniversitesi]. YÖK Ulusal Tez Merkezi.

Giuliani, F., Gaglio, F., Martino, M., & Falco, A. D. (2024). A HBIM pipeline for the conservation of large-scale architectural heritage: The city walls of Pisa. *Heritage Science*. https://doi.org/10.1186/s40494-024-01141-4

Graham, K., Chow, L., & Fai, S. (2018). Level of detail, information and accuracy in building information modelling of existing and heritage buildings. *Journal of Cultural Heritage Management and Sustainable Development, 8*(4), 495–507. https://doi.org/10.1108/JCHMSD-09-2018-0067

Günay, B. (2025). *HBIM ile Restorasyon Süreçlerinin Vakalar Üzerinden İncelenmesi ve Isparta Aya Yorgi Kilisesi Uygulama Örneği.* (Tez No: 953771) [Yüksek Lisans Tezi, Mimar Sinan Güzel Sanatlar Üniversitesi]. YÖK Ulusal Tez Merkezi.

Jongeling, R. (2008). *BIM instead of 2D-CAD in construction projects: A*

comparison between today's construction processes based on 2D-CAD and BIM [Master's thesis, Luleå University of Technology].

Kalaycık, B. (2021, March 3). *LIDAR Teknolojisi Nedir? Nasıl Çalışır? Nerelerde Kullanılır?* Evrim Ağacı. Retrieved January 2025, from https://evrimagaci.org/lidar-teknolojisi-nedir-nasil-calisir-nerelerde-kullanilir-10214

Karaoğlu, G. (2020). *Mimari Tasarımda BIM*. (Tez No: 633007) [Yüksek Lisans Tezi, Eskişehir Teknik Üniversitesi, Eskişehir]. YÖK Ulusal Tez Merkezi.

Korumaz, A. G., Dülgerler, O. N., & Yakar, M. (2011). *Kültürel mirasın belgelenmesinde dijital yaklaşımlar*. Selçuk Üniversitesi Mühendislik-Mimarlık Fakültesi Dergisi.

Nieto-Julián, E., Bruno, S., & J. M. (2024). An efficient process for the management of the deterioration and conservation of architectural heritage: The HBIM project of the Duomo of Molfetta (Italy). Remote Sensing. https://doi.org/10.3390/rs16234542

Odabaşı, H. (2022). *Tarihi Mehmet Ağa Konağı'nın Üç Boyutlu Belgelenmesi Üzerinden Mimari Miras Yapı Bilgi Modelinin (Heritage BIM) Oluşturulması ve Yeniden İşlevlendirilmesi.* [Yüksek Lisans Tezi, Başkent Üniversitesi]. http://hdl.handle.net/11727/8722

Sarıcaoğlu, T. (2021). *Arkeolojik Miras Bilgi Yönetimi: HBIM Erythrai (Ildır) Örneği.* (Tez No: 698457) [Doktora Tezi, Dokuz Eylül Üniversitesi]. YÖK Ulusal Tez Merkezi.

Sewasew, Y., & Tesfamariam, S. (2023). Historic building information modelling using image: Example of Port City Massawa, Eritrea. *Journal of Building Engineering.* https://doi.org/10.1016/j.jobe.2023.107662

Succar, B. (2009). Building information modelling framework: A research and delivery foundation for industry stakeholders. *Automation in Construction, 18*(3), 357–375. https://doi.org/10.1016/j.autcon.2008.10.003

Toldo, I. (2016). *Implementation of building information modelling systems for architectural heritage conservation* [Master's thesis, University of Southern California].

Trizio, I., & Savini, F. (2020). Archaeology of buildings and HBIM methodology: Integrated tools for documentation and knowledge management of architectural heritage. IMEKO TC-4 International Conference on Metrology for Archaeology and Cultural Heritage.

Tunay, H. M. (2022). *Tarihi Yapı Bilgi Modellemesi (TYBM) Yönteminin Taşınmaz Kültür Varlıklarında Belgeleme Amaçlı Kullanılabilirliğinin Araştırılması; Afyonkarahisar Ulu Camii Örneklemi.* (Tez No: 766530) [Yüksek Lisans Tezi, Eskişehir Teknik Üniversitesi]. YÖK Ulusal Tez Merkezi.

Yılmaz, H. M., Yakar, M., Güleç, S. A., & Dülgerler, O. N. (2007). Importance of Digital Close-Range Photogrammetry in Documentation of Cultural Heritage. *Journal of Cultural Heritage, 8*(4), s. 428–433

Yörük, M. Ş. (2025). *Dijital Mirasın Rekonstrüksiyonu Sürecinde HBIM Metodolojisine Dayanan Bir Yaklaşım Önerisi.* (Tez No: 924226) [Yüksek Lisans Tezi, Antalya Bilim Üniversitesi]. YÖK Ulusal Tez Merkezi.

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